Adaptive sawing -
Yield of a concept in reality

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It has been quite a special experience writing my master thesis in Kostomuksha. Even though this not always meant that it was a positive experience, I am really happy that I got the chance to do it. It has been very interesting and sometimes very funny to be working in environment like the one on a fairly new-launched production site in Karelia.

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No matter what I will do in the future I will always remember the months I spent in Karelia. To get a grasp of how all the parts in the production chain from log to glue board, is knowledge that I will carry with me, and hopefully have much use for. I hope that I can stay in touch with all the nice people I met in Kostomuksha. People can be really warm in a cold environment too.
Abstract

Glue board is the base for much solid wood furniture produced by the IKEA-owned company Swedwood. Glue board is glued together from lamellas which can be produced in different ways but in all cases is produced from boards coming from a saw-mill. In a saw-mill there are different techniques for producing boards from logs. This thesis is about the Adaptive sawing concept and its implementation at the Swedwood site in Kostomuksha. The idea with the concept is to raise the output from the raw material, the yield. This is partly achieved by edging away as little as possible from the boards in the saw-mill. The boards in the saw-mill are sawn in a way not unlike through-sawing. When brought to the glue-board factory they are scanned in order to optimise how to rip out as much lamellas as possible. The ripped lamellas are then cross-cut into different sizes which later are glued to glue board. The objective of this thesis is to examine the yield from log to glue board for the log classes 135-148 mm and 110-120 mm, to try to improve it and to identify problem factors.

In order to achieve that it was necessary to be sure of the volume figures at all stages. The incoming volume was given by the scanner at the log sorting; effort was therefore put down to make sure the figures could be trusted. For the smaller log class the logs were instead measured by hand and the volume was calculated. The logs were then sawn in the saw-mill. This was done with a low production speed and some problems were noted compared with when sawing with a standard technique. The absence of edging was the main reason for these problems. The saw-mill line was deemed inappropriate for sawing the smallest log class but could handle the 135 -148 mm class and the yield for that class was in line with what could be expected.

In the lamella production line some minor problems were noted and the boards from the four different batches from the 135 – 148 mm log class got different yields mainly due to differences in wood quality. The yield from log to glue board for these four batches varied from 17.6 % to 21.5 % with an average at 19.3 %. The yield was lower than what was achieved for earlier adaptive sawing test batches on other places. Those tests were however done on other diameter classes and with material that was slightly different than the one in Kostomuksha. Simulations were done to check how much the yield could be raised if other lamella widths than just the standard 46 mm lamella width was used. A raise to an average of 20.9 % could then be expected when using the lamella widths 46, 55 and 60 mm.

A similar simulation was done for the adaptive material that was produced from the 110 – 120 mm log class. The total yield for that material rose from 19.4 % to 22.4 % when using more lamella widths. Lamellas from this material were tested as there was fear, that they would not meet the standards for glue board production. This did however not prove to be the case. To use the lamella production for producing such material is however not ideal, since a very small volume is produced.
Sammanfattning


I lamellproduktionslinjen kunde en del smårre produktionsproblem noteras och brädorna från de fyra olika omgångarna av 135 – 148 mm stockar fick olika utbyte mest beroende på skillnader i råvarukvalitet. Utbytet från stock till limfog varierade från 17,6 % till 21,5 % och låg i snitt på 19,3 %. Detta utbyte var lägre än vad som uppnåtts för adaptiv sågning på andra platser vid tidigare tester. De testerna utfördes dock på andra diameterklasser och det är därför svårt att rakt av jämföra siffrorna. Dessutom kan råvaran ha varit något annorlunda. För att se hur mycket utbytet kunde höjas om andra lamellbredder användes förutom bara 46 mm, gjordes simuleringar. Totalutbytet kunde då höjas till i snitt 20,9 % i fall lamellbredden 46, 55 och 60 mm användes.

En likadan simulering gjordes på materialet som producerades från diameterklassen 110 – 120 mm. Totalutbytet för denna klass steg från 19,4 % till 22,4 % när fler lamellbredder användes. Eftersom det fanns viss oro att lamellerna skulle hålla lägre kvalitet övervakades de i limfogsfabricationen. Oron visade sig obefogad. Att producera lameller från den diameterklassen är dock inte idealt eftersom den producerade volymen blir så liten.
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1 Introduction
This chapter introduces the reader to the background and the objective of the master thesis and overall method and thinking throughout the work.

1.1 Background
In all kind of production the efficiency of the process is crucial. This applies both in terms on how efficient the people producing the products are and on how efficient the process itself is. In the latter case one important parameter is how efficient the use of the raw material is. An efficient use of the raw material available not only makes economic benefits possible but can also add a dimension of environmental thinking and sustainability. This applies even more for natural resources like oil, which are known to be sooner or later depleted. However, as competition as always is getting tougher and tougher and energy and labour costs might continue to rise, it is also clear that natural resources and raw materials that are renewable should be used efficiently if possible. Such a raw material is wood.

Wood is used as raw material for a number of products, of which one of the first that might spring to ones mind is furniture. Even though wood can, as earlier was stated, be seen as a renewable resource it is of course necessary to use it as efficiently as possible. Furthermore, wood according to Hoadley (2000) is a material with an appearance and properties that varies very much depending on from which log the wood comes from. Not to mention the differences between different tree species. If one however just looks on how to use wood from a specific species, which is commonly used for furniture production in the northern hemisphere, in an efficient way there are a few things that have to be in order. It is necessary to have a good basic production concept and the technology required to make an efficient use of the wood possible. The wood species in question throughout this thesis is pine and the company that has developed a production concept for how to increase the yield from pine logs to furniture is Swedwood. The company is one of the world’s leading furniture producers and it has mainly to do with the fact that Swedwood is the most important supplier of IKEA. The investigations that this thesis is based on, were mainly carried out at Swedwood’s site in Kostomuksha, Karelia, Russia. The technology that is being evaluated is the so called adaptive sawing concept. The basic idea with such sawing is to use more of the log, which is possible since less is edged away in the saw-mill. The boards that result from the sawing shall then as optimally as possible, be used to make lamellas of and from them then in turn glue board.

1.2 Objective
The objective of this thesis is to investigate the yield from log to ready glue board for the adaptive sawing concept in Kostomuksha. In addition it is examined, how to increase the yield even further and to identify problem factors.

1.3 Delimitations
Since it during 2008 was not possible to saw all diameter classes with the adaptive sawing concept this report focuses only on the smaller diameter classes, i.e. 110 to 148 mm logs. Logs with a bigger diameter were not possible to saw in the saw-mill in Kostomuksha in an efficient way in accordance with the adaptive sawing idea.

In accordance with directives the direct economical aspect of the yield figures as such, is also left out. A full analysis of the economical effects of the adaptive sawing concept in comparison with
a more traditional sawing technique is not the scope of this thesis. Focus is instead on the technical issues and mainly on the yield itself.

1.4 Overall method

First of all the studied system and its components are identified. Thereafter a certain amount of material is followed through the system. This is in a way the essence of this report, since the objective is to investigate the yield for the material through the system.

This is done for two diameter classes of logs in a total of five batches. Each batch is followed separately and volume in each step is noted. This means that volume for incoming material as well as material in shape of boards in the saw-mill and in the glue board factory is followed in detail. The first four batches come from the same diameter class and first of all the incoming volume is measured with help of a scanner. The logs are then stored and later taken to the saw-mill. In the saw-mill the logs are sawn into, in this case, four boards. In order to make sure that nothing of the produced volume disappears, it is essential to keep track of how many boards that actually goes through the whole saw-mill line. These boards are counted by a system in the saw-mill and the volume is also calculated. When the very same boards have been dried, they are moved to the glue board factory where they are planed and the volume is once again measured by a scanner. The boards are then ripped and scanned again. Based on this last scanner’s data it is decided how to cross-cut the lamellas into so called lamellas. Lamellas are later on glued into glue board. When the lamellas are cut, the volume of all pieces is registered and this together with data for lamellas produced from rejected ripped lamellas makes up the volume of ready lamellas, which divided with the incoming volume measured by the first scanner makes up the yield figure which is summed up for every batch. Four such batches of the diameter class 135 - 148 mm are followed and then a batch for the diameter class 110 – 120 mm is in a similar way followed, with the difference that the logs are measured manually in the first stage.

This is not all as easy as it may sound, since the system is very complex and large. The overall method is in its nature very practical and is in the early stages mainly about gathering data to be able to calculate the yield from log to glue board. In order to accomplish this, it is necessary to have complete control on the number of pieces and volumes in all steps of the process, to get as trustworthy statistics as possible. This means that scanner, manually collected and other data are gathered at certain points in the system in order to follow the nr of pieces and the volume at every point.

In practice every log is followed from the log sorting to ready lamella. After that the process of making glue board is generally not followed, since the material taking part in the test there will be treated as any other lamella and will be mixed with the lamellas coming from another production line. Hence, the yield is just possible to calculate until the end of the lamella production line. After that an estimated yield for the usual production is used.

In order to be able to increase the yield, simulations on which widths of lamellas can maximize the usage of material, are done. It is then assumed that more than just one lamella width can be used at the same time. In practice three and four different lamella widths were tried out. The yield raise that more lamella widths result is then extrapolated into a raised theoretical total yield from log to glue board. In this work a yield that is as high as possible within the given conditions, is the goal.

1.4.1 System approach

Since a saw-mill and a glue board factory in many ways can be seen as a supply chain or flow of material it is not farfetched to use the same way of thinking as in other science disciplines than
explicitly wood technology. The way of thinking in the field of logistics in general seems logical to use. According to Gammelgaard (2004) the systems approach has long been the prevailing approach to logistics analysis. According to Arbnor & Bjerke (1997) the basic idea of the systems approach is that the whole differs from the sum of its parts. Gammelgaard (2004) therefore means that it is necessary to identify the system and its parts, how these are attached, goals and which mechanisms of feedback exist within the system. In this context “the studied system” is often mentioned. With a studied system the part of the system that is seen relevant for the investigation is described. In general, the studied systems are created to give a clear picture of which factors can influence the studied parameters and get a reasonable amount of affecting factors. (Arbnor & Bjerke ,1997)

Since the goal always is to improve the system, the investigating person should according to Arbnor & Bjerke (1997), work very closely to the studied factors, but at the same time partly outside of the system. This is done in order to be able to see the system with other eyes than the people working within the system, gather information and then give proposals for improvements. This can be seen as true for this investigation, since the investigating person not completely is part of the system. A perspective of the system as a whole is also necessary to be able to give relevant suggestions for improvements, which take into account factors of the whole system.

1.4.2 Studied system

The studied system in this report is the log sorting, the saw-mill and one of the production lines for lamellas in the glue board factory in Kostomuksha. All this is described in detail later in the report. Of the two production lines for lamellas one of them, which is the oldest line is not part of the studied system since boards cut with the adaptive sawing do not enter that line. The later part of the studied system is instead the second production line, which is, one might say, the key part of the adaptive sawing concept. It is there that the boards are supposed to be cut in such a way that the overall yield increases. A requirement for that is of course that the boards are sawn in the right way in the saw-mill to start with, but it is in the glue board factory that one can say that the effects of new technology, in shape of scanners and so on, really can be used. The second production line for lamellas is on a daily basis usually named after its characteristic component, in this case the Raimann, where the lamellas are sawn. In Figure 1, the studied system and its boundaries can be viewed. The parts of the studied system are described more thoroughly later on. Although the forestry part before the studied system and the manufacturing of glue board from lamellas, immediately after the studied system are not a part of the studied system itself, they do however affect parts within the studied system. Therefore they are also described, but in general not as deep as the components of the studied system.
1.4.3 Validity and reliability

In order for a report to be scientific in its approach it is according to Björklund & Paulsson (2007) important that the conclusions are drawn with the help of well known and accepted methods. These simply have to be trustworthy. The term reliability tells how trustworthy the measuring method is. Merriam (1988) also means that reliability can be defined as a measurement on how possible it is repeat a result. Throughout the work with this report the goal has been to achieve a reliable result on the overall yield. A reliable result would mean that the yield does not differ too much from time to time. When evaluating the production reports that lay the foundries for all kind of yield statistics a very strict view was applied. If a figure deviated too much from what was seen as the normal picture the reason for the deviation had to be found out. In this fashion it was possible to detect several sources of error. If the difference still remained after looking at all possible explanations for a strange yield or volume figure, the figure was accepted, since wood is a raw material from the nature. It is therefore to expect some deviations in quality and behaviour of the material and consequently, yield. Nevertheless, some possible sources of error of course exist and they were dealt with are discussed later in the report. Since yield mainly is about volumes it could be worth mentioning that many of the volumes used, come from scanner reports. These reports were all thoroughly evaluated in terms of reliability. Reports that were deemed not fully reliable were not used as basis for yield calculations.

Besides from reliability another term that is central when it comes to trustworthiness is validity. Validity is according to Bell (1999) measurement of how much the investigation quantifies or describes what it is supposed to measure. During the work with this report there has been not much doubt that the right kind of yield has been measured. The question of validity could more be asked in terms of whether a yield result for one log class is in any way valid for other log classes and if it would be possible to generalize the conclusions.
1.5 Structure
This report starts with a description of the Swedwood group and a brief history of the Kostomuksha site. It then moves on to describe the adaptive sawing concept and its background and first tests. For a reader familiar with the adaptive sawing concept, the Swedwood group in general and the site in Kostomuksha in particular it might be advisable to move on to the later chapters. The tests done in Kostomuksha are described in chapter 5, “Calculating yield”, where both the whole processes of the respective batches and the results for them are described. In chapter 6, “Optimization of lamella width” the process of how to increase the result in shape of yield is described. This is done with help from simulation and the results from the simulations are presented. After that follows an analysis in chapter 7, “Analysis” and finally all the results are summarized in chapter 8, “Results” and then a quick outlook is given about what could be the subject of further studies.
2 General background of the Swedwood group

In the manufacturing industry it has since the fall of the communist bloc, been popular to move especially labour-intensive production to Eastern Europe, where the wages are much lower than in Western Europe. The manufacturing industry working with wood and producing furniture can according to Seppänen (2000) be said to be labour-intensive. In cases where the raw material needed, is also present locally at the site in Eastern Europe, the move is of course even more beneficial. According to van Weele (2005) the raw materials must be regarded as strategic it is highly plausible to avoid unnecessary transport, since these also cost money. The logical choice is of course to place the production units as close to the supplies of the raw material as possible. Since Russia is the country in the world with the biggest wood reserves it is in many ways logical to have production based on wood in Russia, whereas two crucial components for a factory – labour and raw material, are available and that for a relatively low price. When a local market for the products is at place in the country as well and there are custom tariffs for importing the goods into the country, this makes up yet another reason for a company to start producing in the country. Such is the situation in many ways for one of the world’s leading furniture retailing companies, IKEA, in Russia. The company early on realized that Russia had huge potential in many ways. Since IKEA according to Torekull (2006) already had had presence in Eastern Europe, mainly in Poland, the decision was perhaps easier to take than for other western companies. At the same time as IKEA built warehouses all over Russia the furniture production in Russia needed to expand at a similar pace. IKEA’s most important supplier has for several years been Swedwood.

Swedwood is owned completely by the IKEA group and was according to Swedwood.com (21/7 2008) founded in 1991 with the purchase of five Western European furniture factories. Swedwood was according to Torekull (2006) given several objectives from the owners. First of all the company should secure the supplies from IKEA’s furniture suppliers in Poland and all over Eastern Europe. The enormous changes in Eastern Europe after the fall of the Berlin wall in 1989 made it necessary for IKEA to try to make sure that the company would continue to get its share of the furniture produced in this region. The objectives for Swedwood have then developed into today’s business concept in which it in a broad way is stated what the tasks of Swedwood are. In accordance with these statements Swedwood shall be a reliable supplier to IKEA especially in areas where it is hard for IKEA to find other steadfast suppliers that offer reasonable prices. Competitive prices and effective production is therefore a must for Swedwood and also Swedwood is supposed to be a kind of Model Company for other IKEA suppliers in terms of quality, environment, safety and general conduct. It is not the wish of IKEA to be completely dependent on supplies from Swedwood. Therefore it is also stated that Swedwood only should stand for a limited share of IKEA’s total furniture needs. On the other hand many suppliers simply cannot handle the sheer volumes that IKEA requires and therefore Swedwood has often stepped in as a supplier when there were no real alternatives. The company has grown by 1 to 3 new plants every year since the foundation in 1991.

During the 1990s the expansion took place mainly in Poland, but also in other eastern European countries, in Germany and Sweden. The first IKEA warehouse in Russia opened in 2000. In 2002 the first Russian saw-mill and furniture production site was opened in Tikhvin, near St Petersburg. Since 2000 to the present day a total of 11 Russian IKEA warehouses have opened and the expansion continues, as in other eastern European countries. Therefore, it is necessary for Swedwood to continue to expand in order to meet the growing demand from the IKEA warehouses. Tikhvin is one of Europe’s largest sites for producing furniture from log to ready furniture. Besides Tikhvin, Swedwood also has a distribution centre and some production outside
Moscow, in Esipovo. An overview of the sites of Swedwood in Europe can be seen in Figure 2, where the three red triangular dots that are placed next to each other in Russia not are located in different cities but just mean that there are three production units in Tikhvin.

Figure 2: Map of Swedwood's units in Europe. The red triangles indicates where Swedwood has its production units and the two blue spots indicates the main offices of the company (source: Swedwood.com 17/6)

As one can see, there is a clear weight point on a line from south Sweden through Poland and down to the Carpathian basin and then there are the Latvian and Russian sites. As a step in the expansion of Swedwood in Eastern Europe a saw-mill in Kostomuksha, Karelia was founded in august 2004. The site is marked on the map in Figure 2 as the most northern location. The saw-mill was part of a bigger project that was started the year before with acquiring control of quite large forest areas nearby the location of the saw-mill. As everywhere in the Russian Federation the forests are in fact owned by the Russian state, but in this case controlled and rented by Swedwood for 25 years. (Sandgren, 17/9)

In august 2006 the next step in building up the Karelian complex of Swedwood was taken when the glue board factory opened. The saw-mill had until then sold all sawn materials on the open market and had therefore adapted its production to that instead of optimising it for the glue board factory’s needs. Traditional export diameters with for instance widths like 95 and 120 mm were usually sawn. This fact may have caused a few minor problems when wood was finally going to be used primarily for lamella production in the first place. The production of the saw-mill was earlier adjusted to what the world market demanded and not after the dimensions that were most desirable for lamella production. For some time the saw-mill may have had a bit of a problem to change the way of thinking to be completely oriented towards what the lamella production requires. This is however no wonder, given that the saw-mill since its foundation had been market oriented and the long term plan for the “Karelian project” of Swedwood had not been the forehand choice. (Andersen, 17/6)

In the long term plans for the Swedwood site in Kostomuskha is also included a furniture factory. The idea is that Swedwood should be able to support its saw-mill with a reasonably large part of wood from its own forests and the saw-mill should be able to support the glue board factory with all raw material it needs. The glue board factory shall in turn support the planned furniture factory with enough glue board for it to be completely supplied locally. Until the
furniture factory in Kostomuksha is built, the ready glue boards produced are sent to other furniture factories within Swedwood. These have been mainly Goleniow and Konstantynow in Poland, but also Tikhvin in Russia.

The units in Tikhvin and Kostomuksha together with the site in Esipovo naturally make up Business area Russia of the Swedwood group. Within the Swedwood group there are different business sectors. The sectors are named and grouped after what kind of furniture production they mainly have. There are sectors for Kitchen, Flatline, Board on frame and last but least the business sector Solid wood, which as the name implies mainly produces solid wood furniture. Business area Russia with Kostomuksha is a part of this sector.
3 Adaptive sawing

In the long term plans for the saw-mills and glue board production factories of Swedwood in Kostomuksha and in the company in general, one of the basic ideas is to use the wood more efficiently and to increase the overall yield from log to ready furniture. One of the key figures within Swedwood has always been the yield from raw material to ready product. This has mainly to do with economic reasons. If the company needs to buy a little bit more raw material on the open market, instead of relying more on its direct supplies, then the extra costs of that can be considerable. Therefore a lot of effort has for a long time been put down to try get highest possible yield from log to ready furniture. This can be achieved in different ways. For Swedwood one key concept is the so called Adaptive sawing concept. In Adaptive sawing the sawing method in the saw-mill is changed from traditional block-sawing to a variant of the pattern through-sawing. The idea is that the boards are more or less not edged at all. The boards then enter the glue board factory and there with help from extensive use of scanners it is possible to cut lamellas from the boards in a more efficient way than is the case without such equipment. The idea is to, among other things, use areas that normally can be lost in the edging. Hence the raw material can be used in a more efficient way than earlier and less wood becomes waste and used for by-products. The overall yield from log to furniture is therefore supposed to get higher. The adaptive sawing and the first tests made with it are described more thoroughly in this chapter.

3.1 Theoretical background of adaptive sawing

Before describing the adaptive sawing concept itself it could be on its place to point out a few elementary things. With adaptive sawing boards are sawn in the saw-mill. The boards are sawn for a very clear purpose – to make excellent raw material for as many lamellas as possible. The lamellas are moulded from dried, planed boards in the glue board factory. A lamella is a long piece of wood which together with other lamellas is glued to glue board. The reason for the name adaptive sawing is partly that the idea is that the saw-mill should adapt its production of boards to the needs of the lamella and glue board production. Adaptive sawing does among other things mean that how much should be edged away from a board more or less is decided in the glue board factory.

The basic idea of the adaptive sawing concept is of course to increase the yield of wood and hence save a lot of money in better efficiency and in the long run decrease how much wood, which in fact is needed for every glue board. It is however to be stated that for IKEA the economical benefits are not the most crucial reasons, what is more important is the idea of taking better care of the raw material that is available. That is a part of the environmental awareness thinking of IKEA. If the company has a certain amount of logs available from its own supplies, then it is of course essential to use these logs maximally. It can be seen as a part of a sustainable forestry. It should not be necessary to chop down more trees than necessary and by increasing the yield and using the available logs maximally; it is possible to decrease the number of trees that have to be cut down. That would also have many side effects. These could for instance be decreased need for purchasing wood and decreased need of transport capacity. Thus, the dependence of external business and other companies is reduced. These are the more “strategic” objectives of the concept.

The basic sawing technique that is the foundation of the concept is in itself not new at all. The adaptive sawing technique has been used on saw-mills for a long time, but in a different context and has not been used in this particular way. The sawing pattern itself is usually known as “genomsågning” in Swedish and “Scharfschnitt” in German. In English one can use the term
sawing through or through sawing. According to Walker (1993) the name live sawing can also be used. In this report will the sawing pattern however not go under that particular name. Instead it will be natural to call the sawing pattern through sawing or adaptive sawing throughout this report. Through sawing means that the logs are sawn through completely vertically and all boards are taken out of the log and more or less ready already after the first sawing. With this sawing pattern all boards are theoretically given the same thickness. However, as can be seen in Figure 3 there are some problems associated with this.

Since the board in the centre can contain very much of the core, it will dry differently than the other boards. The other boards do mostly consist of sapwood and do therefore not dry as the board consisting of heartwood. This is definitely the case if the log in question comes from most of the softwoods and since the wood species used for adaptive sawing always have been softwoods, this is for sure the case for the adaptive sawing material. The wood shrinks unevenly since there is a big difference between the moisture content in the sap- and heartwood. According to Esping (1977) the moisture content for pine is in the heartwood 32 to 38 % and in the sapwood 123 to 145 %. It is hence then not hard to comprehend that, when dried the wood shrinks at different rates because of the huge differences in moisture content, even though the wood does not start to shrink until the fibre saturation point at about 30 % is reached.

Earlier, the Swedwood saw-mills have usually cut in another way than adaptive sawing when cutting boards for lamella production. This way is still the by far predominating way of sawing in the Swedwood saw-mills. The adaptive sawing is still being used in a very small scale. The normal way has been so called “block sawing”, for which the principle can be viewed in Figure 4. This sawing pattern has usually meant that roughly two thirds of the used volume comes out as centre boards and one third as side boards.
Figure 4: Principle for "block sawing”, to the right the resulting boards. Note that side boards are received on all fours sides.

If one looks at a log in general and then marks the areas that in general usually would become boards for a typical posting of the standard sawing pattern "block sawing” with a brownish colour.

Figure 5: A log, to the left without any marking and to the right, with brown marking for the parts which in general can be cut out with "block sawing”.

