Report on Consultation Work for Rexcel C.V., Zitacuaro October 2007

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Abstract. This report details observations on the plant inspection carried out over three weeks in October 2007. It lists the major problems, and gives short and long term recommendations.

1. Introduction

The Rexcel plant at Zitacuaro has one 8 daylight 16 x 6 foot particleboard press producing about 180,000m^2 per year. There are two laminating presses and one two stage Vits treater, and a foil laminating line that I did not observe in any great detail. There are major problems in the quality of the low pressure melamine panels produced especially the appearance of white spots on dark colors and also the poor machinability of the product.

1.1. Major Objectives of Visit

The major objectives of the visit were to identify and if possible solve the problems of white spots at laminating especially with dark colors. In addition the scratch resistance of the low pressure laminates was also raised as an issue. However it transpired that there were many more fundamental problems associated with the operation which result in the major problems noted above and these are detailed below.

1.1.1. *Problems with Particleboard manufacture*

The following major problems in particleboard were identified:

- Poor surface quality of particleboard causing laminating problems i.e. white spots due to pinholes in the surface.
- Poor bending and tensile strength.
- Warp especially after single sided laminating.
- High resin consumption 86kgs/m^3

- Poor surface machinability, high surface density and an imbalance in the surface to core ratio.
- Blending inefficiencies.
- Thickness swell
- Poor surface appearance

1.1.2. *Problems with Impregnation and Laminating*

The following major problems in laminating were described:

1. White spots on dark colours
2. Stacking of treated paper
3. High resin use in some papers
4. Scratch resistance
5. Some papers are very difficult to treat requiring the use of melamine formaldehyde resin in the first stage bath.

2. Particleboard production

2.1. Flake preparation

This section includes the drier and flake classification. There are numerous wood inputs as follows:

- Eucalypt roundwood
- Pine roundwood
- Fruit tree roundwood
- Billet offcuts
- Veneer peelings
- Veneer cores
- Old particleboard
- Sawdust from local sawmills