One can see that there is more of the log that could be of use. Outer parts of the logs, which are in general edged away, could in many cases be used for boards. These parts are marked light blue in Figure 6. Those parts of the log can in general be said to be as usable as what in fact is sawn into boards and used. This means that the yield from log to ready glue boards or furniture is not as high as it could be. Some wood, that could be used to make excellent furniture out of, is not used at all and is instead cut into chips or just becomes dust. It should also be noted that the sideboards which result from the sawing pattern get a figure or pattern of growth rings that might not always be ideal for furniture production. So called vertical annual rings and edge-grain boards are not received and the pattern that is the result of this gives a figure with flat-grain boards. This figure is usually not the most desirable since it means that the board shrinks differently in different directions and is also aesthetically not the most wanted.
In order to get a higher yield, the question was how to make use of these areas and with which sawing pattern a higher yield could be achieved. The research & development department at Swedwood came up with the idea to use an old sawing technique, “through sawing”. The sawing technique was a normal way of cutting in Scandinavia during the 20th century, but more and more lost in importance in favour of “block sawing”. The yield usually became higher when sawing with the block sawing technique and it was seen as more profitable in the context it was used. However, as it has become possible to use new technology in shape of scanners and so on, it is now possible to use even completely unedged boards and make lamellas of a bigger volume with help of that. When the sawing technique was used a few decades ago boards were usually more or less completely edged in the saw-mill. When a board is edged in the saw-mill a certain proportion of the board that in fact consists of good material that would become excellent lamellas, is removed. This is inevitable if full edging is required. Since a log is not completely cylindrical and the logs vary and very rarely can be said to be completely symmetrical the resulting boards are not completely straight and rectangular and when the sides are removed to make the boards rectangular much good material can be lost. One of the basic ideas was therefore to skip the removal of these areas in the saw-mill. With unedged boards coming out of the saw-mill, the wane will then of course have to be removed later on in the production chain. Usage of the “old” way of sawing, through sawing, the problem with losing parts of the good material still persisted. Hence, a really high yield could not be achieved. Why is that so? It is simply because the boards are completely edged. If one looks at Figure 7, one can see that there is much of the log that does not become boards in the outer annual rings. It should also be noted that the picture might be a bit misleading, since the distance in the picture between the boards is larger than in reality.
Figure 7: A log sawn with "through sawing", the resulting boards marked dark brown. Note that the distance between the boards in reality is not as can be seen in this picture, this is just an example.

If one then decides to edge as little as possible in order to really maximize the yield, the question is just how to get out the good material. If one edges as little as possible and cuts through the logs completely the resulting sawn log will look like in Figure 8. This way of sawing can be called adaptive sawing. One could say that the “adaptive” in the concept is to adapt to how the material looks and try to saw out lamellas in a way that is adapted to how every single board looks and not the other way around. Traditionally, it could perhaps be said that a part goal was to try to adapt the material to the technique when one edged and tried to achieve completely rectangular boards that were cut into lamellas. With the adaptive sawing, one could almost say that the idea behind it is to try to adapt the technology to the material in order to get out all the material that can be used for furniture production. The question is just how to get out as much of the good material as possible. Since all the usable material is still present in the boards if no edging is done in the saw-mill, the question is just about how to make use of it and achieve maximum volume of lamellas from each board.

Figure 8: Log sawn with adaptive sawing
The way to solve this is to make extensive use of the image processing has more and more given possibilities to the last 25 years or so. With help from a scanner, that the boards pass through a good view of the defects and the wane can be received. Theoretically, it can then be decided by the scanner how to optimally rip lamellas from the board in order to use the material in the boards maximally. Depending on the settings in the scanner and which widths of lamellas that are accepted a very high yield from the boards can, theoretically seen, be received. Depending on the equipment available, one or two scanners will then be needed. Either both lamellas are cut lengthwise (moulded) and directly afterwards are cross-cut based on the data from the first scanner or, the cutting is done in two steps. In that case the first scanner scans the boards and based on the scanner data the boards are cut lengthwise, moulded, into lamellas by a rip-saw. The process is perhaps best portrayed by a series of pictures. Figure 9 shows an unedged example board and Figure 10 with possible lamellas that the first scanner would indicate. The rip-saw rips the board accordingly and the result can be seen in Figure 11.

Figure 9: Example board coming from the saw-mill. Note that few boards in reality has this kind of shape, this is just an example to clarify specific characteristics of the adaptive sawing concept. The brownish edges represent wane and the dark dots black knots or other defects.

Figure 10: Our board with possible lamellas marked. Please note that in case of normal edging in the saw-mill would just the 3 central lamella be possible to produce. The others would have been edged away. The area coloured purple is an area that could have become a little lamella if smaller lamella widths than today’s had been used.
After that the lamellas move on and should be scanned a second time by a scanner that sees the defects in the lamellas and give order to a cross cut equipment to cut the lamellas in desired lengths and according to the given quality definitions. An important thing to note is that the lamellas produced from material coming from Adaptive sawing in general has the same quality as lamellas produced with a more traditional technique. The lamellas can be mixed with each other without any problem at all. The same amount of defects can usually be expected. The defects are then of course cut away by the cross-cut and removed as waste. What is then received are waste, lamellas of the set up sizes and qualities and finger-joints. These products for the example board can be seen in Figure 12.

This whole concept can be called adaptive sawing. As was earlier mentioned, with other sawing patterns it is common that many of the sawing patterns mostly result in boards with a figure that is not ideal. What is here intended is then primarily what is called block sawing, which, as the attentive reader noted in Figure 4 gives much side boards. The share of edge-grain can be relatively low, which is not ideal for a number of reasons. First of all, if the sawing pattern gives wood with standing year rings, the wood dries symmetrically and does not get nearly as many cracks as wood without standing year rings. Secondly it is generally regarded as not as aesthetically appealing with furniture that is without standing year rings. With adaptive sawing a larger portion of standing year rings can be achieved. More or less 50 % less sideboards could be received, since sideboards are just taken from two out of four possible sides. An illustration of this can be seen in Figure 13. The reader could also return to Figure 4 to see what a traditional sawing pattern would result in. Since sideboards in general have all but an ideal figure and proportion of edge-grain this is one of the advantages with the adaptive sawing concept.
The main advantage is however the much higher yield that at least theoretically should be the case. This would reduce the need for raw material and dependence of external suppliers. What is then yield? By yield is here meant how many percent of the incoming volume that in fact becomes material usable for furniture production. With a lower yield much more of the wood would be removed and become chips instead. As this is economically not beneficial it is of course not desired.

Another effect of the adaptive sawing concept is that the decision on which thickness the ready glue board should have, can be made already in the saw-mill. If a thickness for the ready glue board of for example 18.3 mm is wanted, then a certain number of millimetres should be added to that figure in order to receive the wanted thickness that the saw-mill should saw. For 18.3 mm glue board this would then mean that for instance a thickness of 23 mm after drying is wanted. This means that the saw-mill should saw boards with a thickness of 24 mm. This implies in a way that the thickness of the ready glue board is already at the very first sawing in the saw-mill decided.

It must however be stressed that the main advantage with the adaptive sawing concept over the traditional way of sawing was and still remains the difference in yield. That is the main key to success for this production concept. For traditional sawing the yield from log to ready glue board differs depending on the local conditions, but can often lie somewhere between 21 and 29 %. The yield for adaptive sawing was in theory to be much higher than that. In theory, the yield could, depending on log class end up somewhere between 30 and 38 %. This would of course have a dramatic economic impact. If one for instance manages to raise the yield on the raw material from 25 % to 30 % this gives a raise of 20 %. This does then mean that from the same incoming volume of wood 20 % more ready products result. For a company like Swedwood, this would mean a lot in real economic terms. The question is just if a change of this magnitude is at all possible in reality.
3.2 First tests of the adaptive sawing concept

The first tests with adaptive sawing at Swedwood were done in Poland in 2005. In total were three tests taken out. According to Ingvarsson (2005) the goal of these tests was to see what possible yield improvement there was with adaptive sawing and to see whether the material received, with adaptive sawing, could be used for normal furniture production for IKEA. The first test was done with Latvian pine pulp wood. The second and third tests were done with spruce and pine from northeastern Poland. All three tests were performed according to the same basic principles. A saw pattern was used that produced un-edged boards for a final thickness of glue board of 18.3 mm. The boards were sawn once with through sawing. After the drying the boards were measured and ripped into lamellas in Stepnica. After that the material was planed with 3-4 mm. After the ripping the material was run through an in-cut line with a moulder, scanner and a cross-cut. The material was cut according the optimization parameters that were set up and then glued and used in the normal furniture production. The yield from log to ready glue board ended up as high as 31.4 % for the Latvian pulp wood, 32.0 % for the Polish spruce and 32.7 % for the Polish pine. The most extreme results were noted for a small batch of small pine logs which had a yield as high as 37.8 %. Yield for traditional sawing usually lied between 26 – 30 %. The difference was therefore so big that it was deemed self-evident to continue to evaluate the adaptive sawing idea. The main yield difference was in the saw-mill. The quality in the glue board produced from the test material did not differ significantly in appearance or quality from glue board produced with material sawn the traditional way.

It could be noted that the results varied very much within the tests, thus showing the unpredictability of the material and the operations. Parameters for improving the yield even more were identified. These improvements did mainly include setting up four different sizes of lamellas in the rip-saw and doing the moulding before the rip sawing. This could raise the yield even further and theoretically reach total yield figures as high as 34 – 37 %. If one then compares with traditional sawing that usually would give a yield of 26 – 31 %, the difference is startling. (Ingvarsson, 2005)

The overall results were as expected positive and follow-up tests were then done in the Swedwood plant in 2006 in Tikhvin, Russia. The aim of those tests was to confirm the positive results on a much bigger scale. The more specific objectives were to investigate the yield from log to furniture and the quality of the glue joints made on the sawn surfaces. In addition yield and quality in each step of the process were of interest. As were points, that could influence future production lines using material sawn this way. Of interest was also to evaluate the tools and how many running meters can be cut before quality would be affected. (Ingvarsson, 2006)

According to Ingvarsson (2006) a technical compromise between adaptive sawing and traditional sawing, so called semi-adaptive sawing was also to be evaluated. The semi-adaptive sawing was found not to show any significant advantages compared with adaptive sawing and just caused a need for more equipment and extra work. One of the, in advance considered, advantages of semi-adaptive sawing, which consisted of the decision point of the thickness moving up the chain, can be said to have worked as planned. A higher yield than in “normal” adaptive sawing was also expected, but this however, appeared not to be the case in this test. The idea was that the use of more so called “dry cuts” would affect the yield positively, but that theory could not be converted into practice. Since in addition to the lack of this advantage in practice, the semi-adaptive sawing gives a more complex flow and an increased need for investments in form of two rip saws, it was found not feasible.

The tests of the adaptive sawing technique did however show positive results. Three batches of logs were used. These three batches were 700 m³ Russian pine, 350 m³ Russian spruce and 350
m³ of Romanian Spruce. Since the quality and properties of these batches of different kind of wood species with different origin can vary a lot, it was no surprise that the results differed. The best yield from log to ready glue board was achieved for the Russian Pine with 25.9%, the Romanian spruce had 25.2% while the Russian spruce had a yield of just 22.3%. Still, this yield can be estimated to be higher than the yield achieved with traditional sawing concept. No problems with gluing arose and neither were any problems reported from the furniture factory that received the material. (Ingvarsson, 2006)

However, since the result was deemed “not completely reliable” a second test was done with a traditional sawn batch as reference. In this test all material could be followed in detail and hence a much more reliable result was achieved. For adaptive sawing the yield was 24.3% and for the traditionally sawn material the yield was 21.5%. The yield did consequently increase with 20.3% from traditional to adaptive sawing. As this is a highly significant increase the result was considered very positive and might possibly even be increased when using a more traditional glue board process. When using modern technology an increase of an additional 1 - 3 % could also be expected. Therefore, altogether a difference in the yield between traditional sawing and adaptive sawing of somewhere between 21 and 25% could be expected in the tests in the future and in the tests in Kostomuksha.

This is where the adaptive sawing in Kostomuksha and the purpose of this thesis comes in. In Kostomuksha did not only a series of test sawings take place, which are thoroughly described in this report, but one could also say that Kostomuksha was the first Swedwood site where the adaptive sawing concept was taken into more or less full scale production. Therefore, here was at last the chance to see whether the positive figures from the earlier tests actually also proved to be true for more of a daily-basis production and during a longer period of time. The adaptive sawing in Kostomuksha did however have a clear delimitation, which makes it harder to draw too far-going conclusions from the results. The saw-mill could not saw adaptive material from all diameter classes, but just for very small diameters i.e. 110-148 mm. The sawing pattern did for this class become the one that can be seen in Figure 14. This did of course mean that adaptive sawing only could be evaluated for this diameter class, but in order to produce enough adaptive material the saw-mill did during 2008 actually produce more adaptive material than just with the adaptive sawing pattern described in Figure 14.

Figure 14: Example of principle of four-x for adaptive sawing for the class 135-148 mm.
The saw-mill took unedged or semi-edged sideboards that were produced as a “by-product” when centre-pieces were saw out from certain diameter classes and delivered them to the glue board factory to fill the orders on adaptive material. This report will however focus solely on the adaptive sawing of the smaller diameter classes. The “semi-adaptive” material, that the sideboards could be called is not the topic of this report at all and that material did during the processes of following the adaptive yield not affect it more than causing minor problems when it came to keeping track of all statistics. The focus of this report is the adaptive sawing concept as originally developed and its yield and not the yield of any “adaptive” sideboards.
4 Swedwood Kostomuksha

In this chapter the Swedwood site in Kostomuksha, the location for this investigation is described more in detail. It could then be on its place to remind the reader of what the studied system looks like. This can be seen in Figure 15. Now, the parts of the studied system will be described more in detail.

4.1 Forestry – provider of raw material

The first step in establishing a production site in Karelia for Swedwood was gaining access to raw material. This was achieved with acquirements of a number of forest areas. According to Russian law it is however not legally possible for a ny other than the Russian state or its subjects to own land that is covered by forest. In order to, in spite of this fact, make it possible for companies, foreign investors and people with knowledge and ambitions to control and cultivate Russian forest it is possible to acquire tenancies from the Russian state. Therefore Swedwood could not buy land, but a number of tenancies were acquired. In the case of Swedwood these tenancies run for 25 years and in the treaty it is stated how many cubic metres of wood that the tenant is allowed to cut per year. Swedwood got the first tenancy in Karelia in February 2004, three more in June the same year and another three during the first half of 2006. Consequently the tenancies run out in the period from June 2029 to June 2031. In total, these tenancies add up to a total area of more than 295 000 hectares. The forest department of Swedwood also cultivates and cuts the forest that is tenanted by a local entreprenuer. His forest areas are located very close to Kostomuksha and consist of approximately 12 000 ha and yearly 11 000 m$^3$ are allowed to be cut there.

Swedwood is according to Sandgren (17/9) allowed to cut 200 000 m$^3$ and has planned to cut 250 000 m$^3$ annually. An additional 50 000 m$^3$ is bought from other forest owners. In its own forests Swedwood has two logging teams with a total of 37 people. They are at the moment equipped with 2 forwarders and mainly manually do the cutting. Swedwood also uses a few
contractors for cutting. The most important one of these is Sosna, which last year cut almost two thirds of the volume cut by contractors. As in Russia in general the logistics is a problem field of magnitude. This is especially noticeable in relatively remote areas like Karelia and of course even more so when it comes to small forest roads. The smallest roads may more or less only be used in the winter and do in general need a season to be fully usable. The logs that are either transported from Swedwood forests or are bought on the external market are all brought to the Swedwood site for measurement and judgement of quality and quantity. The payment is later on done based what is measured at this point. The logs are as yet just rudimentary sorted and are therefore moved to the log sorting later on. (Yuri Vasilyevich Ivanov, 11/1, 2008)

4.2 The log sorting

The log sorting is organizationally counted as a part of the saw-mill and the equipment has a similar background as the saw-mill. Most of the saw-mill production line and its components were bought as a whole from a saw-mill in Boden, Sweden. The same is consequently valid for the log sorting. One can more or less say that the former saw-mill in Boden was moved to Kostomuksha and built up again there. (Eriksson, 5/6, 2008)

4.2.1 The log sorting

Before the logs are brought to the saw-mill to be sawn, it is necessary to sort them. This is done partly to get rid of logs that are deemed to be more or less useless. These logs may for instance have visible problems with rot or can be regarded as being of poorer quality for other reasons. In the saw-mill just pine is sawn. When spruce appears at the log sorting it is sorted as reject and simply rejected. Another reason to sort the logs is the fact that there might be metal pieces in the logs that can damage the saw blades. The logs containing metal must therefore be removed. The logs also need to be sorted in order to make the saw-milling process much easier. In the saw-mill the logs can be sawn very differently depending on which diameter they have. It is hence necessary to sort the logs in accordance with which respective diameter they have. According to Kostikov (25/7, 2008) the log sorting sorts the logs into 20 different diameter classes ranging from 135 to 365 mm and can be seen in Table 1. The diameter that is concerned here is the diameter at the thinner end of the log.

Table 1: Log classes from 23rd of July 2008 and onwards at the saw-mill in Kostomuksha

<table>
<thead>
<tr>
<th>Diameter, mm</th>
<th>Bin Nr</th>
</tr>
</thead>
<tbody>
<tr>
<td>135-148</td>
<td>7-8</td>
</tr>
<tr>
<td>149-165</td>
<td>9-10</td>
</tr>
<tr>
<td>166-175</td>
<td>11-12</td>
</tr>
<tr>
<td>176-185</td>
<td>13-14</td>
</tr>
<tr>
<td>186-195</td>
<td>15-16</td>
</tr>
<tr>
<td>196-205</td>
<td>17-18</td>
</tr>
<tr>
<td>206-212</td>
<td>19-20</td>
</tr>
<tr>
<td>213-231</td>
<td>21-22</td>
</tr>
<tr>
<td>232-240</td>
<td>23-24</td>
</tr>
<tr>
<td>241-249</td>
<td>25-26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diameter, mm</th>
<th>Bin Nr</th>
</tr>
</thead>
<tbody>
<tr>
<td>250-258</td>
<td>27-28</td>
</tr>
<tr>
<td>259-271</td>
<td>29-30</td>
</tr>
<tr>
<td>272-280</td>
<td>31-32</td>
</tr>
<tr>
<td>281-288</td>
<td>33-34</td>
</tr>
<tr>
<td>289-297</td>
<td>35-36</td>
</tr>
<tr>
<td>298-313</td>
<td>37-38</td>
</tr>
<tr>
<td>314-323</td>
<td>39-40</td>
</tr>
<tr>
<td>324-335</td>
<td>41-42</td>
</tr>
<tr>
<td>336-345</td>
<td>43-44</td>
</tr>
<tr>
<td>346-365</td>
<td>45-46</td>
</tr>
</tbody>
</table>
Logs incoming to Swedwood are hence being sorted in accordance with their respective diameter. There are 46 pockets (or bins) in which the logs are sorted. The log lorries come to Swedwood and when the volume has been measured and the log quality controlled in the measuring station the logs are simply moved to the log yard next to the sorting station. From there, the logs are lifted onto a conveyor that takes the logs through a metal detector, which scans the logs for metal pieces. The detector can be viewed in Figure 16.

After passing through the metal detector the log continues to a scanner that scans the diameter of the logs. The scanner used by Swedwood is a “Rema log 3D” and was earlier standing together with the rest of the saw-mill line in Boden. The scanner uses the principle of so called laser triangulating in order to create a 3-dimensional model of the shape and surface of the log. The scanner has 3 measuring units with 16 lasers each and one detector. A laser beam that hits a surface is reflected in all directions and the detector gathers via a lens a part of this light. When the surface changes position the outgoing signal from the detector also changes. The lasers are usually lit one at the time and the reading pace is for every measuring point normally 120 per second. With a conveyor speed of 150 m/min it usually gets 2 cm between each measured cross-section and with the higher reading pace the distance can be reduced to 1 cm. Even though the measuring method with separate laser points has been chosen in order to get the biggest possible laser amount reflected to the detector, there are surfaces that the system has problems coping with. Usually, the scanner has no problem coping with dark surfaces of logs. However, if the logs are both dark and wet at the same time the surface reflects very little light. This is even more so the case when the bark on the log has been carved off. In that case the log’s surface functions almost like a mirror and reflects most of the light in the wrong direction. It can however still be possible even to measure logs that have been stored in water with acceptable results if the surroundings of the scanner are dark enough. The scanner, for which the principle can be seen in Figure 17, is supposed to be able to handle logs with a diameter down to 80 mm without problem. (RemaControl, 1999)

Figure 17: The principle for the Rema log 3D scanner. The grey part of the log represents what has already passed through the scanner and there been given measuring points all over its surface. These points are here represented by white lines, hence a greyish colour of the log is perceived. (RemaControl, 1999)
The scanner is connected to three computers. One computer is gathering and processing the measuring data from the scanner and forwards these data to the calculation computer. This computer receives the processed data and together with information that the operator can enter, the final volume calculation of the logs without bark is done. The operator has the possibility to affect this volume calculation when for instance a big part of the bark has fallen off the log. The operator then pushes a button that tells the system which amount of the bark that is missing on the log. There are four different types of bark listed in the system. There is one button for logs that have bark on less than 30 % of the surface, another for logs with 30 – 60 % on the surface, a third for logs where 60 – 90 % of the bark remains. Naturally there is always the possibility that all or almost all of the bark is remaining on the log and then, the operator does not need to take any action. Until July 2008 the option to reduce the diameter with respect to how much remaining bark there was, was not used at all, at least not in the summer. In the winter the operators usually use a variant of this, which compensates for visible layers of ice. By pressing a special button, which orders the reduction of the measured diameter, a more realistic view of the actual diameter is achieved. The ordered reduction is approximately corresponding to the extra size added to the diameter by the existence of ice or bark.

These actions taken by the operator do however, more correspond to exceptions than are the constant order of the day. Normally a decrease of the measured diameter is done with respect taken to the bark. A formula for calculating the necessary reduction of the bark is used and looks like this: \( y = a + b \times x \), where \( y \) is the calculated double bark thickness, \( x \) is the top diameter and \( b \) are constants that depending on which kind of settings there are. There are three types of bark one has the ability to set. There is thin, medium and thick, whose parameters can be viewed in Table 2.

\[
\begin{array}{|c|c|c|}
\hline
\text{Type of bark} & \text{Pine} & \text{Spruce} \\
\hline
\text{a, in 0,001 mm} & \text{b, (in 1/1000 of the diameter)} & \text{a, in 0,001 mm} & \text{b, (in 1/1000 of the diameter)} \\
\hline
\text{Thin} & 4070 & 10 & 3280 & 37 \\
\text{Medium} & 4910 & 24 & 3280 & 37 \\
\text{Thick} & 65356 & 73 & 3280 & 37 \\
\hline
\end{array}
\]

According to one of the operators (Babkin, 1/7), who has earlier worked on a log sorting in Archangelsk, there are now much better and more accurate programs on the market than the one used on the log sorting by Swedwood in Kostomuksha. If this is correct, this of course adds a bit of uncertainty to all figures from the log sorting.
The logs are sorted in accordance with their diameter in the classes shown in Table 1. The operator decides which logs that should be rejected and they fall down into the very first bin, were rejected logs end up. Logs that are not classed as reject move on until they, on the conveyor, reach the pocket that corresponds with the measured diameter from the scanner. There, the logs fall either to the left or the right of the conveyor depending on in which direction the top of the log points. All logs that are on the same side of the conveyor are supposed to have the top in the same direction. Thus, for every log class two piles of logs are received. In the piles, the logs are pointing in one direction. This makes it a lot easier to ensure that the logs enter the saw-mill with the right, top end first. Nevertheless, as this system is not 100% waterproof, it can of course happen that some logs end up with the top end pointing in the same direction as the bottom end of the surrounding logs. An overview of the log sorting can be viewed in Figure 18.

Figure 18: Principal overview of the log sorting

When an order comes from the saw-mill for logs with a certain diameter, these are sorted out and taken by truck to the infeed of the saw-mill and put with the top pointing to the saw-mill. The top end of the log is supposed to enter the saw-mill first.

(Babkin, 25/6)

4.2.2 Possible errors at the log sorting

It must be stressed that in order to accomplish the objective to give an as accurate view of the yield from log to furniture the volume figures in the log sorting have to be accurate. It is from the incoming volumes that the yield is calculated. If the incoming volumes are not correct, then the whole yield calculation becomes erratic, since it is done on false premises. It was therefore deemed as highly prioritized to find out how accurate the volume measurement equipment in the log sorting is, and what kind of error that could occur.
It happens that logs falling from the conveyor fall a bit closer to the next pocket or bump on logs and more or less jump into it. The conveyor is placed relatively high, it is therefore likely that a certain percentage of the logs sorted as belonging to one pocket, in fact really should be sorted as belonging to another log class.

![Log sorting conveyor](image)

**Figure 19: Two pictures of logs in disorder at the log sorting**

Every morning the workers at the log sorting are supposed to measure the size, or more exactly the volume of two very short test-pipes. These can be viewed in Figure 20. If the values measured, differs too much from the known size they contact Evgeniy Kostikov or someone at the office, in order to find out what the reasons for the errors are. Usually the only error is that the scanner needs to be cleaned and in that case the workers do not contact the office for help with troubleshooting. Therefore, there has probably been one single occasion when the workers needed help from the office. The divergences have generally been very small and are noted in a journal. The scanner can according to these tests be deemed to be working as it should. (Kostikov, 30 / 6)

![Test pipes](image)

**Figure 20: The test "pipes", with which the daily tests are performed. The scanner is tested as it measures the diameter of the pipes and from it calculates a volume. When the scanner was tested by the author in appearance similar, but much longer pipes were used.**

However, as the volume in the log sorting is the volume on which all yield calculations are based in the saw-mill and therefore also if one looks at the total yield from log to ready glue board, it
was deemed necessary to make sure that one can trust the figures from the log sorting. Therefore a test was taken out on the 23rd of July. Three test pipes were used for this purpose. The first pipe was 5930 mm long and had a diameter of 200 mm. In the Rema reports that are given by the log sorting system several different diameters are listed. The two that can be seen as relevant are the reported diameter with bark and the diameter that the logs are being sorted after. As can be seen in Table 3, the difference between the real and the measured diameter is almost non-existent. The exception is of course the second run of pipe nr 1, when something went wrong and the scanner showed completely wrong figures. The volume differences are otherwise so small that they are within the margin for measurement error. One could here note that it is possible that the scanner at least theoretically now and then could make the same mistake for normal logs. If that is correct, one can not expect that all logs end up in the correct pockets.

As with pipe nr 1 five runs were done with pipe nr 2. The results were almost identical. The pipe itself is almost identical with pipe nr 1. The only difference between the two pipes is the length.

The third test pipe that was tested on the 23rd of July had a much smaller diameter, just 110 mm. As mentioned in chapter 4.2.1, “The log sorting”, the scanner should be able to handle logs with a diameter as small as 80 mm. However, as can be seen in Error! Reference source not found., a significant difference between the accuracy of the measurement for the pipes with the 200 mm diameter and the third pipe with a diameter with a diameter of just 110 mm can be noted. The possible diameter measurement error is not utterly significant and could possibly be within the margin for what is acceptable. When one looks at the volume differences, the same can not be said at all. In the two of the five runs it is evident that something went completely wrong. It is not likely with a volume measurement error of about 400 %. Since the test pipe was very light it is not unlikely that it on the shaky conveyor moved during the scanning process and hence in two

### Table 3: Figures for test of pipe nr 1 in log sorting scanner. The difference listed to the left applies to the difference between the reported diameter with bark and the real and to the one in the middle applies to the difference between the diameter the “log” is sorted on and the real. To the right difference between the reported and actual volumes is listed

<table>
<thead>
<tr>
<th>Diameters</th>
<th>Pipe nr 1</th>
<th>Diameters in mm and volume in dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>With bark</td>
<td>Sorting</td>
<td>Real diameter</td>
</tr>
<tr>
<td>201</td>
<td>189</td>
<td>200</td>
</tr>
<tr>
<td>38</td>
<td>34</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>188</td>
<td>200</td>
</tr>
<tr>
<td>201</td>
<td>189</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>188</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>188</td>
<td>200</td>
</tr>
</tbody>
</table>

### Table 4: Figures for test of pipe nr 2 in log sorting scanner

<table>
<thead>
<tr>
<th>Diameters</th>
<th>Pipe nr 2</th>
<th>Diameters in mm and volume in dm³</th>
</tr>
</thead>
<tbody>
<tr>
<td>With bark</td>
<td>Sorting</td>
<td>Real diameter</td>
</tr>
<tr>
<td>201</td>
<td>188</td>
<td>200</td>
</tr>
<tr>
<td>201</td>
<td>189</td>
<td>200</td>
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<td>201</td>
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</tr>
<tr>
<td>201</td>
<td>188</td>
<td>200</td>
</tr>
<tr>
<td>200</td>
<td>189</td>
<td>200</td>
</tr>
</tbody>
</table>
of the five runs gave completely unlikely results. The three other runs did however give consistent results. As seen in Table 5 the error for the reported volumes lies consistently on 10,5 % for pipe nr 3. This is a significant difference and can not be explained in a good way. Even though the test series is such a small one, the steadfastness of the scanner results indicates that it would not be unlikely at all if there really was an error of close to 10,5 % in the reported volumes. It shall however be noted that the tests were carried out with completely cylindrical pipes that according to Åke Svensson, Rema (10/9) actually are intended just for checking that the scanner measures length in a correct manner.

In Table 6, Table 7 and Table 8 the measurements of length for the three pipes are listed. The differences in measurement of length appeared to be very small. The only exception is the second run of the first pipe, where something also went completely wrong with the diameter measurement. It is plausible that all measurements of that very log can be regarded as untrustworthy. That run is therefore to be regarded with a bit of scepticism. It could however be noted that even when the diameter measuring went completely wrong as for pipe nr 3 the length measuring worked as it usually does. The scanner in general measured 20 – 30 mm less than the actual length of the pipes. The conclusion could hence be drawn that the length measurement of the log sorting can be seen as consistent and reliable. The difference between the actual length and the reported could be explained by the fact that the Rema scanner usually expects that the surfaces of the logs are not completely plane and might therefore reduce the length slightly.
Table 7: Length measurement for pipe nr 2

<table>
<thead>
<tr>
<th>Length</th>
<th>Pipe nr 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length in mm</td>
<td>Reported length</td>
</tr>
<tr>
<td>5920</td>
<td>5950</td>
</tr>
<tr>
<td>5920</td>
<td>5950</td>
</tr>
<tr>
<td>5930</td>
<td>5950</td>
</tr>
<tr>
<td>5920</td>
<td>5950</td>
</tr>
<tr>
<td>5920</td>
<td>5950</td>
</tr>
</tbody>
</table>

Table 8: Length measurement for pipe nr 3

<table>
<thead>
<tr>
<th>Length</th>
<th>Pipe nr 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length in mm</td>
<td>Reported length</td>
</tr>
<tr>
<td>4920</td>
<td>4950</td>
</tr>
<tr>
<td>4930</td>
<td>4950</td>
</tr>
<tr>
<td>4920</td>
<td>4950</td>
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<tr>
<td>4930</td>
<td>4950</td>
</tr>
<tr>
<td>4930</td>
<td>4950</td>
</tr>
</tbody>
</table>

Even though the length measurement seemed to be in order, the errors in volume measurement for the smallest pipe was so striking, it was considered necessary to do new tests. This is especially so, since the adaptive sawing in Kostomuksha is done with logs with a small diameter. If it then appears that the volume measurement of these very logs with a small diameter (135 – 148 mm) is proven not to be trustworthy, then the incoming volumes can not be trusted either. Since such grave errors of 10.5 % of wrong volume were observed for the pipe with the diameter of 110 mm it seems most likely that an error exists also for real logs with a diameter of 135 to 148 mm. This, however needed to be tested in practice.

It was therefore decided to make another test. This test was taken out in august 2008 and included 26 logs. Since the main purpose of the test was to find out how accurate the scanner measurements were for the logs of the so called class 7-8 about half of the logs came from that log class. This means that they had a top diameter of 135 – 148 mm. The other half of the test logs were taken from random classes in order to get a view of the differences in the scanners performance in respect to different diameters. The author’s hope before this test was that it would more or less confirm the results from the test with the pipes and hence confirm that for logs with a bigger diameter, the scanner measures the volumes and diameters correctly. For smaller logs the hypothesis was that there in fact was a constant error of something like 10 %. The hope was therefore that it should be possible to find out a coefficient close that and then use that.

The test was not taken out under the best possible circumstances and it is therefore evident that some errors are possible. The handling of the measuring equipment was perhaps not ideal, though consistent. The problem was mainly that the measuring instrument was a bit inaccurate. All measurement was done by hand with an old “calliper”, with which the diameter without bark was measured. The bark was removed at the places were measurement was made with the calliper. Nevertheless, the results from this test gave reason to worry about the trustworthiness of the scanner in general. The results can be seen in Table 9 and indicates that the scanner in fact reports much larger volumes for the logs than they in reality have. For the class 7-8 the
difference is more than 15 % and in general almost as bad. The test also indicated that the sorting into pockets may be done slightly wrong. The reported diameter in the scanner, which is also used to sort the logs on, is much smaller than the medium diameter measured by hand.

Table 9: The results from the second scanner test with the difference for the scanner in percentages compared with the reality

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pocket 7-8</td>
<td>-12.4%</td>
</tr>
<tr>
<td>Bigger</td>
<td>-10.48%</td>
</tr>
<tr>
<td>diameter</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>-11.5%</td>
</tr>
</tbody>
</table>

This however may, according to Svensson (5/11), have to do with the fact that the Rema scanner has more difficulties when it comes to scanning small logs than bigger logs. The lasers that scan the logs and give the data on which the volumes are calculated in the computers connected to the Rema scanner, can in either case not scan the underneath part of the log since they are placed on the conveyor and the computer then extrapolates the bottom surface of the logs. Since a bigger part of the surface of the small logs’ then is extrapolated of the bigger logs, the risk for an error increases. This might give a slightly wrong picture of the volumes, which could explain the errors for logs with smaller diameter, but does however not at all explain the erratic volumes for logs with a bigger diameter. This must have another explanation and the difference has to with differences in how to measure the volumes. One thing that should be noted is that the scanner in Kostomuksha is set up in accordance with how trees are constituted in the Västerbotten region of North Sweden. Since that area is at the same altitude as Kostomuksha it was deemed that the trees there have approximately the same characteristics. Usually, when calculating yield the incoming volume is of course measured without bark.

According to Svensson (5/11) it is important to note that all the volumes which are listed as the volumes that the saw-mill usually use in or one another sense for calculating yield are calculated on top of bark. The Rema scanner is simply set up that way. This means that the yield in fact is higher than it becomes using the figures for that volume. The volume that is used from the reports is the exact physical volume that the scanner sees, which is with bark and everything. This means that the volumes per definition can be seen as erratic and that it is problematic calculating yield based on these volumes. This was initially not known by the author and nobody in Kostomuksha could with certainty say that this was the case. It was not until Åke Svensson from the Rema company came to do service on the Rema scanner that this became clarified. The scanner does in fact have a possibility to measure the volume of the logs without bark, this possibility is however not used at all. The scanner then uses the formulas for bark thickness adapted for Västerbotten and calculates how much volume there is without bark. The author’s solution to this was to figure out how much difference there was between the usual physical volumes and the volumes that without bark that the scanner also could give. The coefficient that came from this work was then used to revise the earliest yield calculations that were falsely based on incoming volumes with bark.

Data was therefore collected from the scanner for two weeks in order to get a correct picture on how much the difference was between the physical volumes with bark and the volumes of the logs without bark. This was done especially for the log class with a diameter of 135-148, since it was that diameter class that was sawn with adaptive sawing and therefore of interest. As can be seen in Table 10, the volume with bark turned out to be almost 10 % bigger than without bark, which was in line with the expectations. The 1403 logs can without doubt be seen as an enough quantity to draw conclusions from. The coefficient of 1.0964 was then used to divide with the
incoming volumes, so that they where without bark, which gives a much fairer view of the total yield from log to furniture.

<table>
<thead>
<tr>
<th>Total volume for 1403 pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>without bark</td>
</tr>
<tr>
<td>133,768</td>
</tr>
</tbody>
</table>

#### 4.3 The saw-mill
The main saw-mill line was according to Eriksson (5/6) originally produced by the Swedish company Söderhamn Eriksson AB. The line is fairly old and dates back to the 1970s. The saw-mill line was bought as a whole from a Swedish company that closed down in Boden, Sweden. The saw-mill in Boden performed badly for a couple of years and because of financial problems the maintenance was put on a very low level for several years according to the technicians that worked there. The staff in Kostomuksha names the age itself and the fact that it could have been even better installed as reasons for problems with the line. When service- and repairmen from Söderhamn arrive they do not always manage to completely solve the problems that the local staff has named, or the problems are just temporarily solved. A general problem in the saw-mill is the problem with acquiring spare parts and new components. They tend to easily get stuck in the Russian customs. If the saw-mill had been located in the European Union this problem would not have existed. Now, that this is not the case there has to be sufficient spare parts on place in Kostomuksha, otherwise a standstill for the whole saw-mill can be the result of lack of spare parts. During a normal day about 3 or 4 longer stops per shift (every shift lasts 8 hours) are not unusual.

The flow in the saw-mill is in many ways similar to any modern saw-mill, but is for orientation briefly described here anyway. The logs that are brought to Swedwood in Kostomuksha from the own forests or other sources are first run through the log sorting and then stored for some time outdoors in the so called pockets (or bins) at the log sorting. A few of these bins with log piles can be seen in Figure 21. From the log sorting the logs are first brought to a kind of log table, from which they later, one by one move on the conveyor towards the debarking, where the bark is cut off.

![Figure 21: To the left; pockets with logs at the log sorting and o the right; the log table from which logs one after another move to the debarking](image)
From there the logs move on a conveyor into the main building of the saw-mill. As the logs enter the saw-mill they pass through a scanner, the Elinova scanner 768. The Elinova scanner counts how many logs that enter the saw-mill. Of the logs entering the saw-mill some may cause a jam. This is not unlikely when one or more of them is of other than completely circular shape, twisted in any way or simply an unusually big log. The log entering the band saw and the gripping equipment that precedes it may then have to be removed and pulled back. More usual is that two logs enter at the same time and have to be removed and pulled back. These examples are of course exceptions, but when they do happen, the conveyor has to be moved backwards and the logs that are moved backwards and then again forward under the scanner are counted at least one extra time. It can also happen that two logs come in completely after one another and that there is no air in between them and hence the, in fact two logs, are counted as one. In an ideal world these two counting errors would outtake each other. This can however not be expected, since the counting errors vary a lot depending on what kind of logs that enter the saw-mill.

For logs with a fairly large diameter it is likely that more jams appear and therefore more often the conveyor has to be moved backwards. Therefore, the number given by the scanner can not be trusted. The scanner also measures volume of the incoming logs. These figures can for the same reasons not be completely trusted. Logs moved backwards and then into the saw-mill once more contribute to the total volume two times more than necessary. Since bigger logs logically have easier to get stuck, they are more likely to be measured more than once and therefore a look on the diameter classes which Elinova scanner indicates that the incoming logs have, can in fact be a bit misleading. It happens very often that the scanner shows that the incoming logs have a bigger diameter than they in fact should have, when one looks at from which pockets the logs are taken. In the saw-mill this is explained simply by the facts that, as mentioned earlier, bigger logs have a greater probability to be measured more than once. Since the volumes from the Elinova are not used by the saw-mill, it has however, according to Eriksson (27/8), not been calibrated or checked for more than a year. During the time for the examinations that lay the foundation for this report, the author helped with evaluating the trustworthiness of the Elinova scanner. A test was done. 15 logs that first had been measured by hand and then measured in the Rema scanner were taken through the Elinova scanner in order to find out how correct the Elinova scanner was. The Elinova scanner showed in average an error of 20 % in volume compared with the Rema scanner. This is in itself of course serious, but much worse was the fact that the Elinova for a few logs showed completely impossible volumes. The inconsistency was a bit startling. Through the work and in the yield calculations in this report is therefore not single digit from the Elinova scanner used. During the process, the Elinova scanner volume figures were sometimes used as a reference figure if the volumes were big, otherwise they were ignored.

The logs are after passing through the Elinova scanner almost immediately being sawn in the saw-mill in the band saw. The band saw can be seen in Figure 22. The outer boards are there sawn off and are after the band saw kicked down by kickers down on the sides and are brought with another conveyor to the so called Millomatic, where the edges of the boards are being cut off. Since the edging is of particular interest for the adaptive sawing concept it is described further below.

Figure 22: The bandsaw in the saw-mill in Kostomuksha, 2 blades out of 4 can be seen here
On the way to the Millomatic the boards pass the operator sitting in the control room, with a good overview of the boards, has the possibility to remove boards with bad quality. These boards are rejected and fall downstairs, where they are collected and brought to the chipper, where from it and together with the other wood, classed as reject or waste, wooden chips are made. The Milltech (Millomatic) also has the opportunity to reject boards and they are then removed as waste. This is done automatically. From the Millomatic the ready outer boards move on with a conveyor and they later on join the flow of boards from the “main” flow. The “main” flow consists of the treatment of the major part of the logs, i.e. what remains of the logs after the outer parts have been cut off in the band saw. The logs are then turned on the side to be able to cut them with the right angle. After that they move on to the reducer where the edges are being cut down. They rectangular centre pieces that remain then go into the second saw, the so called Eurosaw. There, what is left is sawn into a number of boards. This “main” flow does however not exist when logs are sawn with adaptive sawing of smaller diameters, since all boards fall down on the conveyor that brings them to the Millomatic edger.

![Figure 23: The flow immediately after the band saw, in this case two sideboards fall down and the centre piece moves on to the Eurosaw. In case of adaptive sawing of small logs four boards would have fallen down and nothing would have moved on.](image)

The idea with an edger is simply that it should cut away the parts of the boards that are not desired, i.e. the edges. In order to accomplish this, the Millomatic has a scanner that scans the boards before its infeed. The process starts with the board or “work piece” being completely moved through the scanner where four beams scans the board. The information received from the scanning is transferred to the optimization computer which optimizes on where to rip and the board is then advanced to the infeed chain. Centering arms that touch the board helps to centre it and it is advanced on the chain towards the edger. If the optimization computer thinks the board does not fulfil the demands set up the boards are as a whole rejected and fall down onto a waste conveyor. If the board is in order just the edged-away sides fall down and the edged board moves on. (Söderhamn Eriksson, 1993)

As was mentioned not long ago, the edging is of particular interest when it comes to adaptive sawing since how much is edged has a direct effect on the yield. Originally, the idea in the adaptive sawing concept was that no edging at all would be done on the boards. The reason for that was that there should as big area as possible to cut out lamellas from. In normal saw-mill production all boards are completely edged. No wane is left at all, since it is naturally not desired to have boards that have wane. When wane is edged away, is however as said, some good material lost since the aim of the edging is to remove all wane. If all wane is to be removed then
straight cuts are required and this means that if a board has a bit of an irregular shape quite much wood is lost when the sides are edged off. As wane is normally not desired at all, this is perfectly normal. However, for adaptive sawing the wane is removed later on, in the glue board factory when lamellas are cut. Therefore as much of the boards as possible should be left. During earlier tests this caused problems in the saw-mill, since a lot of extra handling with completely unedged boards was the result. Söderhamn Eriksson did therefore develop new settings to the software that decides how the boards should be edged in the Millomatic edger. The new settings allowed that up to 30 % of the length of the board might be completely edged away. An example of how a board edged this way looks can be seen in Figure 24.

If one moves on for a moment and thinks a bit about the lamellas that will be produced from the boards and the effect of the edging on that. At least one thing can be stated from that. Since the lamellas taken out through from the boards have a fix width of 46 mm and narrower it was estimated that not too much material would be lost if some edging was done on up to 2 metres. The decrease in yield would be highly marginal because of edging on the sides of the boards and that was by far beaten by the positive effect it had on the production efficiency in the saw-mill. Work went much smoother when the boards were edged.

![Figure 24: Example picture of board that goes through the Millomatic. The outer areas are wane and the thin line represents where the cut will be done in the edging](image)

After edging of the boards they move on conveyors for some time before they eventually reach the raw sorting. Before going into detail on that process it might now be in order to look at the flow in the saw-mill in overview. This can best be done by looking at Figure 25. The flow there is portrayed from above and hopefully gives the reader an idea of how the flow goes. Since calculating the yield is the aim of this report it is of course of interest to have an idea of which points data on how many pieces and how much volume passes. In the saw-mill there are three places where the passing logs are counted. The first place is at the very entrance of the logs to the saw-mill. There, the entering logs are, as mentioned before, being counted by the Elinova scanner. The logs are later on counted on two more places. The second place is after the band saw, where the “outer” boards have been cut off and have gone on a different conveyor. The third time is in connection with the sawing of the central boards. The problem with the counting on all these places is that when small logs are sawn with adaptive sawing then there are no boards that go past these detectors. Those places are placed on the part of the saw-mill line that is marked with a reddish colour in Figure 25, which are not used when sawing adaptive sawing of logs with a smaller diameter. Since the counting of the Elinova scanner not really can be trusted, this means that there is no point in this part of the saw-mill that gives trustworthy figures on how big the volume is that is being sawn. Exact figures for number of logs or boards are also not received as long as the main line with the Euro saw is used. This means that manual counting of logs is necessary in order to get more control over the incoming volumes.
The boards are however counted later on in the saw-mill at one point. This is done at the raw sorting by the so called REMA – system which in addition to sorting all boards which passes this point also counts them. The wet, “raw” boards are being sorted on width, thickness and length. In advance parameters for different classes are set. For the thickness a dimension of for example 25 mm is set and the instruments then sort all boards with a thickness that is measured to 25 mm or more within a tolerance of for instance 3 mm are sorted as having a thickness of 25 mm. This tolerance may be adjusted and a bigger tolerance level might be needed when adaptive sawing is used. The thickness is measured at the thickest point by measuring the distance between two
gripping jaws all boards pass between. For adaptive sawing it is likely that the surface as for many boards is not completely flat.

The lengths are calculated from the information that is received from when the boards pass a very simple kind of sensors that are placed with 30 cm intervals. When a board with for instance a length of 405 cm passes it will then be sorted as belonging to closest length class below 405 cm. Instead of sorting the board as 420 cm, it will then be sorted as having the length 390 cm, since the sensor farthest away is what decides which length the system adopts. (Wiklund, 1989)

When it comes to the width it is according to Wiklund (1989) measured at the same place as the thickness, which means about 120 cm from the top of the board. When a board moves through this point the width is measured by a photo cell. When a board reaches the photocell one could say that it sees the board as a dark object. While this dark object moves under the photo cell it starts counting the number of pulses that are given by the movements of the conveyor. This does in turn give how far the conveyor has moved the board when the dark object is no longer “seen” by the photo cell. A width is then calculated. The width may of course be different for different boards and in order to make it possible to sort the boards, certain intervals have to be decided in advance. The width class of 150 mm may for instance involve boards with the measurements from 125 to 175 mm. Since the width is measured this way it makes it not trustworthy when it comes to measuring unedged boards. The system would in case of an completely unedged board calculate its volume based on the width with wane 120 cm from the top of the board. That would render a false picture of the actual volume. Therefore the volume figures given for the adaptive material were not used to any greater extent in the work with this report, usually just as reference figure.

Combinations of widths, thickness and lengths are together setup and sorted as one class and the REMA system lets the boards of the same class down into one of the 40 existing pockets that contain raw boards. The boards of one class are emptied into to the first pocket with already existing boards of the same class. These pockets do after a while get full with boards, depending on what number of boards that are calculated to be in every package. If the pocket with the desired class is full, then the board is moved until it can be dropped into the first empty pocket. If a board does not fit into any of the classes or if something has gone wrong, it is moved to the very last pocket, number 40. Before the boards go into process an operator controls them at the raw sorting and the ones that look bad are classed as reject and fall into pocket number zero, were reject is placed. (Eriksson 7/6)

When a pocket is full the operators usually empty it and the boards move on a conveyor to the sticker stacker where stickers are being placed between the boards and packages containing boards are made. A maximum of 9 stickers can be placed by use of the current system. Therefore, normally a distance of 70 cm between the stickers is the result. A distance between the stickers of 40 – 50 cm, which is recommended from Swedwood in Sweden, is hence impossible to achieve with the current sticker stacker. A new sticker stacker will be bought this year and hopefully installed early in 2009. For adaptive material the widths of the boards usually result in packages with 270 or 324 boards in each. (Eriksson 7/6)

As for most material flows or supply chains there are potential bottlenecks that can dictate the maximum pace of the production. In the saw-mill in Kostomuksha the bottlenecks are before the sticker stacker and at the raw sorting. These are processes that can not be speeded up much more in general. If the saw-mill at any time needs to slow down its production pace it is likely that it would because of bottlenecks in these places.
4.3.1 The Kilns

The Boards coming from the saw-mill are then dried in the kilns down to a moisture content of 8 – 10 %. The kiln in Kostomuksha consists of 2 chambers and 3 tunnels. When boards are dried in the tunnels they move on wagons through a conditioned area. This can make it slightly harder to dry thin material like adaptive material in a good way. In addition, the adaptive material is usually not sawn in large enough amounts to fill an entire tunnel, which would be preferable. If adaptive material would be dried in the tunnel it would according to the responsible for the kiln be done in tunnel number 2 or 3. Tunnel nr 1 could theoretically also be used, but the second and third tunnels are newer and are therefore used for this, as it is of importance that the material is dried as efficiently as possible.

In practice the adaptive material is almost always dried in the chambers since it is easier to regulate the drying there. A more efficient and controlled drying is the result of this. A sketch of the chamber kiln in Kostomuksha can be seen in Figure 26. The boards are always dried together in the chamber with boards with the same thickness in order to optimise the drying for that particular thickness.

![Figure 26: Sketch of typical chamber kiln from Wsab (Wsab.net, 17/2)](image)

When the first adaptive sawing test in Kostomuksha was carried in April a drying program that was developed in Tikhvin was used. This was developed with the experiences drawn from the tests done on adaptive material there. The boards had the dimensions 25 mm thickness and width varying from 100 to 250 mm. The drying took 82 hours. Almost the same drying program was later used during the other tests of adaptive material in Kostomuksha. The only major difference was that in general, less time was needed since the thickness after the first test was 24 mm and not 25 mm.

4.3.2 Glue board factory

After drying, the packages with boards usually stay for some time in the yard next to the kilns. If possible, they are put under the roof which is situated next to the kilns. As dried wood that lies outdoors for a long time may take up humidity it is of course essential not to let the wood lie outdoors too long. During the winter months this is not a real problem, since wood according to Hoadley (2000) does not take up much humidity under winter conditions. In any case, the packages with boards are usually moved as quickly as possible down to the storage room belonging to the glue board factory. The storage room has some heating and fans that can be turned on in order to keep the moisture content down in the wood. The storage room does however not have enough heating to keep it really warm and is therefore in daily talk referred to as “the cold storage”. The raw material is in shape of “packages”, containing usually around 270 boards, brought on to a big conveyor. Packages containing boards with a thickness over 50 mm
move on until they reach the tilt reserved for the first line, which the production line for the 50 mm material can be called. They are lifted up by the tilt and from it layer after layer of boards slide down and go into production. The 50 mm material can also be referred to as “traditional” material since adaptive material in comparison with this represents something new. The second production line for lamellas will here be referred to as “the adaptive line” and was also referred to as the “Raimann line”. The first line, where lamellas are made out of 50 mm boards will not be of any importance in this investigation and is therefore not described thoroughly here. The only thing worth noting is perhaps that material can be taken from the Waco planer to the Wood eye scanner of the adaptive line. The material will in those cases be mixed which means that yield in that case is not meaningful to calculate. This has therefore been avoided when production to find out the yield was run.