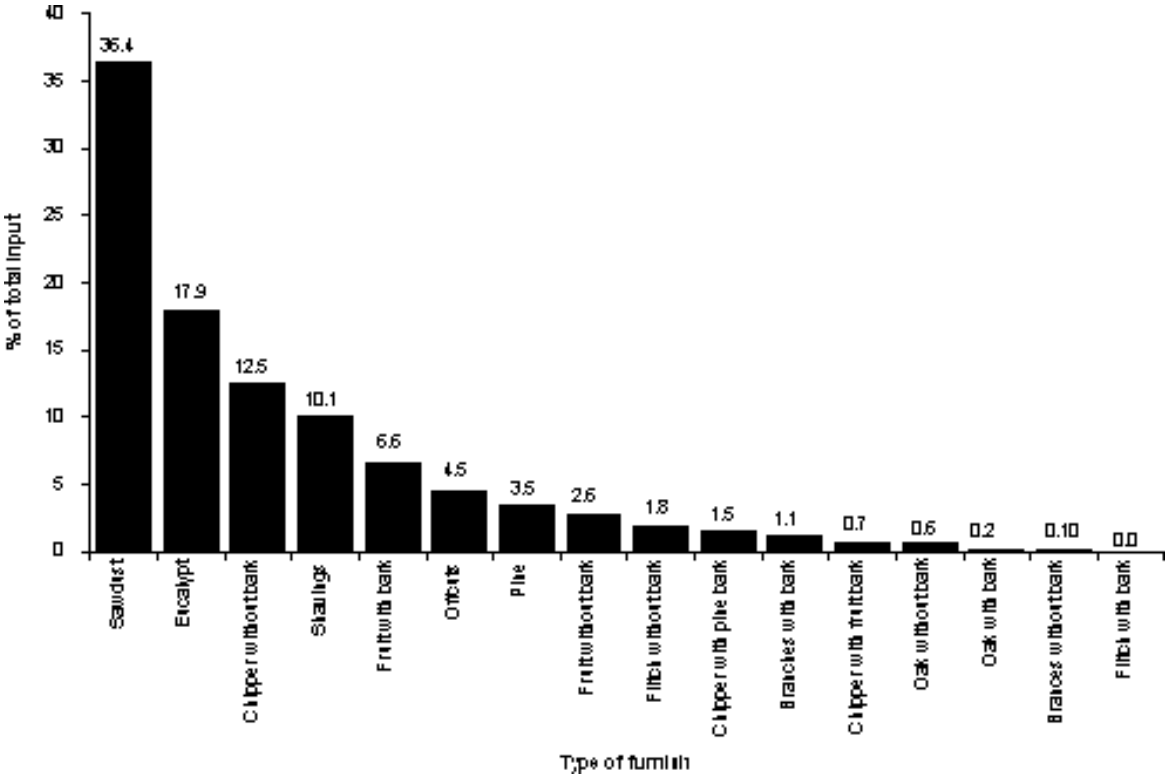

Figure 1. The furnish mix for the particleboard plant

– Mix of sawdust and oversize timber i.e. particleboard or large slivers.

Figure 1 shows the makeup of the furnish for the plant. Of the total input 11% comes in with bark on. This is unacceptable and the allowable bark specification will be talked about later, however as a matter of course, no material should come in with bark on. It was noted that the fruit tree roundwood did not have the bark removed (Figure 2). Bark in particleboard will cause problems with reduction in the physical strength properties as well as the quality of the surface. Bark does not resinate well and tends to chip out of the surface during sanding which results in a poor quality board for laminating. A bark content specification should be set up so that furnish contains no more than 0.05% bark.

20% of the roundwood is flaked using a Hombach flaker and the material is transferred straight to the Hombach storage silo. Some of the roundwood is chipped, the the major inputs being Sawdust 36%, eucalypt roundwood 18%, Bark free chip 12% shavings 10% and fruit

Figure 2. The roundwood sourced from fruit trees has got the bark on.

tree wood bark on 7%. Most of this material goes to Pullman PZ ring mill flakers. All of the veneer peelings and old particleboard is chipped then put through the PZ mills. One very noticeable aspect was the very old age of some of the chip being fed to the PZ mills. It was also extremely dirty which will be detailed in the following section. It is essential that effective chip rotation be implemented. Sawdust goes straight to the silo and the mix of sawdust and oversize gets screened with the oversize being thrown away and the accepts going straight to the silo. The sawdust in the shed had a very high amount of mud balls as well as bark. This sawdust goes straight to the sawdust silo.

There are three green flake silos, one each for Hombach flake, PZ flake and sawdust (which makes up to 40% of the furnish and is full of dirt). The proportion they are fed to the drier are 20, 40 & 40% respectively. Where possible, the furnish mix to the mills should be kept constant. Once the furnish is cleaned, with dirt removed the life of the knives will be increased. At the moment the average time between knife changes is about 8 hours, and this could easily be extended to 12 hours with clean furnish. The other impact of dirty furnish is the fact that the prematurely blunt knives produce poor quality flake and a large amount of fines.

Flake is then dried with a drier fired by diesel and sander dust, the inlet temperature of which is $600°C$). This very high temperature is as a result of insufficient drier capacity and results in over-dried finer material particularly the dust fraction. This creates a gray colored board which is significantly different from Chihuahua which is a very pale colored board. When there is a shortage of sander dust, diesel is used. [1] Ex drier moistures vary between 2.5 & 4.5%. Some material such as peelings and some chip material goes straight to the dryer and given the size of the oversize screen in the flake classifiers (16 x 16mm) this results in very large flake in the core of the board which often results in show through.

2.1.1. *High grit content of furnish*

A factor noted above is that the furnish raw material contains large amounts of dirt. The log yard area is very dirty and this is swept into reclaimers (Figures 3 & 4). Figure 5 shows the amount of dirt coming in with furnish from external suppliers. The effect of dirt from external suppliers on the chip furnish about to be sent to the PZ mills is clearly seen in Figure 6. Not only does this cause problems with machinability as will be shown later, it also increases the need to change the knives in the PZ ring mill flaker as previously discussed. The dust material also contains the bulk of the grit which is 1.3% of the total of the surface flake which is which is nearly two orders of magnitude of what it should be i.e. $< 0.05\%$. Most plants in Australia have grit specifications of $<0.05\%$ and actual results of 0.003 - 0.008% so there is a long way to go for the Rexcel plant at Zitacuaro (Figure 7). Interestingly the size of the sample required to obtain enough grit to put through the sieves was 1000g yielding 13g of grit which gives the exact percentage of the original grit analyses conducted. When considered as an 8 x 4 foot 16mm board, with a 55% surface ratio and 45% core ratio, there is 19.8kgs of surface in such a board. At 1.3% ash this yields 257g of ash per board. i.e. nearly 86g of ash/m^2. Figure 7 shows that the proposed 0.4mm dust screens will remove about 90% of the grit however it is the larger fraction of the grit that creates the most problems for customers. One of the recommendations from this report is that furnish contains no more than 0.01% grit, and that the logyard is regularly cleaned of mud and dirt and that the surface flake is passed through the air sifter currently used to remove metal from the core flake to remove the larger fractions of the grit that the flake classifiers will not.