The material flow in the second, i.e. the adaptive line starts with a package with adaptive material being taken from the conveyor and moved up on a tilt. From the tilt the boards fall down layer after layer on a conveyor and move as can be seen in Figure 27 one after another to the Ledinek planer, where they are fed in and planed.

![Figure 27: Boards that just have fallen down from the tilt line up on the conveyor. They then move on the conveyor to the Ledinek not seen in the picture.](image)

**Ledinek**

The Ledinek planer planes both from the top and the bottom. One option to adjust on the Ledinek is how much it planes from the bottom with its teeth. Since the boards appear in different thickness it is sometimes necessary to adjust this parameter. For instance, if the average thickness of the boards in one package lies at 25.8 mm and the following package has an average thickness of 24.8 mm, this implies that it is unlikely that there should be the same settings for the boards from these two packages. If the “floor” in the planer is put too high it means that the planer planes more than adequate on the bottom of the boards but can leave virtually unplaned areas on the top side of the boards. When a new package is used it can take some boards until the settings are completely correct. This can explain some of the reject pieces from material which is usually of good quality. This could of course lower the yield slightly on a few occasions, but since many packages have the very same thickness, the effects would be so small that it would not really show in the figures. Experienced operators should however be able to keep the amount of waste at setups at a minimum. The incoming thickness is seen as 23 mm. In fact it is usually more than 23 mm, since the saw-mill saws the boards with a thickness of 24 mm. There is however an allowed marginal upwards with up to 2 mm. When dried a board of thickness 24 mm shrinks to somewhat more than 23 mm. Since most boards are thicker than 24 mm when fresh, this also means that almost all boards will be thicker than 23 mm when dried. During the first
test, boards with a thickness of 25 mm and a marginal of 2 mm upwards were sawn in the saw-mill. This was done since it was deemed necessary to have much marginal for the planer. The planer planes the boards on both sides and out comes a board with a thickness of 19.8 mm. Since boards can have different thickness at different places and be bent or have other kind of shape defects it is necessary to have a few mm of marginal to get boards with a good surface. Originally it was considered to have as much marginal as is the case when 25 mm is sawn in the saw-mill. This was however later seen as unnecessary and 24 mm was deemed as a sufficient raw thickness. In any case what comes in to the glue board factory are boards that have been edged quite little or not at all. The example boards from 3.1, “Theoretical background of adaptive sawing” might with advantage be used as example for what happens to a board in the factory and hence we have as starting material Figure 28.

![Figure 28: Example board coming from the saw-mill. Note that few boards in reality has this kind of shape, this is just an example to clarify specific characteristics of the adaptive sawing concept](image)

**Control Logic scanner**

When the planed boards come out from the Ledinek planer they are supposed to move one and one to a scanner, The Control Logic scanner. There were however at least initially problems sometimes with getting this working perfectly since boards had a tendency to pile up or to jump over to the place of the neighbouring board. This most likely had to do with sensor and programming errors. In order to get the scanner working as supposed it must receive just one board at the time. The whole concept is based around that. If two boards are scanned at the same time, the scanner perceives them as one and hence optimizes wrongly and the cutting of these boards is bound to be performed badly. What the scanner should see and regard as lamellas in the example board can be seen in Figure 29.

![Figure 29: Our board with possible lamellas marked. The area coloured purple is an area that could have become a little narrow lamella if smaller lamella widths than today’s had been used.](image)
First it might however be on its place to explain a little bit on how the Control Logic scanner is working. A board is run through the scanner and is scanned by several lasers on its top and bottom sides. The Control logic is a 2D-scanner which means that it scans and optimizes on those sides and then sends signals about how the board should be ripped into lamellas. Wane and clearly visible shape defects are areas from which lamellas not will be taken. The scanner tries to take out the maximal possible area from the parts of the board that it perceives as defectless. A typical example of what it may look like can be seen in Figure 30. Since only lamellas with a width of 46 mm are desired some waste is always likely, since the boards very seldom are a multiple of 46 mm in width. The scanner does not only use its data to calculate how to rip the boards in lamellas in an as optimal way as possible, it does also use its data to calculate volume. The area seen by the scanner is multiplied by the thickness that is set up. This gives the volume incoming into the scanner, which is a very important parameter in following the yield from log to furniture. The volume can, when multiplied by a thickness of 23 mm be seen as the incoming volume to the glue board factory. The scanner also gives a volume of what it expects to come out as useful material when all waste is removed. As an example of useful material can the two long lamellas in Figure 30 be taken.

![Figure 30: Example of a board scanned by the Control Logic 2D scanner](image)

**Raimann multi rip saw**

After being scanned the boards move on to the Raimann multi rip saw where every board is sawn lengthwise in accordance with how the scanner has optimized the cuts. The information from the scanner is transferred when the board has passed some sensors and the stoppers just before the infeed to the Raimann multi rip saw are positioned in accordance with this information. The idea is that the stoppers decide with which blades the board should be ripped and also exactly where on the board the cut will take place. The stoppers could therefore also be called positioners, since that is the function that they fulfil. In Figure 31 a board that has just been stopped and positioned be seen.

![Figure 31: A board on its way into Raimann rip saw. The positioners out of which only the first can be seen here has positioned the board and the rollers are about to be lowered to roll in the board into the Raimann](image)

In Kostomuksha there are at the moment only produced lamellas with a lamella width of 46 mm, this means that the saw blades are set up in such a way that they have a distance of 46 mm between each other. All blades do however not have distances of 46 mm to its neighbouring blade. There are also two blades with 65 mm distance. They are however not used and in general
Figure 32 gives an idea on how the blades principally can be positioned in an arbor with fixed blades.

![Figure 32: Arbor with fixed (F) blades, out of which all blades but the one at the right are placed at equal distances from each other. (For picture source, see B in references)](image)

In theory there is also possibility to use moveable blades instead of fixed blades. In that case the multi rip saw should be set up in such a way that the scanner that optimizes has several different lamella widths to choose from. The blades then move accordingly and lamellas with different widths can as in Figure 33 be the result. It is however of course also possible to get different lamella widths with just fixed blades. They are then simply just set up with the desired distances between them, but can never be moved. An arbour with moveable blades was tried in Tikhvin, but the advantages compared with an arbour with fixed blades placed at different distances might be considered marginal. In the long run, the idea is to fully use the potential of the adaptive sawing concept by using more lamella widths than just 46 mm.

![Figure 33: To the left: Three moving blades and one fixed in an arbor. To the right: An example of a possible result of such a setup; a board with 3 lamellas of different widths and pieces with wane that will be removed as reject. (For picture source, see B in references)](image)

As also could be seen to the right in Figure 33 there will be waste at the edges of the boards. The edge with wane that can be seen to the very right of the board is a typical example of what waste produced by the Raimann rip saw looks like. After the Raimann has sawed a board into lamellas they are moved on and the edge “lamellas” with waste are pushed down on waste conveyors. These can be seen to the left and right in Figure 34.
Occasionally it can happen that also normal lamellas of good quality are pushed down as were they waste. This is of course not good and makes the yield lower if these lamellas are not detected and thrown back onto the right conveyor. This means that it is necessary to have a person supervising the waste conveyor, if not constantly then at least from time to time, to find the lamellas. Another possible problem with the Raimann rip-saw is that it can sporadically happen that a board gets stuck in the rip-saw. This does mainly have to do with queuing errors, i.e. information from the scanner is received in wrong order, which means that the boards are positioned completely wrong. That boards in such cases can get stuck and must be manually removed from the blades might the reader get an idea of by looking at Figure 35.

When the long lamellas move on, they can in a way be seen as any long uncut lamellas, they are in practice not much different from lamellas ripped the traditional way. That they could be mixed with lamellas produced in the first line as can be seen in Figure 38 is therefore no problem. The lamellas move on to Wood Eye scanner which scans the lamellas for defects. Before that, an operator looks on every lamella and removes the ones that do not meet the specified quality standards or cut off parts with wane. Sometimes there is a part of the removed lamella that can be useful and that part is then manually cut off and used as finger-joint. Lamellas that wrongly fell down as waste directly after the Raimann can here also be put back so that it passes through
the Wood eye and can become lamellas. After the manual check the lamellas move on and should be scanned a second time by a scanner that sees the defects in the lamellas and give order to a cross cut equipment to cut the lamellas in desired lengths and according to given quality definitions. The reader might get an idea of what this means by looking at Figure 36.

![Figure 36: The example board with parts that the Wood eye scanner sees as useless marked as red.](image)

The defects are then of course cut away and removed as waste. This is done by a cross-cut equipment from TM called Opti Kap 4003. TM is the brand and in daily talk the name of the transport and feeder system for lamellas and boards that connects all parts in the lamella production line such as the planer, the scanners, the Raimann rip saw and the cross-cut. TM also includes the cross-cut equipment itself and the settings for how to cut the lamellas and when TM is mentioned in this report it is usually the latter part of it, with the Opti Kap after the Wood eye, which is meant. For every long lamella scanned by the Wood eye scanner data on its defects is sent to a computer that based on settings optimises where to make cuts on the lamella. As before the Raimann saw there is a similar, but even smaller risk that queuing errors can occur and then cause lamellas being cut wrongly. What are then received are waste, lamellas of the set up sizes and qualities and finger-joints. These products, for the example board can be seen in Figure 37.

![Figure 37: The final result coming out in shape of lamellas and finger-joint from our example board.](image)

When lamellas are cut in the TM they are registered by the system. Everything – waste, lamellas and finger-joints are all registered and give a very detailed production statistic and are in many way the basis for the yield calculations. To see how many cubic meters of a specific length of for instance bulk lamellas that have been produced during a period of two hours is no problem. This means that there above all are two points where data necessary for yield calculation can be gathered. These are the Control Logic 2D scanner and the 3 Opti Kap saws, which as the rest of the flow in the lamella producing part of the glue board factory can be seen in Figure 38. What
also could be noted is that the number of boards ripped by the Raimann rip saw can be registered and this can be used as a control figure.

What also could be noted from Figure 38 is that all lamellas produced end up on different pallets depending on their size and quality. The short pieces aimed for finer-joint production go to the Grecon equipment where they are glued together. Since the rest of the factory after the end of the so called TM-line, with its three “Opti Kaps”, is of little interest it will not be described here.

One thing that however might be of interest is that the lamellas that are produced, to work in the glue board press, after the lamella production is done, must have a minimum width of 35 mm and as a maximum 70 mm. This effectively puts the extreme limits for the lamellas. The following equation is also to be observed: with any combination of lamellas the maximum width has to be less than two times the minimum width – 15 mm. This is designed so, because there should be no risk that two minimal lamellas by the machinery could be mistaken for one maximum lamella. An example of this is that, when a minimum lamella of 35 mm, then the maximum lamella width becomes 55 mm. During 2008 all lamellas had a width of 46 mm and hence did these limitations have no effect. They do however affect which lamella widths are plausible to use in case of variable lamella widths in the future.

**Figure 38: Schematic picture of the flow in the first half of the glue board factory - the lamella producing part. The blue boxes represents scanners and the reddish boxes where the cutting is done.**
5 Calculating yield

The title of this chapter might be a bit misleading, since this chapter describes far more than just a few simple calculations. It does on the contrary describe far more than just calculations. Here is the method used, when following the yield for the different batches, described. The process for following the yield for all the four batches of the diameter class of 135 – 148 and the diameter class of 110 – 120 mm and the results are also presented here.

5.1 Method for calculating yield

In order to follow the yield from log to glue board it is necessary to have check points at several points in the chain. One could of course say that material is followed the whole way through the flow, which is also true, but it is essential to have some points where the number of pieces is counted and a volume can be estimated. As was stated in part 4.2.1, “The log sorting” it is of utter importance to know the incoming volume of logs that enter the saw-mill. There are a number of variants on how to solve this in the best way. As a rule, all logs are taken through the log sorting and are scanned there. The volume for all logs is registered and the logs are put in their respective pile consisting of logs from the same diameter class. What is then the problem, one might be tempted to ask. As the saw-mill starts sawing a specific diameter class logs are taken from the corresponding pocket on the log yard. It might however be the case, that when the sawing of the class is finished logs will still remain in the pocket. This is not very good since it makes it a lot harder to know the exact incoming volume into the saw-mill.

The reports from the log sorting are taken on a shift basis which means after each shift is the number of logs fitting into every diameter class is reported. This means, that one afterwards can check exactly how many logs and how many m$^3$ that was scanned at the log sorting and were put in every pocket. If the saw-mill when sawing class 7-8 just needs two thirds of the total amount piled up in the 7-8 pockets, then it is actually hard to be sure on exactly how many m$^3$ that were cut. Why is this so? The answer is simply that logs, which are seen as belonging to one class in fact could have quite different volumes, since they have different length and shape. The classes are only based on top-diameter measurements. One way to be completely sure about the incoming volumes is to completely empty the pockets and use all logs lying there. If this is not done one has to try to find which logs did and those which were not sawn, if certainty should be reached about the incoming volume. This may however not prove too problematic and the error causes from this are marginal. The by far superior way to find out how big the incoming volume is, is of course to measure all logs manually and with help from the measurement data calculate the volume of the logs. This would however require much time and people and indirectly resources. Measuring volume of thousands of logs that way would for a single person mean more or less a full-time job for quite some time. This was therefore, at least initially, never an option. By having control over the quantity of logs in the pockets it is however possible to get very close to the correct volume, since one can have a good idea of on which day the logs were sorted. Hence, a trustworthy figure for the average volume of the logs could be received.

Since an average volume for the logs taken into the saw-mill is known, finding out the number of pieces would yield a very good figure of the incoming volume. As mentioned in part 4.3, “The saw-mill” the Elinova scanner can not be trusted with counting correctly. Therefore, manual counting of logs was required in order to find out the exact number of logs that entered the saw-mill. When the number of logs is known, it is easy to calculate the number of boards that at least theoretically should result. Since the adaptive sawing in Kostomuksha always is done on small logs diameter, then the number of boards will be 4 times the number of logs. This is a useful figure since, having that in mind makes it possible to keep track on how many boards that
“disappear” on the way. In order to make the yield calculation trustworthy it is of course essential to keep track on all boards and all reject on the way. The boards can be rejected on several places in the saw-mill line. It might be in order to recapitulate what the saw-mill line looks like, which is done in Figure 39. In the first half of the line there are as mentioned in part 4.3, “The saw-mill”, basically two places where the operator in the control room can choose to remove boards as reject or where such a choice is automatically done by the system. Those are marked in Figure 39 and it is during the adaptive test sawings important to keep track of how many boards that are removed there. One way to do this is simply to have a person counting the boards. In theory it is also possible to take a report from the Millomatic on how many boards that passed through it and how many which were rejected. Theoretically this gives a complete picture of how many board which pass through if the operator is ordered not to remove any boards before the Millomatic.

Figure 39: The saw-mill line in Kostomuksha with places were boards are rejected are marked with elliptic boxes
From the Millomatic to the raw sorting it could happen that a couple of boards get damaged and therefore have to be removed. These have to be counted, but this is often no problem since they move on and end up as rejected boards in the raw sorting. The raw sorting itself, with its Rema system, gives a lot of crucial information and boards classed as reject fall into a single pocket, the first pocket, numbered as zero. As was described part 4.3, “The saw-mill” the Rema can fail sometimes and the boards, that it fails to sort, are not registered and end up in pocket nr 40. Except for those few boards, all boards and their respective number and volume are recorded by the Rema system and therefore gives valuable reference statistics, even though the volumes in themselves might not be 100 % correct. What then needs to be done is to count how many boards that were lost and fell into pocket nr 40 as unidentified. The boards in pocket nr 40 were initially removed as reject even though they could be of decent quality, which of course is unfair. This causes the yield to drop unfairly and to prevent this, they need to be counted and removed from the yield calculation. If for instance 40 boards end up in pocket nr 40 they later on are just thrown away as waste, even though they might be of excellent quality. In order to make the yield fairer in this example, the volume of 10 logs should be removed from the incoming volumes. Otherwise the yield will be lower than it actually was if the problems with pocket nr 40 did not exist. The main things in the saw-mill are, in brief, to be sure of the incoming volume and keep track of what is sawn and that nothing of it is lost or rejected without it being known.

The boards are then put in separate packages and are never mixed with boards that have not been sawn with adaptive sawing. The packages containing adaptive material are as far as possible dried at the same time in the kilns and then moved down to the glue board factory where the packages, one at the time, is used by the Raimann line. Before the boards are planed the operator has the chance to look on the quality of each of them. Boards that are deemed as not useful are removed and the quantity of these is noted. In order to check that no boards have been lost in the handling and drying after the saw-mill the boards can be counted manually in the glue board factory. The 2D scanner and the Raimann rip-saw do however also count how many boards that pass through both of them, which means that a good figure is received on how many boards enter the glue board factory. To have these figures under control means having one “check point” clear when following the adaptive material. Another check point of utter importance is the volumes that the Control Logic 2D scanner gives. Because of minor errors in transferring data from the scanner to the rip-saw it happens that some boards are rejected by the feeding system to the Raimann. There is however nothing wrong with these boards, the errors more or less randomly occur. The boards rejected this way are gathered and run again later on. In order to avoid that the volume of these very boards is registered twice a report is taken from the scanner when a whole package has been run through. After that, if necessary, rejected boards are run again and the volume of them is not added. Since the volumes given by the 2D scanner are among the most important figures, much time was spent on making sure that no operator mistakes happened, that could ruin these statistics. Almost constant presence of the author here was nothing unusual when the packages being part of the test were run. Since the principle was one package – one volume report it was in case of a report, that contained too much strange data or when something had gone completely wrong with taking the report, possible not to use that particular report.

When the boards have been sawn by the Raimann rip-saw there are a certain amount of lamellas that fall down together with the waste from the main conveyor and later become finger-joint. This volume is also included in the volume outgoing from the Raimann line as a whole, since there is no difference between finger-joint material produced this way and material produced after being scanned by the Wood Eye and then cut accordingly by the cross-cut. Since the TM can deliver very detailed statistics on exactly how much of all lengths and qualities that was cut, the problem is just to use it in a good way. The material is followed, package by package, and it is therefore logical to take the statistics for every single package individually which can be done, since it is possible to take reports from the TM for specified time periods. This, then requires that
the operators note at what time they start each new package. With this information in hand it is possible to follow every package individually which was also done. A higher reliability in the yield calculations is the result of this.

It should also be noted that, within the scope of this thesis, it is not possible to follow the yield from ready lamella to ready furniture since the lamellas produced with the adaptive sawing technique are mixed with lamellas produced in a traditional fashion. In most cases it would be very hard to follow these very lamellas through the whole glue board production process since there is an incredible amount of lamellas in such a factory and the workers do not always pay attention if someone from the office declares that specific palettes with lamellas participate in a test. In any case, the lamellas coming from adaptive sawing should not differ in respect of quality in any significant matter and most importantly; there is no reason to believe that the yield on lamellas produced with adaptive sawing would differ much from lamellas produced the traditional way. Therefore, statistics for the overall glue board production is used for the yield from lamella to finished glue board.

5.1.1 Possible sources of error

The 2D scanner sometimes measures the volumes wrongly. This, however, has nothing to do with errors in how the scanner itself works. It is due to queuing errors and stops of the line that make one board stay in the scanner. Luckily, the reports the scanner gives on how big volume passing through, do show if there is reason to believe that something was not correct. If a board gets to stay in the scanner or something goes wrong the scanner usually records this board as belonging to the reject category and can then later easily be removed from the incoming volumes as an error. This is necessary since boards like these usually are registered as having enormous volumes compared to the other boards, which of course is not correct.

One possible error source is the volumes of finger-joints from the lamellas that are cut manually from waste and other material that is removed between the Raimann and the Wood eye scanner. The operator cutting up this material often also has other material to cut finger-joints from. Even though the operators were told not to mix adaptive material with other material it could perhaps happen anyway. Even though one might not expect it, the amount of finger-joint lamellas can vary quite much between different packages. It was therefore hard to judge whether the volume figures of finger-joint for a specific shift, was trustworthy or not. It was normal that they varied much from day to day even when everything worked as it should, and the operator noted everything properly.

5.1.2 First test in Kostomuksha

A first test in Kostomuksha of the adaptive sawing concept was done in March 2008. The saw-mill did at this time start sawing adaptive for the first time. The thickness of the boards was set to 25 mm in order to have marginal for the Ledinek planer in the glue board factory, since it was a bit uncertain whether it was possible to have thinner boards without problem. Since it was just considered feasible to set up adaptive sawing for the diameter class 135-148 mm the sawing pattern looked like in Figure 40.
Figure 40: 4 x 25 mm - the sawing pattern for the first adaptive sawing in Kostomuksha to the left and the traditional sawing pattern used to the right

The yield was according to Kostikov (4/6) calculated to 62 % for the adaptive sawing batches if the boards that were removed as reject in the glue board factory are not included, but gets as high as 68 % if they remain. A yield for the traditional sawing method with the same input of wood with bark was also estimated to 40.7 %. From now on, the yield figures that are referred to in this report are in general without bark. The reader could go back to part 4.2.2, “Possible errors at the log sorting” for an explanation of this choice. The saw-mill yield can be viewed in a more concretized shape in Table 11. The yield might however not be correct since it is estimated that at least 120 – 150 boards were missed in the raw sorting and in the so called REMA system. A report on how much the Millomatic edger in the saw-mill actually did reject was not possible to make. Another, smaller problem that was noted was the lack of a, for the adaptive sawing necessary software completely adapted for logs to be sawn that way. The current software, SDM Plus had limitations that according to Evgeniy Kostikov (4/6) made it less appropriate for adaptive sawing purposes.

Table 11: The saw-mill yield for the adaptive sawing in March if the saw-mill statistics are correct. The incoming logs had a volume of 164 m$^3$ and 1.66 m$^3$ boards were outsorted and 112 m$^3$ of boards were produced.

<table>
<thead>
<tr>
<th>Volume incoming</th>
<th>164.04 m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume without bark!</td>
<td></td>
</tr>
<tr>
<td>Outsorted</td>
<td>1.66</td>
</tr>
<tr>
<td>Saw-mill out</td>
<td>111.78 m$^3$</td>
</tr>
</tbody>
</table>

Since this was the first time that adaptive sawing was done in Kostomuksha it is perhaps not surprising that it took quite long time. To saw the whole batch took according to Kostikov (4/6) 16 hours and 25 minutes. To saw a similar quantity with traditional technique usually takes much less than one shift (which lasts 8 hours). The “clean” sawing time when all production stops have been removed was 7 hours. The main problems that caused this slow production speed did, in some sense, have to do with the lack of edging. The boards were not edged at all in the Millomatic. The elevator in the Millomatic became stuck, which caused standstills. The kicker in the band saw was also stuck, which caused long stops. The most striking problem did however have to do with the fact that no edging was done. At the step by step in feeder at the raw sorting did the boards slide over each other and overlap, which caused a much slower raw sorting than usual. A similar problem with overlapping boards could be observed at the stick stacker machine were packages are made of the boards. Normally a package can be put together as fast as 5 – 10 minutes. For the adaptive material did the stick stacking take something between 30 and 60 minutes per package, with an average at about 40-50 minutes. These figures might sound
absurdly high, but one has to keep in mind that this was the very first time the operators encountered completely unedged boards. According to Eriksson (4/6) the system did have problem dealing with the widths that result when the boards are edged in that little extent. The stick stacking did clearly turn out to be a bottle neck as was the raw sorting. The conclusions drawn from this led to some changes to the next adaptive sawing batch. To get less problems at the two bottle necks it was decided to edge the boards much more. This could raise the production speed in the saw-mill to a more reasonable level. (Kostikov, 4/6)

The stick stacking was not just problematic in the sense that it turned into a clear bottle neck. Another general problem was linked to the drying. Instead of recommended width between the stickers of 40 to 50 cm, the REMA system on the saw-mill places the stickers with a distance of 70 to 100 cm. The system could just place a maximum of 7 stickers on the boards instead of needed 9, or more. Since the distance between the stickers are so big some errors can be the result in the kiln drying. Cupping, thickness changes, due to pressure from some sticks, after drying and strange geometrical shapes can be the result of the too wide distance between the stickers. The results from using such material could not be said to be completely representative for a modern Swedwood site. Had the drying been fully acceptable a higher yield should have been the result in the glue board factory, no matter which sawing method had been used. It is hard to evaluate the impact of this on the yield since it until November were no resources available to make some packages with manually put stickers. The situation did hence remain the same for the following three adaptive sawing batches as well.

The drying of the 24 adaptive material packages, took place in one of the chambers in April and it took 87.1 hours to reach a moisture content of 8 %. After drying, the adaptive material was not put into production until more than a month later. The adaptive material soon showed signs of being of poor quality. The drying and the handling of the material had apparently been far from optimal since many boards resembled the look of rubber. An estimated total of 12 m³ of boards was sorted out, from the 111 m³ that according to the saw-mill entered the glue board factory in shape of boards. The 2D scanner reports, that were available of the volumes of the very same adaptive material, gave different figures for the incoming volumes and according to them just 89 m³ went through the scanner, which then is far less than the 99 m³ that should have entered. The Rema system is as mentioned in part 4.3, “The saw-mill”, however not able calculate the volume of adaptive material correctly and therefore there is no wonder that there was a difference.

Since this was the first time that the operators worked on a daily basis on the Raimann line it was no wonder that the inexperience made them do many mistakes and the yield was affected negatively by that in another sense. The clearest indicator for this was that an estimated 1 to 2 m³ of planed boards had to be removed from the Raimann since it had been set up incorrectly. Queuing errors between the Control Logic scanner and the Raimann occasionally appeared, as did problems with coping with the waste. The former might have had a slightly negative effect on the yield, while the latter sometimes caused production stops and just affected the production speed. The flow looked like in Figure 41 and the yield of 48 % from incoming boards to lamellas and finger-joint was not precisely a positive surprise. It is however possible that the yield is even lower than this figure because of handling mistakes with the scanner reports. One thing that did not cause any problems was the thickness of the boards. 24 mm dry thickness was more than enough as a marginal for the Ledinek planer. 23 mm was thus considered enough as dry thickness for the adaptive material. This meant that the saw-mill could saw 24 mm instead of 25 mm thick boards.
If one then goes on to look at what was actually produced in the 42.83 m³ there is not overwhelmingly much positive to say about that either. As can be seen in Figure 42 just 4 % of the produced volume was in shape of so called split lamellas, which is the finest class of lamellas and the most coveted in a glue board factory like the one in Kostomuksha. The split lamellas are later used in the most visible parts of furniture. As much as 37 % came out in shape of finger-joints, which on the contrary to split lamellas usually is not so desired. The split lamellas are used as edge lamellas in furniture and it is therefore of utter importance that they have a good appearance. One should nevertheless keep in mind that there were problems with the optimization settings also for the traditional lamella producing line in Kostomuksha the whole summer of 2008. This meant that much, much more finger-joint than normally was produced there as well.
As the objective of this thesis is to investigate the yield from log to ready glue board it is necessary to see what happens with the lamellas and how much is lost before they have become ready glue board. Based on statistics for August 2008 and previous experience on Swedwood sites in Poland, the production manager in Kostomuksha put together figures for how much is usually outsored in connection with the pressing, the sanding and the formatting of the glue board. The so called rework yield refers to how much from glue board or lamellas, that were removed, that could after all be used after the parts of poorer quality had been cut away. The remaining parts could These figures can be seen in Table 12, where the technical yield refers to how many percent of the volume that is left after sanding and formatting to reach the desired size respectively. The GB (glue board) yield in the table refers to the yield from incoming boards to ready glue board. This yield of 74.4 % for material from lamellas to ready glue board will be used for all the batches described in this report. The yield received for the Raimann line is multiplied by that figure to get the final overall yield for glue board.
Table 12: Yield statistics for processes leading from lamella to ready glue boards the figures in the m3 column refers to sheer volumes

<table>
<thead>
<tr>
<th>Yield from lamellas to ready glue board</th>
<th>m³</th>
<th>Local yield</th>
<th>GB yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Before Press</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsorted lamellas</td>
<td>5%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total rework Yield</td>
<td>65%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42.08</td>
<td></td>
<td>98.3%</td>
<td>47%</td>
</tr>
<tr>
<td><strong>After Press</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsorted GB</td>
<td>16%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield rework GB</td>
<td>65%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>39.72</td>
<td></td>
<td>94.4%</td>
<td>45%</td>
</tr>
<tr>
<td><strong>Sanding</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Techn. yield:</td>
<td>92.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsorted GB</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield rework GB</td>
<td>70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.52</td>
<td></td>
<td>89.4%</td>
<td>40%</td>
</tr>
<tr>
<td><strong>Formatting</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Techn. yield:</td>
<td>93.6%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outsorted GB</td>
<td>13%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield rework GB</td>
<td>70%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.86</td>
<td></td>
<td>89.7%</td>
<td>35.8%</td>
</tr>
</tbody>
</table>

To summarize the findings when it comes to the yield of the first adaptive sawing batch in Kostomuksha it might be useful to gather the most important figures in one Table. This is done in Table 13. One should also keep in mind that the incoming volume had a thickness of 24 mm which compared to a thickness of 23 mm means a higher local yield in the saw-mill, but a lower in the glue board factory.

Table 13: The yield for the first adaptive batch in brief with the yield for the respective part to the left and to the right the yield outgoing from log

<table>
<thead>
<tr>
<th></th>
<th>Local yield</th>
<th>Overall yield</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Saw-mill yield</strong></td>
<td>61.60%</td>
<td>61.60%</td>
</tr>
<tr>
<td><strong>Raimann line yield</strong></td>
<td>48%</td>
<td>26.1%</td>
</tr>
<tr>
<td><strong>GB yield</strong></td>
<td>35.8%</td>
<td>19.4%</td>
</tr>
</tbody>
</table>

5.1.3 The adaptive sawing on June 26th

With the mistakes that were made during the work with the first adaptive sawing batch in mind, a more accurate approach was necessary. The mistakes resulted in uncertainties when it comes to the yield mainly depending on disappearing boards in the saw-mill and possible mistakes in the drying and in the lamella production. In harmony with the conclusions, drawn in part 4.3, “The saw-mill”, it was also of utter importance to be sure of the number of incoming logs. The author of this report was therefore on place during the whole process, which started on June 26th, logs for the adaptive sawing were taken from the pocket 7 – 8, which is supposed to contain logs with a diameter from 135 to 148 mm. These logs are stored on both sides of the log sorting line. As usual, the drivers took the logs lying at the uttermost parts of the piles; one can simplify and say
that the freshest logs were taken. However, the drivers said that the logs did in general not look
very fresh and new. One driver estimated that maybe one fourth of the logs can be said to be
looking good.

During the whole test, which lasted almost two shifts or from 10.00 June 26th until 01.15 the 27th
of June, there were operators who counted all the incoming logs manually. They were informed
to tell the main operator to slow down in case they felt that they had any problems at all counting
because of high feeding speed. It appears however, that this never was the case and there is no
real reason to doubt that the final figure of the operators manual counting is trustworthy. The
final sum of logs was 2124. That number can easily be compared with the number of logs that
the scanner Elinova indicated. This was 2171 and hence there is a difference of 47 logs. It is no
real surprise that the scanner shows higher figures than the manual counting. As mentioned in
part 4.3, "The saw-mill", the scanner can show higher numbers. In order to get some kind of
backup check of the figures, one person was placed to count the boards coming out from the
Millomatic manually. The basic idea was to get as much figures as possible. The counting of
boards did however prove to be a much harder task than the log counting. The sheer amount,
nearly 4 times more than the number of logs, did of course make it hard. It was also observed a
few times that two boards came out from the Millomatic on top of each other.

The number of boards disappearing in the line during the two shifts has to be regarded as
extremely low. Unfortunately, the pockets 1 – 13 were filled with other boards than adaptive
material. In general it can occasionally happen that a board gets stuck over especially the pockets
1 to 3. The boards then fall down into these pockets and are mixed with the boards there and
disappear from the yield. During the adaptive sawing on the 26th a maximum of 10 boards did
probably fall down into these pockets. A much, much bigger loss of boards was caused by the
fact that a high number of boards could not be classed by the REMA-system and therefore fell
into pocket number 40. In the very beginning of the test, the system was not correctly set up,
which meant that all the first 50 or so boards ended up there. The total number of boards ending
up in pocket number 40 was 307. Then there is the reject, 65 pieces, which unfortunately later
were put together in the same pile.

On the line as a whole, especially before the sticker stacker, a few boards also fell down. This
number is likewise not higher than 10. One can complain about the lack of certainty here, but
with very high certainty it can be said that the boards were not more than 10. Before the adaptive
sawing started the boards that were lying along the line were put aside and put in special piles to
avoid any risk for confusion with the boards sawn with adaptive method. It did, however, happen
a few times in the evening shift that adaptive material, removed from the conveyors, was put in
these very piles. Even though the material looks a bit different it is therefore possible that a few
boards were lost here. The remaining missing boards disappeared as reject at the Millomatic. The
number of logs was 2124 and this gives the total number of how many boards that theoretically
can be produced with 4X which then gets 8496. As a matter of fact 8496 boards did not exit the
saw-mill in the packages containing the adaptive material from the second batch. The boards
were just 7889 pieces. The difference of 607 pieces has been explained above, but it might be on
its place to put together the information, which is done in Table 14.
Table 14: Lost nr of pieces of boards in the saw-mill on the 26th of June

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max nr of boards theoretically</td>
<td>8496</td>
</tr>
<tr>
<td>Actual nr of boards in packages</td>
<td>7889</td>
</tr>
<tr>
<td>Difference</td>
<td>607</td>
</tr>
</tbody>
</table>

Explanations for difference

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lost nr of pieces in pocket nr 40</td>
<td>372</td>
</tr>
<tr>
<td>Lost over pockets 1-13</td>
<td>10</td>
</tr>
<tr>
<td>Reject in the Millomatic</td>
<td>215</td>
</tr>
<tr>
<td>Lost boards on line</td>
<td>10</td>
</tr>
</tbody>
</table>

The problems with the adaptive sawing in a production-oriented aspect on the 26th of June were according to the foreman (30/6) mainly problems with the Millomatic itself. Pieces of wood tended to get stuck there and one can say that the Millomatic tended to get a bit “overloaded” by the shear amount of wood that is supposed to go through it. Theoretically the Millomatic should be able to handle this without any real problems. However, this was not the case on the 26th of June. On the second shift the main reason for stand stills was the Millomatic and more specifically problems with the communication to the Millomatic from the control room. There were also some problems with the sticker stacker. Since the boards are not edged, or in some cases, just partly edged, more problems than usual occurred. The boards tend to roll on top of each other much more frequently than when the boards are completely edged as after “normal” sawing. This was on the 26th an acceptable problem, since the total amount of boards was not as high as during normal production. In case of a higher a production rate, which would be the case if adaptive sawing would be run on a more daily basis, the problems with the sticker stacker could become more visible. The sticker stacker would become much more of a bottle neck with higher production and the problems with not edged boards gliding over each other and causing the operator having to move the boards manually. The problems could be said to be milder than when the first batch was sawn. Another problem during the sawing on the 26th was the fact that the Millomatic had problems to centre the boards. This meant that some of them became asymmetrically edged since one side was completely edged while the other side was left untouched. The effect on the yield is probably possible to neglect, but there was most likely an effect on the yield in the glue board factory. When boards are asymmetrically edged like this, the Control Logic software in the glue board factory has a smaller area to optimize the outtake of lamellas on. The problems at the raw sorting were, on the other hand, smaller this time and putting stickers in the packages went a little bit faster, but to say that things went smooth, would be not far from an outright lie. This did however not affect the saw-mill yield in itself, which can be seen in Table 15.

Table 15: The saw-mill yield for the adaptive sawing batch from June, without taking into account lost boards in pocket nr 40

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume incoming</td>
<td>185.1 m³</td>
</tr>
<tr>
<td>Volume without bark!</td>
<td>1.01 0.79%</td>
</tr>
<tr>
<td>Outsorted</td>
<td></td>
</tr>
<tr>
<td>Samwmill out</td>
<td>111.8 m³ 60.4%</td>
</tr>
</tbody>
</table>

A yield figure of 60.4 % as was shown in Table 15 might sound low compared to the preceding batch. But is this true? What could be expected? As a matter of fact a yield of 60.4 % is higher than what theoretical calculations showed could be the yield for the diameter class of 135 -148
mm. As can be seen in Figure 43 the yield could be expected to end up somewhere between 57 and 60 % for the diameter class as a whole. Why exactly the saw-mill yield turned out so much higher for the first batch than expected for the first sawing is hard to speculate about since the author was not present during that sawing. Likely explanations are errors in the log sorting or that a misleading yield was received when boards that disappeared had been removed from the calculations. The adaptive sawing yield for the second batch lies much more in line with what could be expected.

![Figure 43: Theoretical yield for adaptive sawing of four 24 mm boards for different diameters, put together based on calculations made by Stefan Rydbergh.](image)

The drying for 24 of the 28 packages produced in this batch, took place in the kiln from the 8th of July to the 15th and took 88 hours. When brought down to the glue board factory it could quite fast be seen that the adaptive material was much better this time than the material from the first batch. The same magnitude of drying errors or quality problems did not exist, which might indicate that the drying program was more suitable for material with a thickness of 23 mm than for material with a thickness of 24 mm. The drying program was almost not changed at all, compared with the first batch, which then implies that it might have been not really ideal for the drying of the first batch’s adaptive material. Just 65 boards were outsorted before the Ledinek. This equals nearly one m³ which is far from the 12 m³ which were outsorted from the first batch. There were boards with rubber-like shape, but very few compared to the first batch. It might, by the way, be an idea to give the reader a more vivid expression of what a “half-edged” board looks like. If the reader remembers Figure 24, then the same board, which had gone through the special edging program in the Millomatic, would theoretically look like the half-edged board in Figure 44.

![Figure 44: Board edged with the "special edging" program used in Kostomuksha](image)

The problems with the production in the Raimann line were in general similar with the ones for the first batch and it happened quite frequently that boards had to be run twice through the
Control 2D scanner since they came in pairs. Even though the boards were half-edged they could pile up sometimes after the Ledinek which then gave queuing errors or a scanner error when the scanner had scanned two boards as one. This did however not affect the yield but lowered the production speed.

Another problem related to the 2D scanner was the fact that there was a need to take a production report of all scanned volumes after each package had been finished. Boards that should be run a second time where thereafter run again and not included into the report in order to not register a board twice and after that a new report for the next package was started. The operators working on the evening shifts sometimes did not succeed in doing this correctly which resulted in useless reports or reports that in one or another way had data that seemed not fully reliable. The idea with this whole thesis is to get first class or in other words reliable and trustworthy figures for the yield, so packages that gave any reason to doubt about the trustworthiness were excluded from the yield calculations. So were of course also all logs from which the boards came as well as lamellas produced from these packages. This meant that the yield for this batch in June is based solely on 20 out of the 28 packages. It is only the volumes and yield for those packages that can be seen in Figure 45.

![Diagram](image-url)

**Figure 45:** The flow of adaptive material produced in June 2008 (the second batch) in the Raimann line and its yield at certain points
Queuing errors did often occur between the scanner and the Raimann rip-saw. This meant that boards could be sawn in accordance with another board’s appearance. This did of course prove disastrous for the yield of those boards. This is one of the explanations to why the calculated output of useful volume is clearly higher than the one registered by the TM system. The system for removal of waste, after the Raimann, did also during this time remove many lamellas together with the waste. It is hard to estimate whether the manual saw operator managed to take care of all this material or if some of it just disappeared as waste. Figure 46 seems to indicate that the manual saw did take care of much material since as much as 31 % of the total production came from the manual saw. The total share of finger-joint is high, but could perhaps to a great extent be explained by the unbeneficial product mix that the Kostomuksha GB (glue board) factory had at this time and problems optimizing the production to this. It was earlier mentioned that the quality of the adaptive material was higher than for the first batch. This is clearly shown by the share of split lamellas which rose from just 4 % to 14 %.

![Figure 46: Share of different products for the second adaptive material batch](image)

Not just the quality of the output was up but also the yield on the output overall. As can be seen in Table 16, the yield rose distinctly to an overall yield of 22.7 %. The rise can mainly be attributed to two reasons. Firstly, the boards in pocket nr 40 in the saw-mill were removed from the yield calculations. Secondly and by far most importantly; the quality of the material was much higher and obvious drying defects were for instance rare. Working in the other direction was the problems with the asymmetrical edging which might have lowered the yield in the Raimann line slightly.

<table>
<thead>
<tr>
<th></th>
<th>Local yield</th>
<th>Overall yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw-mill yield</td>
<td>61.6%</td>
<td>61.6%</td>
</tr>
<tr>
<td>Raimann line yield</td>
<td>49.7%</td>
<td>30.6%</td>
</tr>
<tr>
<td>GB yield</td>
<td>36.9%</td>
<td>22.7%</td>
</tr>
</tbody>
</table>
5.1.4 The adaptive sawing in August

During the adaptive sawing in June it was a little bit of uncertainty when it comes to the incoming volume. To avoid any such uncertainties the idea was to gather exactly the amount of logs necessary for a batch separately on the log yard and then start sawing when there was just enough for one batch. For the adaptive sawing in August the logs for pocket 7 – 8 were, starting on the 21st of July, put on one side of the log sorting line and were not mixed with other logs. This meant that it in fact was the very logs measured by the scanner at the log sorting that entered the saw-mill and no others.

The production started on the second shift the 31st of July at 18.45. Very little, was however accomplished because of several reasons. There were problems setting up the pockets correctly and with the communication with the Millomatic. There were production stops lasting for 5 hours and 22 minutes and hence only 211 logs were sawn. When the sawing continued on the 1st of August the problems with long standstills continued. Many of them could not, per definition, be ascribed to the adaptive sawing itself, but a few certainly could. The sawing took about 18 working hours from which more than half was pure still stands.

There were continued problems with the kickers after the band saw and the Millomatic faced some stops probably linked to the fact that so many boards went through it. The Millomatic did this time edge symmetrically without any problems. The maintenance had successfully set up the so called servopos in the Millomatic which solved the problem. No matter whether the edging is working correctly or not it certainly can produce a lot of waste in Millomatic. A drawback when it comes to the “half-edging” settings was that the waste produced was hard for the waste cutter to deal with. This did partly have to do with the fact that the waste cutter had just gone through service and had not yet been adjusted properly to deal with this. This meant that the long waste pieces got stuck and occasionally caused jams as can be seen in Figure 47. This did in turn make it necessary to stop the production from time to time clean the resulting mess. This was probably the most striking problem are during the sawing of the third adaptive material batch. As long the edging waste is concentrated to one place, which it is in Kostomuksha, it will remain a problem with the adaptive sawing concept.

![Figure 47: Waste from edging causes a jam](image)

The increased edging and possibly the increased experience or rather patience of the operators, when dealing with the boards at the stick stackers, seemed to make this to much less of a bottle neck. Making a package in general took 10 to 20 minutes, which of course was a clear improvement compared to what it looked like when the first batch was sawn in March with times of over 40 minutes for the same task. This seems to indicate that increasing the edging is the solution to the problem with the bottle neck of overlapping unedged boards at the raw sorting
and at the sticker stacker. The edging did on the other hand, as mentioned, cause decreased production speed because of problems with the waste. These problems did not have to do with the yield itself but with production speed. The yield was severely lowered by the high amount of reject of boards in the raw sorting. This was probably due to unexpected poor quality in one party of logs that was sawn on the 1st of August. That as much as almost 9% of the boards, which can be seen in Table 17, were rejected at the raw sorting did lower the yield considerably. Normally, less than a third of this share would have gone as reject. Just 4 boards were lost into pocket nr 40, which adds weight to the impression that the yield in the saw-mill after all was accurate.

Table 17: The saw-mill yield for the adaptive sawing batch from July-August

<table>
<thead>
<tr>
<th>Volume incoming</th>
<th>143.8 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Volume without bark!)</td>
<td></td>
</tr>
<tr>
<td>Outsored</td>
<td>682</td>
</tr>
<tr>
<td></td>
<td>8.76%</td>
</tr>
<tr>
<td>Saw-mill out</td>
<td>74.0 m³</td>
</tr>
<tr>
<td>Saw-mill yield</td>
<td>51.5%</td>
</tr>
</tbody>
</table>

The drying went in accordance with the drying scheme from the second batch. At that time there were no worries that this drying was going to cause many problems. This would however prove to be the case. At this time the Raimann line was also running with material that could be classed as “adaptive side-boards” and there was in general an abundance of adaptive material. In combination with some production stops for the Raimann line, this delayed the production of much of the adaptive material. With the weather conditions, with high humidity in the air the dried packages standing and waiting outdoors quite soon became soaked and had a too high moisture content, which meant that they had to be dried again. Drying the same boards naturally puts them into great risk of getting many cracks they are put under much physical stress. A high amount of cracks was also what the result was of this. The adaptive material from the third batch was in production in the lamella production line from August to October, which is far from ideal. It is therefore not so easy to judge in exactly which manner the production in the glue board factory went for the batch as a whole, since it varied during the period. Even though the problems with waste jams in the “guillotine”, which takes care of waste from the Raimann line persisted, routines were found to decrease this problem slightly. The yield was nevertheless registered in a flawless manner in the Raimann line and can be seen in Figure 48.
As can be seen was the actual outcome in shape of lamellas and finger-joint much lower than what can be anticipated when looking at the figures given by the Control Logic scanner. This clearly affects the yield and has much to do with the problems with cracks. Very much material simply had too many cracks for it to be worthwhile making finger-joint or shorter lamellas from it. This was even more apparent when the operator at the manual saw was looking at the lamellas more carefully. The result was that the operator rightfully rejected lamellas and that the output from the manual saw became as low as 14 % of the total volume produced, as can be seen in Figure 49. This remarkably low share was also caused by an increased tendency by the operators to throw up lamellas onto the conveyor and take them through the Wood eye scanner and the TM together with the main flow, rather than cutting it up at the manual saw. That the share of split lamellas dropped to half compared to the second batch can largely be attributed to cracks and other quality issues such as colour defects because of the second drying.

Figure 48: The flow of adaptive material produced in august 2008 (the third batch) in the Raimann line and its yield at certain points
The yield did then consequently not get as high as for the preceding batch and as can be seen in Table 18. 17.6 % is a low figure but under ideal production circumstances would probably a much higher yield have been achieved.

Table 18: The yield for the third adaptive batch in brief with the yield for the respective part to the left and to the right the yield outgoing from log

<table>
<thead>
<tr>
<th></th>
<th>Local yield</th>
<th>Overall yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw-mill yield</td>
<td>51.5%</td>
<td>51.5%</td>
</tr>
<tr>
<td>Raimann line yield</td>
<td>45.9%</td>
<td>23.6%</td>
</tr>
<tr>
<td>GB yield</td>
<td>34.2%</td>
<td>17.6%</td>
</tr>
</tbody>
</table>

5.1.5 The adaptive sawing in October
The adaptive sawing of the fourth batch was taken out on the 13th and 14th of October. That the staff in the saw-mill now had much more experience than during previous runs was evident. During the autumn the saw-mill had successfully done experiments with the edging when sawing so called adaptive side boards and decreased the edging to a minimum, i.e. in theory multiples of the 46 mm lamella width. This had showed clear positive effects on the production speed. In order to get boards suitable for simulation it was however decided that the old “half-edging” settings should be used once again during the adaptive sawing in October. This meant that a maximum of 2 meters on each board should be allowed to be edged.

How to get this edging working, but still remain a decent production speed, was in focus and it was attempted to edge boards in the so called Edgar equipment in another part of the saw-mill. The idea was, that it would take care of the boards in the same way as the Millomatic, but this did not completely succeed and hence the edging had to rely on the Millomatic solely. In the future it will probably be possible to use the Edgar as well, and then the production speed can clearly be increased. At last, it was possible to get reports from the Millomatic and how many boards it let through and how many were rejected. This meant that it now was easier than ever before to follow the yield and the figures, hopefully, were more correct than ever. In a way did however temporary problems with the Millomatic make the statistics a bit deceitful, since
something like 170 boards out of the 235 listed in Table 19 normally should not have been rejected by the Millomatic if it had not been for a temporary error. For some time the error caused all boards passing through to be rejected by the Millomatic, which in most cases was evidently wrong.

Table 19: The saw-mill yield for the adaptive sawing batch from October

<table>
<thead>
<tr>
<th>Volume incoming</th>
<th>165.1 m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Volume without bark!)</td>
<td></td>
</tr>
<tr>
<td>Rejected by the Millomatic</td>
<td>235 pieces</td>
</tr>
<tr>
<td>Outsorted at the raw sorting</td>
<td>154</td>
</tr>
<tr>
<td><strong>Outgoing volume</strong></td>
<td><strong>Saw-mill yield</strong></td>
</tr>
<tr>
<td>74.6 m³</td>
<td>45.17%</td>
</tr>
</tbody>
</table>

During the 16 hours, the sawing of the batch, took, the edging did again get asymmetrical, which despite attempts to reset the Millomatic was not possible to solve completely. This meant that some of the boards in this batch as well did not become symmetrically edged. This was of course not desired. What in fact was desired by the glue board factory was different length of packages which also was achieved. There were done two different types of packages, a longer and a shorter type, which both took about the same time to put stickers in, in average 24 – 25 minutes. Still, this did in fact not prove to be a real bottle neck since the pockets did not get full in the same pace as packages were finished. This actually meant that the operator at the stick stacker had to wait for some time before being able to start with the next package.

The drying of the packages in the chamber kiln went according to the same schedule as the preceding batches and took 90 hours. No special problems were reported and the material could not be said to be of bad quality. In the sense of gathering data with high reliability, this was with no doubt, the batch that was most successful. This was even more evident in the glue board factory than in the saw-mill. The reports were taken perfectly correct after each package and there is no real reason to put any disbelief to the figures presented in Figure 50.
Even though the product mix in Kostomuksha had begun to change and hence the possibilities to get a smaller share of finger-joint had gone up, the share did, as Figure 51 shows, still remain as high as at 34%.
When then looking at the overall picture of the yield in Table 20, it can be seen that the yield lies as low as 18.5 % from log to glue board. With the Millomatic falsely not rejecting as much as was the case this time, the saw-mill yield would instead had ended up at an estimated 46.5 %. A saw-mill yield like that would in turn have rendered an overall yield of about 19 %.

Table 20: The yield for the fourth adaptive batch in brief with the yield for the respective part to the left and to the right the yield outgoing from log

<table>
<thead>
<tr>
<th></th>
<th>Local yield</th>
<th>Overall yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw-mill yield</td>
<td>45.17%</td>
<td>45.17%</td>
</tr>
<tr>
<td>Raimann line yield</td>
<td>55.07%</td>
<td>24.88%</td>
</tr>
<tr>
<td>GB yield</td>
<td>40.97%</td>
<td>18.51%</td>
</tr>
</tbody>
</table>

5.2 Conclusions from the adaptive sawing of the class 135 – 148 mm

As the adaptive sawing in October was the final batch it is on its place to summarize the findings. These may be divided into purely production related, and purely yield related. Even though production related issues, for sure in many cases, do affect yield, it might be more convenient to do this way. Problems that long ago have been solved and are unlikely to reappear will not be listed here.

5.2.1 Main problems in the saw-mill

The most obvious problems that were observed during the sawing of the batches with adaptive material were the following things:

- The kickers directly after the band saw – when kicking down boards on the conveyors the kickers have difficulties working correctly
- The waste – taking care of the waste, that results from the edging can cause many and sometimes long stops in the production. When the edge-pieces that are cut in the Millomatic edger, shall be taken care of, and chopped to chips pieces of waste tend to get stuck in the chipper and the production has to be halted, in order for the operators to have
time to clean it up. Otherwise a complete jamming of the cutter of the wane-pieces on the first floor in the saw-mill, would result. With the settings for special edging that have been created specially for edging of adaptive boards in Kostomuksha, this problem is significant. The waste consists of quite thin pieces, which are easily twisted and get stuck in the in-feed. To get an idea of what this means in reality taking a look at Figure 47 helps.

- A problem, which mainly causes lower production speed, is the fact that the boards, especially before the sticker-stacker go on top of each other and overlap. This means a lot of extra handling for the operator of the stacking machine.
- Slower raw sorting because of overlapping of boards.

As can be seen, many of the problems were connected to the edging which is a key part of the adaptive sawing concept. However, many of them will probably at least partly be solved when all lamella widths that are to be used in the glue board factory have been decided. The edging will then be optimized in accordance with that and as much as possible will be edged down to a multiple of a lamella width. In general, there is one simple rule for edging vs. production speed and handling problems. More edging - less problems. The ideal would be to edge as much as possible without causing the raw sorting or stick stacker to become bottle necks. If the Millomatic gets help by identical equipment like the Edgar and thus the production speed would nearly be doubled, bottle necks later in the material flow would be almost inevitable. This is however probably one of the few drawbacks one has to live with when it comes to the adaptive sawing concept.

5.2.2 Main problems in the Raimann line

Many of the main problems in the glue board factory with the adaptive sawing concept were solved at least partly, but the following problems that were observed during the production 2008 deserved to be mentioned:

- Dealing with waste seems likely to be a continued problem. The waste “guillotine” is somewhat under dimensioned to deal with all the waste produced. To avoid stops this requires much extra attention and work from operators.
- As yet, the waste remover after the Raimann rip saw is not working perfectly, which means that some good adaptive material will be pushed together with the waste. To avoid this from affecting the yield requires extra work from an operator and can otherwise also cause production stops.
- Queuing problems both before and after the 2D scanner, which creates a need to run the same boards more than once, which gives a slower speed. This problem became smaller as the sensors were set up better.
- One problem with the adaptive sawing, when it comes to using logs with a diameter as small as 135 – 148 mm, is that the outcoming volumes inevitably get fairly small. This also means that a whole line, like the Raimann line is running but actually producing fairly little since its raw material consists of narrow boards which are used one by one. The produced volume per hour therefore gets quite low compared to the traditional lamella production line.
5.3 Test of adaptive sawing for a diameter of 110 – 120 mm

The adaptive sawing had now thoroughly been tested for the diameter class of 135 – 148 mm in several batches. One could of course continue to gather data eternally, but somewhere has to be the end point. It was time to see whether it was beneficial with adaptive sawing for other classes as well, not just the same. Changes on the world raw material market, also meant that the idea to produce furniture out of what can be classed as pulp wood came up. It was no longer lucrative for Swedwood to try to sell pulpwood on the open market. A better idea would therefore be to try to use pulpwood on the own site as raw material. A diameter class that hopefully, would be possible to saw in the saw-mill, and that earlier had been considered being of no immediate use for glue board production, was the diameter class 110 – 120 mm. The idea was to cut this class in the same manner as the class 135 – 148 mm, and to get a figure on the yield from log to ready glue board. This yield would later form the basis for a decision on whether it was economically reasonable to use pulpwood in general as raw material for furniture production within Swedwood. Since this decision is of strategic importance, and it might be necessary with follow up tests with other diameter classes are the process and all its details described thoroughly here.

5.3.1 Manual measurement of logs

In order to get as good and reliable figures for the incoming volume as possible and to find logs of the desired diameter class, it was decided to measure the logs manually and from these measurements later on calculate the yield. During the first day, 27th of October it took some time to make it fully clear for everyone involved, what to measure and how to work in the most efficient way. Since it soon turned out, that very few of the provided logs fitted in to the decided diameter class of 110 – 120 mm, it took time and effort just to find these logs. The testing team in the log yard consisted of six persons including the author. There was a huge pile of logs, from which the driver from time to time picked out a number of logs and put in the “measurement yard” next to the pile. Three persons were handling the logs and made a first measurement with a not too trustworthy, old calliper. When a log that probably had right diameter was found it was handed over to three other persons in the team, who made two measurements in the middle, in the bottom and at the top. This was usually conducted by a measuring “team” where two persons did the measuring and a third person noted the measurements and supervised the measuring person. Such a team in action can be seen in Figure 52. In most cases the author had this position. Usually, first of all, a first top measurement was done in order to check if the log actually fitted in the correct diameter class. Since half of the work force was occupied with just identifying logs of the right log class it was decided that the pile with pulp wood should be run through the log sorting in order to identify the logs that would fit into the defined log class if 110 – 120 mm. This was necessary since something like 10 – 15 % of the logs fitted into that class.
Figure 52: A measuring team measuring pulpwood. In the background logs that did not fit into the decided diameter class can be seen.

On the third day of measurement this proved valuable as it was now possible to pick out logs with the right diameter much quicker. One extra measurement instrument was acquired from the saw-mill, where it usually is used for checking that the thickness of the boards after the cutting in the band saw is correct. This meant that it was possible to have two measurement teams at the same time measuring accurately with callipers. A much higher pace could therefore be kept. On the third day the team consequently ran out of logs at the end of the day. The forest department was aware of this, but just had not had the possibility to get logs to the log yard earlier. The main reason for that was mainly that the forest roads were terrible because of mud, which resulted from the weather conditions. The delay of the logs from the forest meant that much time was lost on the Thursday. The logs that arrived from the forest in the evening before and in the morning had to be sorted in the log sorting before being hand measured in order to avoid too much handling. This took longer time than expected, which meant that not much time could be put on the measuring. There were simply not enough suitable logs to measure.

More logs were then sorted in the log sorting in the evening and in the morning of the fifth day there were more than enough logs to reach the in advance decided 600 pieces. 500 pieces were, as stated in Figure 53, aimed for the adaptive cutting and another 50 for cutting in a more traditional way. Usually such small diameters are not cut, therefore it was hard to find a sawing pattern that fitted for this “traditional” sawing, but so was eventually done in shape of 2 boards of 38x75 mm. The 550 logs were all measured 2 times in the top, two times at the bottom and exactly in the middle two times as well. The measurements were done perpendicular to each other, in order to compensate for the fact that few logs are completely round. The length was of course also measured and at the same time the middle diameter was measured in order to be sure that it was really measured in the middle. In case of clear, big knots or other clearly visible irregularities of the surface the diameter measurement was done next to the irregularity with the aim of assuring that the diameter measurements just were fair.
During the measurement logs with an average diameter of 110 to 120 mm were accepted, others were rejected and were put aside. That meant that an approximate of 15% of the logs that the forest department brought fitted the requirements. The measurement was done without bark and the measuring team after each measurement subtracted an approximately the number of mm that the bark consisted of. Naturally, the bark on pine varies in thickness depending on from which part of the tree the log is taken and which individual tree it is taken from. The thickness of the bark was mainly estimated just by looking at it and estimating the thickness based on that. This does of course mean, that one or another log could have been given the wrong bark thickness. In order to avoid this, measurement of the actual bark thickness were done on a regular basis.

About the logs can in general be said that they came from both the bottom end of trees and the middle part of the tree. The logs were cut in September in forests rented by Swedwood. During September and October there was no real warm period that, in any way, could have caused biological threats to thrive in the material and the logs could according to the forest department by all means be described as “fresh” wood and most likely without any defects. Some of the ends of the logs were not completely sharp cut. For one thing this could affect the volume calculations slightly if not correct measurement of the length was done and for instance the length was measured on the longest part of the log. To avoid this and other side effects the top and bottom ends were in some cases sawn off. This can be seen in Figure 54. This was primarily done to make it possible to write the correct number on each log in the both ends of the log. The logs were numbered both in the top and in the bottom end. A more reliable length measurement came as a positive side effect of this.
The logs in the test had according the manual measurement an average top diameter of 115 mm and the diameter deviation was 2.82. The diameter distribution can be seen in Figure 55 and what could be noted is that if the average diameter of the two diameter measurements was rounded upwards when it was for instance 114.5. Since all diameter figures are in whole mm this gives a little bias, but does not affect the overall picture.

![Top diameter distribution](image)

**Figure 55: Diameter distribution of the pulpwood logs in the test batch**

Of some interest might also be to see how the volume varies between the logs in the batch. The fact that there were both logs from the top part of the trees and bottom logs of course influence the shape of the logs. What one indirectly can read out from the volume distribution seen in Figure 56 of the logs is that some logs were almost cylindrical and hence had a small volume and other logs were much more conical and therefore had a much bigger volume. Their top diameter was small enough to fit into the diameter class, but the rest of the log might have a much, much bigger diameter.
5.3.2 Taking the logs through the log sorting

Problems with logs of the diameter 110 – 120 mm and a length of about 3.2 meters exist already at the log sorting. Because of the size of the logs they have, according to the log sorting operators, a tendency to jump and bump and make the log sorting having more production stops than usual. This was noticed already when the logs coming from the forest department were sorted, even though as earlier mentioned there was just a small proportion that fitted into the demands on the diameter. The overwhelming part of the logs that did not fit the diameter specifications had a bigger diameter than the desired. In spite of that, problems caused by the size of the logs, could be noticed already during the first sorting, which indicate that it is mainly the length that is the problem in the log sorting. It should however be pointed out, that this problem in itself, may not be so serious but means some extra work for the drivers to gather the logs in a proper order. Another aspect of this problem is, if it is decided that logs of this size actually will be a new log class for the saw-mill to saw, the logs aimed for that pocket will probably have a tendency to bump into the surrounding pockets and areas. In the long run that means that a not insignificant amount of logs can be cut with a suboptimal posting. This can at least partly be avoided if the logs were longer. Another negative effect of running logs as short as around 3.2 m through the log sorting is that the logs can more or less fall down in the gap between the conveyor parts. This means a few extra stops per shift just because of the sheer size of the logs. One such can be viewed in Figure 57.
The problems connected with running logs through the log sorting could be observed already during the first sorting to get logs to measure manually. After finishing manual measuring the 600 logs were taken through the log sorting in order to turn them right and to get a view of what the scanner says about the volume of the logs. Similar, or even worse problems with production stops, could be observed at that time. The logs were run in the portions of 50, 50 and 500. First the 500 logs were run through and then another 50 and yet another 50 logs. Of the 500 logs one (log nr 368) was cracked when it fell from the conveyor in the log sorting. Two other logs were to be removed because they were a bit crooked. This was number 211 and 340. Since the sawmill was in a bit of a hurry to start sawing there was however not time to remove log nr 211 in the morning before starting the sawing. This means that out of the 500 logs there were 498 pieces that were to be sawn as the major part of the test.

The figures from the log sorting gave a different picture of the volume of the logs than the manual measurement. If one first of all actually looks at the volumes that were received from the manual measurements, then there is a small difference between the volumes calculated based on the middle diameter and the volumes calculated with the top-bottom-formula from the Swedish agency for log measurement (Virkesmätningsrådet, 2000). This volume was calculated to 20.5 m$^3$. If one instead chooses to calculate the volume based on the diameter in the middle of the log a total volume for the 547 logs in the test batch of 20.2 m$^3$ is received. This can be seen in Table 21. The volume given in m$^3$top in the two following tables is the volume calculated based on the top diameter of the log and the on the length of the log, which then gives a cylinder from which one gets a volume in m$^3$top.

### Table 21: The volumes based on the manual measurements

<table>
<thead>
<tr>
<th>pcs</th>
<th>Volume</th>
<th>m$^3$to</th>
</tr>
</thead>
<tbody>
<tr>
<td>547</td>
<td>20,2</td>
<td>16,6</td>
</tr>
</tbody>
</table>

If one then moves on the see what the log sorting gave in shape of volumes for the very same logs it turns out to be an almost remarkable difference. The volumes are about 24 % bigger than the volumes calculated based on the manual measurements. That there is a difference is not so remarkable since the physical volumes of the log sorting are including bark and the manual measurement was done without bark. This does naturally far from explain the whole difference, but possibly at the most a third of the difference.
Table 22: Volumes for the test batch logs according to the log sorting Rema scanner

<table>
<thead>
<tr>
<th>pcs</th>
<th>Physical volume</th>
<th>m³to</th>
</tr>
</thead>
<tbody>
<tr>
<td>547</td>
<td>25,1</td>
<td>18,0</td>
</tr>
</tbody>
</table>

If one then puts the volumes next to each other to get a better picture of the differences, then it looks like in Figure 58. The blue volumes are the ones that the log sorting gave and the dark purple ones calculated from manual measurements.

5.3.3 The sawing on the 1st of November

The sawing was scheduled to the first of November and the idea was that all of the 600 logs should be sawn and that they hopefully also should become packages. This did, however, not be the case. First of all it took some hours to saw the remaining logs from the preceding log class, which had a different posting. Next, the idea was to saw 50 logs with a different pattern than adaptive sawing. That did, however, not work since it immediately turned out that the reducer could not be set up to less than 86 mm. This meant that it was impossible to saw the planned 38 times 75 mm boards. It was therefore quite quickly decided that there would be no cutting with such a sawing pattern. Instead everything should be sawn adaptive. First 19 logs were planned to be used to set up for the first sawing pattern. As it already after the three first logs was clear that it was not possible to saw with the wanted sawing pattern it was decided that the remaining 16 pieces should be used for setting up the line and preparing for the adaptive sawing. This was done and it soon turned out that it was not possible to get exactly the desired thickness. The boards became much thicker than wanted. Instead of an intended 24 mm +2 and -0 mm which usually means that the boards are sawn with a thickness of 25 mm with a deviation of 1 mm up or down or possibly about over 24 mm, the boards got a thickness of around 27 mm. All three boards were of about that thickness. The reason for this was again that the reducer could not be set up to less than 86 mm. This meant that with an estimated thickness of 3 mm of the sawing blades it remains a width of 80 mm that can be sawn into boards. 80 mm divided into 3 means 26.67 mm thickness for each of the three boards. About 26.67 mm was also approximately the thickness that was received.

In the sense of what is required for the Ledinek planer to work properly the thickness is according to Andersen (1/11) no real problem at all. However, the author would like to draw the readers’ attention to the lack of possibility that the saw with the exactly desired thickness will
notably affect the total yield in the end. One might of course ask in what way that could affect
the yield. The reason for that is actually quite simple. No matter if the raw, wet thickness of the
boards is almost as much as 27 or as little as 24 mm the boards will sooner or later anyway be
planed down to 19.8 mm in thickness. This means that about 2 mm of “good” thickness is planed
away in wane if the thickness is 27 instead of 25 mm in wet thickness. This might not be so bad
one can be inclined to think – the two other boards from the sides of the log are of the same
thickness and that would then imply that there is no real loss of material. That is however not the
case. This might be best explained in pictures. The log to the right in Figure 59

![Figure 59: Postings of a 110 mm log with the 26.67 mm thick boards to the left and the log to the right with the 24 mm thick boards](image)

If the centre board is thicker than needed it means that “good wood” in the end becomes dust
instead of lamellas, since the board nevertheless is planed down to 19.8 mm thickness. The parts
marked red in Figure 60 represent the “good wood”. The two side boards are both moved a little
to the sides, which mean that they get more wane and more unusable material. The side boards
are in this case both moved roughly one mm to each side, which means that for a width of the log
of let us say 120 mm, means that about 0.6 litres of wood is lost per log. For 497 logs 0.079 m³ is
lost due to this.
The problems with the reducer are of mechanical nature. This means that there are no settings that can make the sides of the reducer be moved closer than 86 mm from each other. There will always be at least a centre-piece of at least 86 mm left in the middle. This is one of the reasons why one cannot say that the saw line in Kostomuksha can not deal with really small logs in an optimal way. This meant that on the 1st of November that the first 50 actual test logs which were meant to be sawn with an alternative posting instead were sawn with adaptive. One can say that the sawing itself went without bigger problems. What can be noted is, that much more frequently than for bigger logs, is that two logs come at the same time to the reducer and therefore the conveyor has to be moved backwards or sometimes a log needs to be pushed by hand to solve this problem. Since these logs are so small it is not so hard to do this, but of course still takes a little time. A “mild” variant of this problem can be seen in Figure 61.

Figure 60: The postings for the 26.67 and 24 mm boards put on top of each other

Figure 61: Two logs coming in almost at the same time, causing a possible short delay
One could perhaps say that the conveyor is not exactly adapted for such small diameters; there is without doubt room for two logs with a diameter of 110 mm on the conveyor. The sawing of the logs into three boards did, as mentioned, go well, apart from the fact that exactly the desired thickness not was received. However, after the band saw, there was one notable problem. The sawn boards fell down too quickly when they exit the band saw. The “gripping equipment” that normally should grip the boards was located too far away from the band saw to be able to grip such shorts board that were sawn this day. In most cases it worked ok, but in a few cases there were boards, which fell down immediately after the band saw and got stuck up into band saw. These had to be removed, and caused a slight loss of time in a few cases, but nothing that could be regarded to be of serious nature.

Once the boards had moved on after the sawing, they moved on to the edging equipment, the Millomatic. There were problems to set up the Millomatic equipment in a way so that there was no edging at all. This was the main problem during the sawing the first of November. The problem was to make the Millomatic not to reject narrow boards. Neither the software nor hardware had been prepared for this. Because of some settings it was impossible to make the program set up in a way that no boards were edged or rejected. The Millomatic continued to want to reject the narrower ones of the boards. Luckily, there were just boards from the test logs that were lost in this way. This meant that several hours were lost in attempts to set up the Millomatic in a way so that no edging was done, and that no boards were rejected without having a need for that. The solution turned out to be, that the function to reject boards was physically removed from the Millomatic itself. This meant that even though the software of the Millomatic gave an order that a board should be rejected it could not possibly be rejected since the conveyor that the boards move on, could not be moved to the side. This is the way the boards are rejected in the Millomatic. Even though the signal about rejecting the boards came, the action could not be performed. When this was finally solved and seemed to work in a proper way there was not much left of the working day. The 50 test logs were used up mainly for this purpose and the 50 logs that were meant to be sawn with another posting were also sawn, but with adaptive sawing.

According to Eriksson (1/11) it should probably be possible to set up the Millomatic software in such a way that it edges or does not edge at all boards that are as narrow, as the ones that are the result of an adaptive sawing of logs with a top-diameter of 110 – 120 mm. According to the production manager the reason for this was also found and that means that it should be possible to edge these narrow boards in a desired way. Some further testing and possibly assistance from Sweden it could work frictionless.

5.3.4 The sawing part two – 5th of November

Because of the simple fact that the Russian calendar looks the way it does the 2nd, 3rd and 4th of November were holidays at the saw-mill in Kostomuksha. The sawing started again on Wednesday the 5th. In general, the 50 logs that were sawn the 1st of November were sawn in a proper way. One thing was however missed. The operators at the raw sorting usually do cut away the top end of all boards, more or less no matter what the boards look like. They are told to do so in order to comply with the quality definitions given by the glue board factory. This can nevertheless be seen as unnecessary in the very case with boards from the small logs. An unnecessary big cutting away at the top ends means that material is lost that in fact not should be lost. This of course affects the yield in a negative way, even though it is marginal. Therefore it was decided that when the 498 logs were sawn, the boards resulting from the sawing should in general not be trimmed in any way. The exception from that rule was of course the cases when it was obvious that the top ends could not be used for anything useful, when for instance the end of the boards were covered with a rounded surface and wane. In that case it is of course not possible to make any lamellas at all from that part of the board and then it is better to cut it away.
immediately. It must also be noted that the raw sorting and its pockets were set up in such a way that it was not possible for any boards to be lost. The hooks that tip down boards into their pockets were simply locked already after the first pocket, which usually just contains rejected boards. This meant that no boards at all ended up in completely wrong pockets. Instead they all ended up in the very first pocket, no matter if they should end up there as if they usually had been sorted as reject or if they were heading for their “right” pocket. In the system pockets were set up more or less as usual which meant that the boards were aimed for a pocket, which was set up to take boards with the fitting parameters. The boards could however not reach these pockets and instead all fell down into the very first pocket together with the rejected boards. In short, all boards ended up in one pocket.

The adaptive sawing of the remaining 498 logs started in the morning of the 5th of November. Although it was assured that the very same settings were to be still working as on the 1st this turned out not to be completely correct. Although nothing really had been changed, almost immediately two boards were rejected by the Millomatic. These boards of course needed to be counted and so was done throughout the shift. All in all 7 boards were rejected this way and an additional 3 were rejected since they were deemed as completely useless. One can say that the sawing on the 5th initially went quite well. The problems that were observed were, besides from the ones earlier mentioned, at least initially small. Much more often than for other logs with a bigger diameter two of the small logs came together on the conveyor and caused jams before the reducer and on other places. This can be seen as a minor problem, it did take down the speed on the saw-mill line since the operators frequently had to move the whole conveyor backwards and try to get just one log through. These minor problems were observed after the debarking machine and at the infeed to the saw-mill. When logs had entered the saw-mill and were heading for the band saw there was another problem for logs of this size. The log turning machinery was not able to turn logs properly. It had frequent problems when dealing with logs with this type of diameter. It was simply not possible to turn logs that have a diameter of less than 110 mm.

This problem, which is directly linked to the small diameter, is maybe a minor problem in that part of the saw line can however have serious implications earlier in the saw line. When logs enter the debarking machine the very size of them can have several effects. Before the sawing there was according to the maintenance staff a little fears that the debarking machine could not deal with logs shorter than 3 meters. Apparently one could say that this does not precisely seem to be the case since logs slightly shorter than 3 meters actually could be run through the debarking machinery. Initially there was therefore hope that the debarking machine would not cause much problem at all when it came to cutting these very small logs. That did however soon turn out to be false. After just a few hours sawing on the 5th of November the chain for the conveyor that remove bark from the debarking machine broke. This was most likely a result of the fact that such short logs with such a small diameter first of all easily can be damaged by the driver when he gathers the logs with the gripping claws and moves them. Such an action can be seen in Figure 62.
When one such damaged log comes to the debarking machine it is likely to completely crack and even split in two. This was according to the production manager what happened during the sawing the 5th. A part of the log then went down and destroyed the chain that moves the conveyor of bark that is debarked. It should be noted that this chain is of the stronger type, a so called M 160. Nevertheless it broke. It is plausible that this will happen again if logs of a similar size are sawn in the future. A way to make this problem smaller would be to have longer logs. That could help a bit. The risk for that the driver continues to damage logs would of course still persist and damaged logs can continue to cause problems in the debarking machine. These might not be as serious as if the logs had been short.

The replacement of the chain caused a standstill for almost 8 hours and first in the evening shift the sawing could start when new chains were put on place. The second part of the adaptive sawing was started 18.20 and went relatively smooth and was finished 19.55. Two boards which were cracked on the middle were discovered. The cracks had become worse and worse and eventually the boards split when the boards were unloaded from the pocket. It seemed plausible that these boards came from the very same log and that the log had been damaged by the driver when he gathered and loaded the logs in the log yard. This is also according to the production manager the most likely explanation. The thinner the logs, the greater the risk that the logs are damaged by the gripping claws without the driver even noticing anything.

One more thing that was noted during the sawing was that there were some minor problems with overlapping at the raw sorting. Overlapping has often been observed during the earlier adaptive sawing in the saw-mill line. One could say that there is a covariance between the likeliness for overlapping and narrowness of the boards. The narrower the boards the more problems can occur. The amount of wane and then consequently how much edging that is done also affects this phenomenon in a clear way. The less edging that is done on the boards the more problems with overlapping occur. When this then sums up for extremely narrow boards that were not edged at all, it means that a lot of problems with the boards in shape of overlapping could be expected. One should however not exaggerate the importance of this problem. The overlapping did this time just mean some extra handling at the raw sorting. Luckily the boards were not taken to the sticker-stacker this time. If they had been there would have been much extra handling for the operator standing there. The boards would have overlapped and slid on top of each other causing a much lower speed when making one package. Instead packages were stacked manually. Therefore it was not possible to observe exactly how big problems the boards would
have caused, but based on observations on adaptive sawing of logs from the diameter class 135 - 148 mm it is not unlikely that a package would have taken 20 – 30 minutes to make, compared to a “normal” package that can be put together in around 8 minutes. Since the boards are so narrow they will most likely overlap each other and cause much extra handling. This was, as mentioned, observed already in the raw sorting in a smaller scale. However, since a new sticker-stacker will be bought and installed, this will not be a problem at all.

The boards that resulted from the first sawing with the first 50 logs on the 1st of November were temporarily stored outdoors under the roof near the kilns. The boards that resulted from the sawing of the 497 logs were manually sticker-stacked. The packages were of about 420 cm length and had 10 stickers. The outer stickers in the packages were put on a distance of 5 cm from the end of the package. The inner stickers were put on a distance of 45 cm from each other. Before putting into packages the boards were numbered and the amount and the length of the cracks were measured. There were in general very few cracks. The first package was laid according to the authors instructions and this process can be viewed in Figure 63. For some obscure reason the same shift that put stickers so beautifully in the first shift put stickers in the stickers in the second package not even close to the directive. The package therefore had to be put apart and again stacked with stickers. After that, two more packages were stacked, which meant that in total four packages resulted from the sawing. In each package there were 364 pieces. 12 boards were left over and they were on the day after the sawing put into a package with the boards coming from the 50 logs.

![Figure 63: The first package is manually sticker-stacked](image)

What were then the actual results of the adaptive sawing of the small logs? The yield in the saw-mill ended as can be seen in Table 23 up at 51.8 %.

<table>
<thead>
<tr>
<th>Volume incoming</th>
<th>22.2 m³</th>
<th>(Volume without bark!)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outsored in saw-mill</td>
<td>23 pcs</td>
<td>0.69%</td>
</tr>
<tr>
<td>Outgoing volume</td>
<td>11.5 m³</td>
<td>Saw-mill yield</td>
</tr>
<tr>
<td>Saw-mill yield</td>
<td>51.8%</td>
<td></td>
</tr>
</tbody>
</table>

Table 23: The saw-mill yield for the adaptive sawing batch consisting of logs with a diameter of 110 to 120 mm
5.3.5 Problem matrix

The problems that occurred during the adaptive sawing can be synthesized into a problem matrix. This shows the problems that occurred and the severity of them. The reader should keep in mind that it is hard to accurately judge how problems should be weighed against each other. The following matrix is the result of the subjective opinion of the author and should be taken for what it is. Others may have different opinions on how to rate the same problems, and may then reach a different conclusion in the column “Implications”. The other columns should however not be disputed in the same manner since they are less subjective.

Matrix 1: Problems in the sawing line in Kostomuksha for sawing logs with the diameter of 110 - 120 mm

<table>
<thead>
<tr>
<th>Problem</th>
<th>Implications</th>
<th>Other comments</th>
<th>Solved if longer logs?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marginally slower log sorting</td>
<td>Notable</td>
<td>Logs can get stuck and are more likely to fall into another place than the correct pocket</td>
<td>Mostly, yes</td>
</tr>
<tr>
<td>Damage of logs at log sorting</td>
<td>Notable</td>
<td>Hard to avoid for small diameters</td>
<td>No</td>
</tr>
<tr>
<td>Problems in the debarking</td>
<td>Severe</td>
<td>Can cause very long production stops</td>
<td>Yes, to some extent</td>
</tr>
<tr>
<td>“Log positioner” problems</td>
<td>Marginal</td>
<td>Even smaller diameters is not a good idea</td>
<td>No</td>
</tr>
<tr>
<td>Several logs on the conveyor simultaneously</td>
<td>Marginal</td>
<td>Causes a slightly lower sawing speed</td>
<td>No</td>
</tr>
<tr>
<td>Reducer can not be set up to less than 86 mm</td>
<td>Notable</td>
<td>Causes a lower total yield by roughly 0.05 % - 0.1 %</td>
<td>No</td>
</tr>
<tr>
<td>Boards fall down too early after the band saw</td>
<td>Marginal</td>
<td>Can cause shorter stops</td>
<td>Yes, partly</td>
</tr>
<tr>
<td>Overlapping at the raw sorting</td>
<td>Marginal</td>
<td>Can make the raw sorting to more of a bottleneck</td>
<td>No</td>
</tr>
</tbody>
</table>

5.3.6 Technical issues on future sawing of pulpwood in the saw-mill

If the saw-mill in Kostomuksha was to saw logs with an even smaller diameter, i.e. pulpwood, this would inevitably lead to problems. The sawing of a diameter class like 110 – 120 mm was in itself on the borders of the possible. The most striking technical issue would be the debarking machine. It is certainly not designed for such small diameters but on the contrary intended for extra large diameters. The same goes partly for the Millomatic. It is not intended for boards narrower than 100 mm. The fixation arms that centre the boards can not grip boards narrower than 101 mm. It can not centre boards narrower than that, which then suggests that the only solution, for successfully sawing pulpwood with the Millomatic in the line, would be to turn off its rejecting function. It would otherwise automatically reject all boards narrower than 100 mm. Turning off the ability to reject and distort the communication between the Millomatic and its software would mean that very few boards are edged at all. This would in turn mean that the pulpwood adaptive material would be unedged, which could cause much extra handling and overlapping. The narrower an unedged board is - the harder is it to deal with it. If this way of
production still would be of interest, one way to increase the speed would be to use the second edging machine – the Edgar. (Eriksson, 27/11)

What also could be noted is, that it turned out to be possible to reduce the minimal width in the reducer before the band saw. It seems as if 84 and not 86 mm is the minimal width possible to set up. This does at least have a positive effect on the yield of class 110 – 120 mm. When margins are this small, one could also note that the saw blade of steel has different thickness depending on if it is winter or summer temperatures. The author usually used 3 mm for calculations, while the thickness usually lies at 2.7 mm and in the summer at 3.4 mm. This might sound highly marginal, but could still be worth mentioning.

5.3.7 Recommendations from saw-mill

The saw-mill manager (7/11) means that it would be preferable to have much longer logs if one were to avoid many of the problems that now happened a length of the log of at least 3.5 m would be necessary.

When looking at the problems that are connected with sawing logs of this size in the present sawing line in Kostomuksha the conclusion can according to The saw-mill manager (7/11) be drawn that it would be more suitable to saw this kind of material in a saw line specially built for small logs. Such sawing lines exist throughout Scandinavia and buying a second-hand sawing line could probably be done for a reasonable price in the current economical situation in Europe. The sawing line in Kostomuksha is not suitable for sawing logs with such a small diameter and the number of production hours that are put down for producing such a small volume can hardly be seen as economically beneficial in itself. If this, after all would be the case, then longer logs would be essential.

5.3.8 Yield for traditional sawing

If the same diameter class had been sawn with a more traditional sawing pattern, which in this case as for Swedwood is with a thickness of 50 mm, a completely different yield would have been the result. If the saw-mill in Kostomuksha had managed to saw the test batch logs frictionless with a traditional sawing pattern the result would have been a much lower yield. The only dimension that fits into these logs is 50x94 mm and if one was to saw just this one board then the yield according to Motuz (25/11) would be an estimated yield of just 32.9 %. One should however note that there is space in the log for more than just one board of 50x94 mm. As sideboards, one could possibly squeeze in two pieces of 19x75 mm boards. The sideboards would however get much wane, since they are on the limits of what there is room for. Nevertheless, theoretically a yield in the saw-mill of 47.8 % could then be received. With the same way of calculating in the very same software, a theoretical yield of 39.5 % was calculated for three 24x100 mm boards. This yield is however far from the truth since the software not exactly is adapted to adaptive sawing postings. Nevertheless the figures gives a little indication, that if there is a market for 19x75 mm boards then it might not then at least not in theory be much worse to saw logs with the diameter 110-120 mm in one piece of 50x94 mm and two pieces of 19x75 mm. This is however a highly theoretical way of reasoning, if it in reality is anywhere close to appropriate to saw this diameter in this fashion is highly questionable. First of all, one has to be aware of the fact, that all the 50x94 mm pieces would be centre pieces. Hence there would be enormous problems drying them without getting too much cracks. It is also likely that twisting, propeller-like shapes and all such kind of interesting geometrical phenomena would appear.
5.3.9 The drying process

A clear centre board is the result of sawing the logs this way, since the sawing pattern gives 3 boards. This means that the effect of drying is extra interesting to follow for the centre board. Both according to the author himself and the operators from the quality experts from the saw-mill’s dry sorting line that controlled the boards the quality of the boards can in general be said to be high. The amount of cracks is low and there is very little blue stain.

The stickers were, as earlier mentioned, put manually. The four and a half packages that resulted were after that put outdoors under the roof next to the kilns. The weather conditions gave during these days, no reason at all to worry about the effects on the material. There was almost no precipitation and the temperature was quite steady under 0 degrees. The packages were loaded into one of the chamber kilns on 8th of November. They were dried together with other adaptive material, mostly side boards.

The packages were dried until the 12th of November and the drying took 82 hours. The material then stayed in the kiln until the 14th, when they were brought to the glue board factory. There, the packages were stored in the cold storage until the 18th of November when tests started. After drying the moisture content was measured, and it was according to the kiln staff completely in order, even below 8 % for some of the measurements. The drying process went without any real problems. The only real problem was that the effect in the kiln was not high enough for the drying, to work completely perfect, during the middle part of drying. The supposed value for “dryness” was not reached for more than a day. This might, however, not have serious implications.

What later on, however, did turn out to have some implications was the shape of the boards, which in turn was an indirect result of the nature of the logs. Some of them had most likely been standing on a slope, with the wind blowing in from just one direction. Especially for younger trees, and their top parts, this can be a significant problem. This gives according to Esping (1988) reaction wood with different density and properties than normal wood. In some cases this can not so easily be detected on the logs if one does not examine them more closely. One could, in some cases see it on the shape of the logs and in other cases a good indication is if one can see a more
darkish tone of colour than usual on the wood. This means, that it is not realistic to expect, that one can sort out these logs in an effective fashion at the log sorting. Then one has to deal with the complications that this fact gives. To recapitulate what the raw material defects exactly can consist of for the test batch boards, then this could be summed up as a couple of problems. The first problem that is connected with the existence of reaction wood is the bent shape of the boards. Of one looks at one of these boards from above it has a “banana-like” shape. The quantity of these boards was however not huge and it is in general hard to evaluate how significant this problem is. Other problems that are more significant for lamellas from pulpwood, are also connected with geometrical properties. After the rip saw more lamellas than from other adaptive material batches are bent, have a propeller-like shape or are slightly twisted. However, these problems were mostly observed for the material that came from the very last package. Three of these boards can be seen in Figure 65. This package was only half-sized, which meant that they could not be put under enough pressure, since the package simply was not placed high enough. There were very few lamellas like this, which came from the packages that had been stored lower in the kiln, but some more from the top package of the four whole test packages.

![Three rejected boards](image)

Figure 65: Three rejected boards, of which the one at the bottom of the picture has a propeller-like shape

For packages with boards from pulpwood it is even more important than usual that they are put under sufficient pressure. Therefore, it could be a standard procedure never to put packages like these as the top package.

### 5.3.10 Lamella production

One of the packages was tested for amount and length of cracks, in the storage of the glue board factory. The results indicated that the increase of cracks was probably not big enough to make it worthwhile to continue testing all the packages in this manner. The way of evaluating the cracks may also have been slightly different, which became clear when comparing the figures from the measurement in the saw-mill, before drying and the measurements done after drying in the storage. Therefore, it was decided that it was not worth wasting time on measuring cracks from all five packages manually. Instead it was decided to rely on the scanner data to get a good picture of how many cracks resulted from the drying. According to Pedersen (11/11) the programs in the kilns were set up in such a way that cracks were to be expected. Until this problem has been solved, one could of course expect a lower yield than if the kilns had been working perfectly.

The amount of boards with cracks before drying was 4.71 %, which is low and indicates that the material was really fresh and recently cut. In the package that was checked more thoroughly, the
total length of the cracks increased by 73 % during the drying process. The boards that came from the centre part did not show any increased frequency of cracks compared to the sideboards.

On the 18th of November the first part of the test was taken out in the glue board factory. Two packages each containing 364 boards coming from the 497 logs were run through the Raimann line in the GB Factory in Kostomuksha. The first package took 2 hours and 12 minutes to get through the line. One could say that the operators initially had difficulties handling the material in a proper way. It was naturally the first time that the operators got into touch with a whole package with such narrow boards. The fact that the boards were not edged did naturally explain some of the problems before the Ledinek planer. The problems on the conveyors and in the feeding system before the planer can be divided into several. In a chronological order one could start with the first problem that occurs when the material has been brought in the Raimann line for lamella production is the tilt for the boards. For wide sideboards it usually works quite frictionless or at least without serious problems. For the test boards the problems were much worse than usual. The tilt was a bit shaky and the boards fell down in disorder and caused much extra handling for the operator on the Ledinek planer. Even when the boards had been put in some kind of order, they piled up and overlapped each other at the first sensor. Unedged boards with this small diameter will always cause extra handling and this is easily observed at this point. As one can see in Figure 66 the boards lie in a pile. For instance for normally edged sideboards the boards lie one after another and in general do not overlap.

![Figure 66: Pile of boards from the pulpwood piling up on the conveyor after the tilt](image)

The fact that the boards are so short, less than 3.3 m, also caused some problems in various places on the Raimann line. To decrease these problems, the speed in the Ledinek planer was set a bit lower. This meant that another smaller problem appeared. Since the speed in the conveyor that gives the infeed to the planer had a higher speed, boards occasionally went on top of each other, causing the operator having to stop now and then to drag out a board. During the test, there was constantly one operator watching the boards coming out of the planer and their movement towards the 2D scanner. The reason for this was that there was a need to make sure that not more than one board went through the scanner simultaneously. That would have caused queuing problems and errors in the statistics of the incoming material in the scanner. Even though the sensors, a week before the test, had been set up to be able to handle also very narrow boards it could happen quite often that boards were missed by the sensors. This did then have the effect that two boards could be run through the scanner at the same time which then caused an error. This was however a more rare phenomena than when a board was supposed to be loaded onto the conveyor to be taken through scanner and the sensors just did not notice that the board that lied after the just moved board is there and therefore lets it through too.
The flow of boards and later long lamellas can in analogy with the preceding batches be described in Figure 67.

Overall yield: 51.8%

Volume in

Volume out from Ledinek

11.50 m³

Ledinek planer
Planes the thickness down to 19,8 mm

9.90 m³

Raimann multi ripsaw

5.80 m³

Manual saw ("Reworks") producing lamellas and finger-joint

Overall yield: 26.1%

Yield in GB: 50.3 %

6.51 m³

TM & crosscut producing lamellas & finger-joint

Outgoing volume from TM and "Reworks" added together

5.78 m³

Figure 67: The flow of adaptive material, produced from 110 – 120 mm logs, in the Raimann line and its yield at certain points

As the attentive reader may have noted in Figure 45 the volumes are slightly illogical compared to previous batches. The registered incoming volume into the TM was higher than the calculated volume from the Raimann. This was, however, no real surprise since all material that this time was deemed to possibly could have been of use was taken into the TM. All long lamellas that fell down and normally were supposed to be taken care of by the manual saw were instead put back on the conveyors and passed through the Wood Eye and the TM together with the other material. Originally, the final outgoing volume from the TM, should in theory, not be much different from the theoretical volume calculated by the 2D scanner. This was now also finally the case since practically all material had been passed through the TM and just obvious waste had been removed before that. This also meant that nothing was produced at the manual saw this time and this did probably contribute partly to a drop in the share of finger-joint compared to the preceding batch. As can be seen in Figure 68 the share was just 19 %, which with the relatively
The high quality of the material in question of course should have been higher, but anyway was better than for earlier batches.

If one then summarizes the problems encountered during the production of the lamellas and the respective implications of the problems Matrix 2 is the result. Since longer logs were a strong recommendation from the saw-mill, the effect of such a measure is also listed.

Matrix 2: Problem matrix for adaptive material from 110 -120 mm logs in Raimann line

<table>
<thead>
<tr>
<th>Problem</th>
<th>Implications</th>
<th>Other comments</th>
<th>Solved if longer logs?</th>
</tr>
</thead>
</table>
| Uncontrolled sliding of boards from tilt and piling of boards at the hooks afterwards | Causes very much extra work for Ledinek operator | - When lamella widths are decided and edging is done accordingly, this problem decreases  
- Need for assistance from TM | No |
| Overlapping and piling at infeed before Ledinek planer | Causes much extra work for the Ledinek operator | - The lower speed of the Ledinek planer cause problem at the crossing  
- TM may have a solution | No |
| Queuing problems at the transfer between TM and 2D scanner | Causes shorter production stops | Need for more assistance from TM company | Yes, partly. Short boards have a tendency to “chase” each other |
| Sensor mistakes at Raimann infeed | Queuing errors before Raimann | Difficult to set up all sensors so that they can see all of these narrow boards, especially if edged | No |
Apart from the purely production related problems more directly possible problem areas related to the raw material were also detected. These did, however, as mentioned in Matrix 3 not prove to be of a too serious nature.

Matrix 3: Problem matrix for adaptive material from 110 -120 mm logs from a raw material point of view

<table>
<thead>
<tr>
<th>Raw material problems</th>
<th>Implications</th>
<th>Action to undertake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction wood in top logs cause “banana” and “propeller” shaped boards</td>
<td>Slightly lower yield and increased amount of reject</td>
<td>- Never put packages from small diameter logs as the top package in the kiln</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Try to have no free space at all between boards in packages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Try a slightly higher wet temperature in kiln</td>
</tr>
<tr>
<td>Less than 5 % cracks and an increase by 70 % during drying</td>
<td>Very marginal – in general good material</td>
<td>The material should be as fresh it was for this batch and start improving the drying process for adaptive material in general – almost no changes have been done since April</td>
</tr>
</tbody>
</table>

If one then moves on to look at what the yield was from this raw material, then Table 24 pretty much sums it all up.

Table 24: The yield for the adaptive batch in brief with the yield for the respective part to the left and to the right the yield outgoing from log

<table>
<thead>
<tr>
<th>Saw-mill yield</th>
<th>Local yield</th>
<th>Overall yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB yield</td>
<td>GB yield</td>
<td>GB yield</td>
</tr>
</tbody>
</table>

5.3.11 Material after TM

All material except finger-joint from the first test day was collected on pallets, marked and stored to check this material further. These lamellas were then later counted and one pallet with bulk lamellas with a length of 1706 mm, was chosen for further testing and was brought to the Kallosoe press for pressing of glue board. The test pallet consisted of 503 lamellas. As can be seen in Table 25, out of these lamellas 19 were outsorted before press. Three thirds of these were out sorted because of cracks.

Table 25: Outsorting of test pallet material of lamellas

<table>
<thead>
<tr>
<th>Nr of pcs</th>
<th>Outsorted lamellas</th>
<th>share</th>
</tr>
</thead>
<tbody>
<tr>
<td>503</td>
<td>19</td>
<td>3.8%</td>
</tr>
</tbody>
</table>

The remaining lamellas were glued together with two split lamellas on each outer side. These split lamellas came from other material and were of good quality. These lamellas should consequently not affect the amount of reject in the press. After the press 10 glued panels out of
44 were outsorted, which gives a share of 22.7%. The reader might here get the idea that this figure is fairly high. That is however not the case. According to statistics put together by the quality manager this is not an abnormal share at all. For November 2008, statistics in Kostomuksha for The Kallesoe press suggests that usually 21% of the boards are classed as second class because of various defects. If one then looks even closer at these numbers and picks out a batch of material of the same length as the test batch material, then it is evident that the statistics for this size do not differ from the overall statistics. The conclusion that can be drawn from Table 26 is that the test batch material from the pulpwood logs does not differ in any significant way at all in terms of quality. There is no real reason to believe that the yield from lamella to ready glue board would differ significantly for this material than for any other lamellas, which normally are in use in the Glue board factory. Even though the tested material is not such a big quantity it is not farfetched to draw such a conclusion since observations of the other pallets of lamellas from the test material gave no reason to fear that the test batch lamellas would be worse than normal lamellas.

### Table 26: The result of the gluing of the test batch material in the Kallesoe press

<table>
<thead>
<tr>
<th>Nr of glued panels</th>
<th>Outsorted</th>
<th>share</th>
<th>For reference material</th>
</tr>
</thead>
<tbody>
<tr>
<td>44</td>
<td>10</td>
<td>22.7%</td>
<td>20.9%</td>
</tr>
</tbody>
</table>

If one then looks a bit closer on what the reasons for the outsorting of the glue board were, then the contents can be displayed in Table 27. It is of course a bit ridiculous to present figures in percentages for such small numbers, but nevertheless it can be of interest. The share of panels rejected because of cracks is equivalent and most of the other defects can be put as almost equivalent to the share of delaminations.

### Table 27: Reasons for outsorting of glue board after Kallesoe press

<table>
<thead>
<tr>
<th>Reasons for outsorting</th>
<th>In % for test batch</th>
<th>Reference material</th>
</tr>
</thead>
<tbody>
<tr>
<td>cracks on the material</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>bad cut (edge to glue)</td>
<td>7%</td>
<td></td>
</tr>
<tr>
<td>bad glue</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>jumping lamellas (not thickness)</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td>jumping lamellas (trapeze)</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>delaminations</td>
<td></td>
<td>11%</td>
</tr>
<tr>
<td>Pull outs</td>
<td>2%</td>
<td></td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>22.7%</strong></td>
<td><strong>20.9%</strong></td>
</tr>
</tbody>
</table>
6 Optimization of lamella width

As figures for yield of the adaptive sawing batches have been calculated for the log class that was possible and an additional yield for a batch with a smaller diameter also was calculated, the first part of the purpose of this thesis is at least partly fulfilled. It is instead time to move on to look at how the yield can be increased. Earlier on in this report, the topic has just been looked upon briefly, and from another point of view, than the one that will be used now. The basis for the adaptive sawing idea is in its essence about how to use the given volume maximally. With the set line and the equipment available in the glue board factory, the natural way to do this is by looking at how to increase the area that is used from every board. The place where it is decided how much that will be cut out from each board, in shape of lamellas, is the Control Logic 2D scanner. The Wood eye scanner and its connected crosscut and the manual saw just try maximize the output of already given lamellas, which they always do, no matter the width of the lamellas. To raise the yield there is more a question of getting the daily optimization work to work out as good as possible and to have a product mix that makes it possible to take out as much as possible of the given lamellas. To take out as much as possible from the start raw material and hence the boards themselves to get these lamellas is best done when producing the lamellas that later on are cut. One way to raise the output is to change the width of the lamellas. This far, the only width for the lamellas, which has been used was 46 mm. That only one lamellas width is used does of course lower the yield since very few boards are exactly rectangular shaped width a width that is a multiple of 46 mm. This means that there will always be a certain part of the area that will be rejected as waste since it does not fit into an optimization with just 46 mm lamellas. To give the reader an idea of what this means in reality, it could be worthwhile taking a look at Figure 69, which shows the old example board with 46 mm lamellas marked and one of the areas that is missed because of the inflexibility with fixed lamella widths marked in purple. The natural solution to the problem with large areas which are lost as waste, would be to have several lamella widths to choose from. The lamella width of 46 mm has been chosen because it was deemed the most suitable and beneficial width based on previous experiences, on mainly other Swedwood sites.

![Figure 69: Our old example board with possible 46 mm lamellas marked](image)

Having just one lamella width means, however, as mentioned, a bit of inflexibility and having the possibility to have several lamella widths simultaneously would without doubt increase the yield. In order not to cause problems with mixing lamellas Andersen (15/9) recommended that there should be at least 4 mm in difference between each of the lamella widths. As the base for the lamella widths would the span 40 to 65 mm serve, since lamellas narrower than 40 mm were deemed likely to cause problems when it comes the handling. Lamellas wider than 65 mm are in
general a rare thing when gluing glue board and were not considered feasible. The exceptions were the widths of 73 and 80 mm, which were of interest to test, since there had been ideas that they sometime in the future would be used for some type of glue board.

The Raimann saw has 11 blades which in theory makes it possible for it to rip 10 long lamellas. The parts outside the outer blades are removed as waste and it is naturally just the parts that lie between two blades that can become lamellas. The blades can be set up with different distances to each other and it is this setup that decides which lamella widths that are possible to cut. The 2D scanner then optimizes how each board should be optimally positioned and ripped by these blades in accordance with how it has been set up with regards to which widths it is allowed to use and if these should be prioritized over each other. If the optimal combination of widths should be achieved, there should not be any widths prioritized over any other. This was also the case when working with simulating different lamella widths. Yes, in order to check the possible outcomes of combinations of lamella widths simulations were done. The simulations were done directly on the 2D scanner, which has software that makes it possible to store desired number of real boards as a test batch and then simulate outcome and yield for different kinds of combinations of lamella widths on this very batch. Boards are then virtually run through the scanner and it is possible to see the effect of new settings on every single board.

Before this was done was also a traditional linear programming optimization model created in Microsoft excel to get an idea of what could be expected and what would be the theoretically maximal yield. An excel yield is though in its nature very simple and can not handle such complex shapes such as boards and it is therefore presumed that the boards in this model have the shape of rectangles. The model was set up with all limitations that exist in reality. There was 4 mm between all different lamella widths and the lamella widths ranged from 46 to 65 mm. The resulting Excel model can be seen in Table 28.
Table 28: The Microsoft Excel model for different lamella widths, where the “variable values” are the ones that can be varied in order to reach an as possibly good solution

<table>
<thead>
<tr>
<th>Variables</th>
<th>Width A</th>
<th>Width B</th>
<th>Width C</th>
<th>Width D</th>
<th>Left side</th>
<th>Relation</th>
<th>Right side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective function</td>
<td>46</td>
<td>50</td>
<td>61</td>
<td>65</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Minimal width</td>
<td>1</td>
<td>46</td>
<td>&gt;=</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal width</td>
<td>1</td>
<td>50</td>
<td>&gt;=</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal width</td>
<td>1</td>
<td>61</td>
<td>&gt;=</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimal width</td>
<td>1</td>
<td>65</td>
<td>&gt;=</td>
<td>46</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Maximum width | 1 | 46 | <= | 65 |
| Maximum width | 1 | 50 | <= | 65 |
| Maximum width | 1 | 61 | <= | 65 |
| Maximum width | 1 | 65 | <= | 65 |

| Max difference | -1 | 1 | 4 | >= | 4 |
| Max difference | -1 | 1 | 11 | >= | 4 |
| Max difference | -1 | 1 | 4 | >= | 4 |
| Max difference | -1 | 1 | 4 | >= | 4 |
| Max difference | -1 | 1 | 15 | >= | 4 |

| Board width | 0 | 0 | 0 | 2 | 130 | <= | 135 |

| 1 | 46 | 0 | 0 | >= | 0 |
| 1 | 0 | >= | 0 |
| 1 | 0 | >= | 0 |

The model was then used in Microsoft Excel to reach optimal theoretical setups of lamella widths and their respective yield. The model with all its flaws could nonetheless still give some information that might be of interest when starting the real simulation. An idea of which lamella widths which were most suitable for the simulation was given. The model did also at least give information on how high a maximal yield could get. For a board width from 46 to 200 mm it could in theory look like in Figure 70.
Figure 70: Maximum theoretical yield for lamella production with different widths

What does then this graph tell us? It tells us that if we had a board with the width 46 mm it would equal a lamella of the width 46 mm and hence the yield would be 100 %. Since lamella widths from 50 to 65 mm also were included in the model a yield of 100 % can be expected for boards of exactly the same widths as them as well. The yield then drops since the board is wider than 65 mm and falls until there is room for two lamellas, i.e. two 46 mm lamellas. The yield then raises to 100 % and remains on a high level since it in theory is possible to find combinations of two or three lamellas that fit into a board perfectly. To be able to reach a high as yield as 100 % as in Figure 70 would however require boards that practically don’t exist and a more realistic maximal yield for the adaptive material that was present would be a bit lower. This yield, which is a theoretical yield that is calculated by the 2D scanner as a ratio between the volume coming out from the Ledinek planer and the volume expected to be produced as lamellas. It is this volume that in previous flow schemes has been labeled “Theoretical or calculated volume” like the one in Figure 71. It has during the first batches in general been somewhere in the span 62 % to 71 % using just the 46 mm lamella width.

Figure 71: Part of an earlier material flow scheme used as example

A slightly higher yield is natural to expect, when a simulation of several lamella widths is done. As high as something close to 100 % would obviously be absurd, but something like a bit over
70% in theoretical yield would not be too farfetched. This would then render something like the curve in Figure 72 for board widths of 46 to 200 mm.

![Yield](image)

**Figure 72: A purely theoretical yield, a more realistic version of the yield in Figure 71**

This yield may in itself not be so telling. A more understandable yield would be the overall yield, from log to glue board that is the consequence of this yield. If the figures from Figure 72 are used and put into for instance the yield calculations for the fourth batch the result is like in Figure 73. In the graph it appears as if the 20% - level would be some kind of upper limit, which in reality is not true at all, but it might according to this model to be hard to get a yield distinctly higher than this. The deep gap to the left in the graph shows the yield for board with a width of less than 99 mm; such narrow boards are in general not used, but are included as reference anyway.

![Overall yield](image)

**Figure 73: Theoretic and highly speculative overall yield based on the October batch figures and the first optimization model**
6.1.1 Simulations done on test packages

The above mentioned figures and yields were as mentioned highly artificial and calculated with Excel. Much less artificial, but nevertheless simulated values were received after simulating with the software in the Control Logic scanner. The scanner was set up with different arbors containing four different lamella widths. During the first 19 different setups were used. A test package, where all boards had gone through the scanner without problems was chosen as test material. The test package was then virtually run through the scanner board by board again and again for each setting and the software simulated how many lamellas of each size that would be produced. This did then also give the totally produced volume and consequently the yield. What is then seen as the yield? To recapitulate this quickly, the yield of a board as seen by the 2D scanner is roughly the parts marked yellow on the example board in Figure 74. The volume outgoing from this area is then calculated.

![Figure 74: Example board with the brown areas as wane and the reddish areas as areas which can not become lamellas. (Ingvarsson, 2005)](image)

For the first simulation with a package from the adaptive material batch from August with boards that had the average width of 122 mm, the yield originally for this very package was at 68.47 %. For the simulation setups the yield was raised to 74.5 % at the lowest to 76.06 % as the highest. There is, hence, quite a small difference between the two. The setup that this time gave the lowest output was the one with a lamella setup of 46-50-54-58, while the highest output was for the one with 46-55-60-65. Not a single lamella was produced with the width 65 mm. This gives a clear indication that three lamella widths seem to be enough. The average rip yield written in Table 29 of 0.85 means that 85 % of the board was calculated to belong to long lamellas to be cut. The reason to that the average rip yield was and usually is higher than the predicted material yield is that the rip yield includes the whole lamellas even though there might wane and defects that are not included in the predicted material yield.

<table>
<thead>
<tr>
<th>Average rip yield</th>
<th>0.85</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nr of 46 mm lamellas</td>
<td>135</td>
<td>44.3%</td>
</tr>
<tr>
<td>Nr of 55 mm lamellas</td>
<td>64</td>
<td>21.0%</td>
</tr>
<tr>
<td>Nr of 60 mm lamellas</td>
<td>106</td>
<td>34.8%</td>
</tr>
<tr>
<td>Nr of 65 mm lamellas</td>
<td>0</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Predicted material yield | 76.06%
The yield figure of 76.06 % might not in itself say the reader much more than, that it is a bit higher in comparison to what was foresaid in Figure 72 for the particular board width. When used as a part of the overall yield calculation it does however show the impact. As can be seen in Table 30, the overall yield increased from 17.8 % to 19.8 %, when using the additional lamella widths 55 and 60 mm instead of just 46 mm lamellas.

Table 30: The resulting simulation yield compared with the real yield to the right for the third adaptive sawing batch

<table>
<thead>
<tr>
<th></th>
<th>Simulation yield for 4 widths</th>
<th>For just 46 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw-mill yield</td>
<td>51.5%</td>
<td>51.5%</td>
</tr>
<tr>
<td>Simulation yield</td>
<td>76.06%</td>
<td>67.65%</td>
</tr>
<tr>
<td>Raimann line yield</td>
<td>51.6%</td>
<td>45.9%</td>
</tr>
<tr>
<td>GB yield</td>
<td>38.4%</td>
<td>34.2%</td>
</tr>
<tr>
<td>Overall yield</td>
<td>19.8%</td>
<td>17.6%</td>
</tr>
</tbody>
</table>

The next simulation was done on a full package from the fourth and last batch of boards from 135 – 148 mm logs with an average width of 128 mm. Since the simulation this time was done on a full package of 324 boards the reliability of the results was naturally higher. Simulations were done in a similar way as with the preceding test package. The difference compared to the preceding simulations was that 73 and 80 mm lamella widths also were included. This fact meant that many more simulations were done. The results were nevertheless not more positive than for the last batch. The simulations with the 73 and 80 mm lamella widths included, did not show any improvement compared to the other simulations and not a single lamella of these sizes was produced in the simulations. The best setup proved to be the very same as for the batch before. This time was, as can be seen in Table 31, actually some lamellas with 65 mm width produced. Since it was just 3 pieces the result as a whole does nevertheless strengthen the hypothesis that having 3 different lamella widths would be sufficient. The two spaces occupied with slots for 65 mm lamellas could instead be used for two more slots of any of the two other widths. Having for instance one 46 mm slot and one 55 mm there could possibly render even higher yield.

Table 31: The best simulation result for the fourth batch, produced in October

<table>
<thead>
<tr>
<th>Average rip yield</th>
<th>0.83</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nr of 46 mm lamellas</td>
<td>367</td>
<td>49.5%</td>
</tr>
<tr>
<td>Nr of 55 mm lamellas</td>
<td>166</td>
<td>22.4%</td>
</tr>
<tr>
<td>Nr of 60 mm lamellas</td>
<td>206</td>
<td>27.8%</td>
</tr>
<tr>
<td>Nr of 65 mm lamellas</td>
<td>3</td>
<td>0.4%</td>
</tr>
<tr>
<td>Predicted material yield</td>
<td>75.24%</td>
<td></td>
</tr>
</tbody>
</table>

The yield for this batch dropped slightly compared to the preceding batch and the impact on the overall yield was as can be viewed in Table 32 not as immense as on the previous batch.

102
Table 32: The resulting simulation yield compared with the real yield to the right for the fourth adaptive sawing batch

<table>
<thead>
<tr>
<th></th>
<th>Simulation yield for 4 widths</th>
<th>For just 46 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw-mill yield</td>
<td>45.2%</td>
<td>45.2%</td>
</tr>
<tr>
<td>Simulation yield</td>
<td>75.24%</td>
<td>69.77%</td>
</tr>
<tr>
<td>Raimann line yield</td>
<td>59.4%</td>
<td>55.1%</td>
</tr>
<tr>
<td>GB yield</td>
<td>44.2%</td>
<td>41.0%</td>
</tr>
<tr>
<td>Overall yield</td>
<td>20.0%</td>
<td>18.5%</td>
</tr>
</tbody>
</table>

The conclusions drawn from these simulations are the following:

- It is no point in using more than three lamella widths for adaptive material produced from logs with the diameter class 135 – 148 mm
- A raise in the overall yield of at least 7 % is likely, if the best three lamella widths are used
- The best arbour for the tested adaptive material appeared to be the one given with the setup seen in Figure 75. Theoretically it might be possible to raise the yield of this setup even further if more experimenting with the placement of the widths is done.

Figure 75: Lamella widths resulting from cutting with the arbour that gave the highest yield. The widths are proportional to the actual size

6.1.2 Simulation on pulpwood adaptive material

Simulations were also done on the material coming from the adaptive sawing in November of the logs with 110 – 120 mm diameter. A test package for simulation purpose was chosen and its boards had the average width of 100 mm. The simulations were done in a similar fashion as the earlier ones. Simulations with all the earlier widths including 73 and 80 mm were included as was also this time the width 40 mm. For the simulations done without the 40 mm width available did not surprisingly the same setup as for the other simulations prove to be the best.

Table 33: The best simulation result for the pulpwood adaptive material when 40 mm lamellas were not used

<table>
<thead>
<tr>
<th>Average rip yield</th>
<th>0.79</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nr of 46 mm lamellas</td>
<td>295</td>
<td>46.8%</td>
</tr>
<tr>
<td>Nr of 55 mm lamellas</td>
<td>161</td>
<td>25.5%</td>
</tr>
<tr>
<td>Nr of 60 mm lamellas</td>
<td>175</td>
<td>27.7%</td>
</tr>
<tr>
<td>Nr of 65 mm lamellas</td>
<td>0</td>
<td>0.0%</td>
</tr>
<tr>
<td>Predicted material yield</td>
<td>65.31%</td>
<td></td>
</tr>
</tbody>
</table>

When simulating with 40 mm lamella width present the yield became markedly higher and the best result was achieved for a setup with 40-46-52-60 lamellas. The yield, did as can be seen in Table 34, increase to 67.53 %.
Table 34: The best simulation result for the pulpwood adaptive material

<table>
<thead>
<tr>
<th>Average rip yield</th>
<th>0.82</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nr of 40 mm lamellas</td>
<td>349</td>
<td>46.0%</td>
</tr>
<tr>
<td>Nr of 46 mm lamellas</td>
<td>162</td>
<td>21.4%</td>
</tr>
<tr>
<td>Nr of 52 mm lamellas</td>
<td>168</td>
<td>22.2%</td>
</tr>
<tr>
<td>Nr of 60 mm lamellas</td>
<td>79</td>
<td>10.4%</td>
</tr>
<tr>
<td><strong>Predicted material yield</strong></td>
<td><strong>67.53%</strong></td>
<td></td>
</tr>
</tbody>
</table>

The yield may, in comparison to earlier simulation batches still seem low but one should however keep in mind that the yield originally was at 58.59 % and the increase therefore was much bigger than for the other batches. This was not surprising since having more sizes to choose from naturally can give more benefits, when the boards are narrow and have a much more limited area to optimize on. If just one lamella size is allowed it makes it much harder to have a fairly suitable setup for very narrow boards than for wider boards. All boards vary in appearance and for narrow boards these variances can mean a clear drop in the yield for some boards if there is just one lamella size available. This did then in turn, not surprisingly mean that, as stated in Table 35, the overall yield went up as much as from 19.4 % to 22.4 %.

Table 35: The resulting simulation yield compared with the real yield to the left for the fourth adaptive sawing batch

<table>
<thead>
<tr>
<th></th>
<th>For just 46 mm</th>
<th>Simulation yield for 4 widths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saw-mill yield</td>
<td>51.82%</td>
<td>51.82%</td>
</tr>
<tr>
<td>Simulation yield</td>
<td>58.59%</td>
<td>67.53%</td>
</tr>
<tr>
<td>Raimann line yield</td>
<td>50.3%</td>
<td>57.98%</td>
</tr>
<tr>
<td>GB yield</td>
<td>37.4%</td>
<td>43.1%</td>
</tr>
<tr>
<td>Overall yield</td>
<td>19.4%</td>
<td>22.4%</td>
</tr>
</tbody>
</table>
7 Analysis

If all these simulation results are to be compared with the ones reached during earlier simulations, made by Tomas Ingvarsson, it is not so easy to draw conclusions. The optimal arbour reached by Ingvarsson did also include just three different lamella widths. Those were 46, 53 and 58 mm. The 40 mm width was initially also used but according to Ingvarsson (2006) these narrow lamellas too often broke and cracked in the TM – line because of knots. This leads one to believe, that it would require more testing with 40 mm lamellas, to see whether it is worth using them. During those tests Ingvarsson was also limited not to use a width more than 58 mm since wider lamellas could not be used in the products. It therefore remains uncertain whether the same setup could have been reached by Ingvarsson as in this thesis if these limitations were not set. One should however also note that the log classes used that time were different. While this thesis is based on adaptive material coming from logs with a diameter less than 148 mm, the investigations made by Ingvarsson were based on adaptive material coming from logs with a diameter more than 141 mm. This means that they overlap but only just and the simulation results are likely to be slightly different for a different kind of raw material, which also has a different origin than the one in Kostomuksha.

One could namely argue that it is not fair to compare the yield in Kostomuksha with the tests done in Poland for instance. One reason is obvious – the diameter class 135 – 148 mm was not sawn in Poland and comparing yield with different log classes is simply not fair since the yield naturally depends on which diameter class that is sawn. There are also other reasons to why comparisons might be a bit misleading. The trees in Kostomuksha do after all grow a bit south of the polar circle and this makes them grow slower. For a pine tree, this may on one side mean that the wood has a higher quality, but does for the adaptive sawing also mean a small disadvantage. The reason for this is the fact that trees on such northern altitudes as Kostomuksha tend to get slightly straighter than trees down in central Europe. This means that the benefits of the adaptive sawing concept are slightly smaller when the raw material consists of trees grown near the polar circle, than for raw material, which comes from southern areas.

Nevertheless comparisons should be done, and even though there are differences in raw material, there might be other explanations for the differences than just that. If one goes back to the first tests with adaptive sawing, which took place in Poland and gave a yield over 30 % for all test batches the raw material aspect could explain a part of the difference, but certainly not all. One factor that always could be noted was that the glue board factory in Kostomuksha in general had a very low yield, some even said disastrous. It has hard to say if any of the processes was working properly during the testing times with the adaptive sawing. Cracks when drying, sub optimization, inexperienced staff, technical problems are some of the things that might have given a clearly lower yield compared to a scenario where the very same tests would have been taken out an older Swedwood site where all processes run much smoother. These factors combined with the raw material issue may explain much of the difference. Another explanation could be that there is a band saw in Kostomuksha, while there at other sites are types of saws, which could give a higher yield in the saw-mill, especially for smaller logs. Another factor not to forget may be that the earlier tests were just that – tests. The batches in Kostomuksha were produced under circumstances more or less similar to a normal production, which inevitably in itself could cause a slightly lower yield since operators may be less attentive. One should however not exaggerate this factor since the production, at least in the saw-mill, could be regarded as tests.
However, it is as said, a bit misleading to compare the yield in Kostomuksha with just the yield for the tests in Poland. A much fairer comparison would be to compare it with the yield for the adaptive test sawings of Russian pine in Tikhvin. For the smallest log class, the 141 – 178 mm, the yield ended up at 24.9 %. Since the yield in general gets higher and higher, it would be no surprise if the yield for the class 135 – 148 mm would have been lower than that in Tikhvin as well. The yield in Kostomuksha varied from 17.6 to 21.5 % for the four batches and the difference is not so big, that it can not be at least mostly explained by already mentioned factors. No far-reaching conclusions can therefore be drawn about the yield than that it was a little lower than what was hoped for.

For very small diameters (less than 130 mm) the present production line for adaptive material can in many ways be seen as less suitable than for bigger diameters. The sensors have had problems coping with the narrower boards. It frequently happened that the sensors simply did not detect all the boards at the conveyors. This fact caused a number of errors, especially that more than one board went through the scanner at the same time and more than one board was sawn by the Raimann rip saw at the same time. (Andersen, 22/10)

In order to avoid this kind of problems in the future, one option would be to treat the material according to a completely different production concept. The idea would then require the usage of different lamella widths. The basic principle would be that the saw-mill sorts boards in packages in accordance with the widths that would fit a certain lamella width. In reality that could for instance mean that the saw-mill gathers all the boards meant to make lamellas of a diameter of 65 mm, and make one package of them. This package is after drying brought to the glue board factory where the boards are taken through a planer. The boards there more or less become long lamellas with wane. These lamellas can then be taken through the Wood Eye scanner and then, as usual, be cut into normal lamellas. Since there would be wane on the lamellas, the concept would only work completely if there was a product, where wane on one or more sides would be accepted.
8 Results

When summarizing the results of the four batches based on logs with a diameter of 135 – 148 mm, it is logical to start by looking at the yield figures for the saw-mill. Theoretically the yield for adaptive sawing of this log class would end up somewhere between 57 and 60%. As can be seen in Figure 76, the yield for the two first batches ended up very close to that. The August batch got a lower yield, which partly can be explained by the fact that too much was edged away because of asymmetrical edging and that the quality of the raw material was not so high. The low yield for the October batch can mainly be explained by the fact that the volume measurement was set up a bit differently, which meant that the yield in the saw-mill was lowered slightly while the yield in the glue board factory rose on behalf of it. The October yield would nevertheless have been at least 0.5 % higher if the Millomatic had not wrongly rejected the amount that it did.

As can be seen in Figure 77 the yield for the October batch was not surprisingly higher than for the other batches. As above mentioned, one could say that yield was “moved” from the saw-mill to the glue board factory. The operators had at this stage also gathered more experience and hence fewer mistakes, that could affect the yield, were done. The April yield is quite low partly because of the simple that this was the first batch and mistakes were done by the operators, which meant a lowered yield. The August batch had an even lower yield, which is due to the fact that many boards were dried twice, which inevitably caused many cracks and hence a lower yield.
Another type of yield that might be interesting to take a look at is the simulation yield that the Control logic 2D scanner gives. It gives an idea about how much of the boards that should be possible to make lamellas of. As can be seen in Figure 78 the yields are quite similar. The exception was the yield for the June batch which was lower partly because of the asymmetrical edging, which took away some of the good material for lamellas, but left much wane instead.

If one then summarizes the main results, which are in shape of the overall yield figures from log to glue board it basically cooks down to a few facts. The standard deviation for the yield of the adaptive sawing batches was 0.0169 or 1.69 in percentages and the yield varied over time as can be seen in Figure 79. The average yield became 19.26 % and with the standard deviation in line it is reasonable to expect a total yield for this diameter class under similar circumstances in the interval 17.6 % to 20.9 %.
The results can be generalized in the sense that it is not unlikely that the yield for bigger diameter classes also could turn out to be slightly lower in Kostomuksha than it was during earlier tests. The validity of a yield for one diameter class when it comes to evaluating the overall yield therefore exists but cannot be said to be overwhelmingly high.

To get a higher yield for the class 135 -148 mm were however also simulations done and when using the best lamella widths from these simulations a clear yield raise is the result. The best lamella widths turned out to be the ones given in Figure 80. It turned it that it is likely that 3 lamella widths give a similar result as four lamella widths. In that case 55 and 60 mm lamellas should be produced together with the standard width of 46 mm.

When using these lamellas widths in the simulations did the yield rise from 17.6 % to 19.8 % and from 18.5 % to 20.0 % for the two last batches and in general about 10 %. What this means in terms of total yield can be seen in Figure 81.
Figure 81: Yield over time for the four batches with the additional yield resulting from simulations added on top of the old yield graph

After the four batches of the log class 135-148 mm was one batch of the class 110 – 120 mm followed and the yield for that one ended up at 19.39%. When using the optimal lamella widths for this class the yield could be raised to 22.4%. The saw-mill line appeared not to be appropriate for such small log diameters as 110 mm, while it was possible to run the material in the glue board factory. The fears of a too high share of boards with drying defects proved to be false and the lamellas produced did not differ in sense of quality in any significant way compared to lamellas produced from other diameter classes.
9 Further studies

One of the first priorities could be the use the possibility which the four blades in the band-saw in Kostomuksha give. During 2008 just three of them were used for adaptive sawing of the smallest log classes with 4X. The next logical step to fully evaluate the adaptive sawing concept more thoroughly would be to find a suitable log class and to cut it with adaptive sawing in five pieces and investigate the yield on that.

During 2009 it would also be a logical next step to use the merry go round system present in the saw-mill in Kostomuksha. A fully functioning merry go round would make it possible to saw more or less all log classes with adaptive sawing, which was what was intended from the start. To learn to master the system would of course take time and initially focusing on some log classes for this purpose would not be a bad start.

It might also not be such a bad idea to continue to saw some sideboards and use them as adaptive material in the adaptive line. The so called adaptive sideboards have not been the subject of this thesis but to continue working with them and to find the ideal mix between them and more “traditional” adaptive material would make for interesting work.
10 References

Andersen, Svend, 15/9, 17/6, 2008

Babkin, Alexander, 25/6, 31/10, 2008


Eriksson, Lage, 4/6, 7/6, 1/11, 2008

Esping, Björn – Trätorkning 1a – grunder i trätorkning, Trätek, 1992

Hanninen, Kari, 7/11, 2008

Hoadley, R. Bruce *Understanding wood – a craftsman’s guide to wood technology*, Taunton press, 2000


Barinov, Stanislav, 7/11, 2008

Kostikov, Evgeniy, 25/7, 2008

Merriam, Sharan, B. *Fallstudien som forskningsmetod*, Studentlitteratur, 1988

Motuz, Galina, 25/11 2008

RemaLog 3D Funktionsbeskrivning, Remaconrol , AlfaLaval, 1999

Seppänen, Esko Olavi, 2000

**Betänkande** - om kommissionens meddelande om konkurrenskraften hos Europeiska unionens skogsbruksbaserade industrier


Utskottet för industrifrågor, utrikeshandel, forskning och energi, A5-0384/2000

(Page 17)

Svensson, Åke, Rema, 10/9, 5/11, 2008

Swedwood.com, 21/7, 2008

Sandgren, Stefan, 17/9, 2008

Söderhamn Eriksson - Special Edging Kostomuksha, 2008

Torekull, Bertil – Historien om Ikea, Ingvar Kamprad berättar för Bertil Torekull – Wahlström & Widstrand, 2006


Virkesmätningsrådet – Kompendium i virkesmätning, 2000-06-07

Walker, J.C.F. – Primary wood processing, principles and practice – Chapman & Hall, 1993

Wiklund, J. , Remacontrol – Råsortering 9050 Regionpärm Bodensågen AB, 1989

**Picture sources**

Nytt om Skog & Trä, Nr 1 2006 Nyhetsbrev, Växjö universitet

Picture source A: [http://www.holzwurm-page.de/fertigung/einschnitt/einschnittart.htm_26/9](http://www.holzwurm-page.de/fertigung/einschnitt/einschnittart.htm_26/9)

Picture source B:
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