[1] There is an opportunity here to burn more dust which can be removed from the surface flake fraction.

Figure 3. Loader sweeping furnish and dirt into a reclaimer

Figure 4. Close up image of the dirt in the furnish being swept into the reclaimer by the loader

Figure 5. Dirt in the furnish from external suppliers

Figure 6. The effect of dirt on the chip furnish for the flakers.

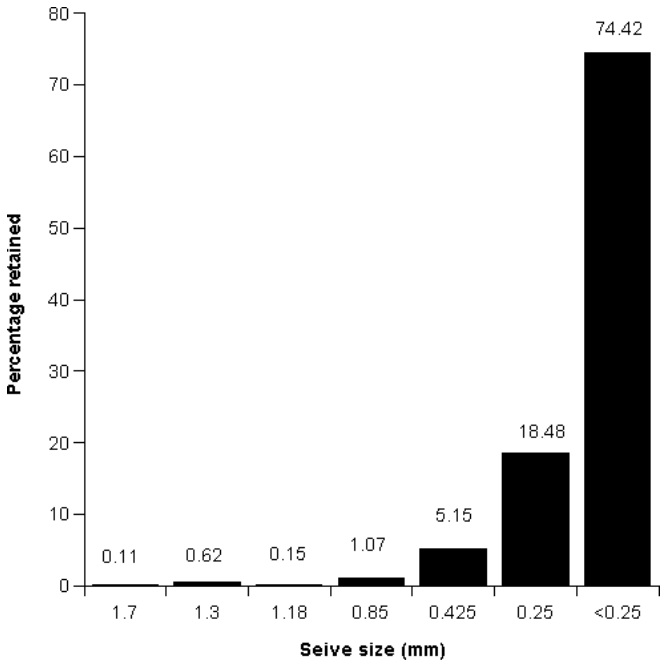

Figure 7. A sieve analysis of grit from surface flake

2.1.2. *Flake classification*
Flake is then classified with two flake classification systems, one Algier and one PAL system with an equal amount of material going to each. The Algier screen is divided into two systems i.e. with two infeeds, the four top screens being 1.5mm with material >1.5mm going to the core, and material <1.5mm going to surface. There with no oversize material being screened out which as will be shown later results in large material in the core which caused show through after sanding. One quarter of the screen has a sieve of 0.356mm below which dust is extracted, the rest of the screen being blocked. This dust is fed into a separate silo and is re-blended into the surface flake fraction as will be discussed later.

The PAL screen similarly has a dual system with two infeeds, and the screen configuration is the top screens are 16 x 16mm to get rid of large chips however this is much too large and these screens should be no larger than 3.5 x 20mm. Therefore core flake from the PAL screens is <16mm & > 1.3mm. There are three screens at 1.3mm and one at 1.5mm. One quarter of the screen capacity is for dust removal from the surface and is also 0.356mm. The difference in screen configurations is unexplainable. An observation of the flake is that the core flake has too much fine material and the surface flake has an excessive amount of dust and in both cases consuming too much resin. This fine material not only uses a lot of resin but also causes significant reductions in board strength properties, particularly bending strength. Given the size of the screens and the resultant poor quality of hte core and surface flake it is strongly recommended that the flake classification systems be completely reconfigured to remove the fines from the core flake and to remove the dust from the surface flake. This will also enable more dust to be burnt in the drier with a consequential saving on the amount of diesel being used.

It is recommended that the following flake classification screen configuration be installed at Zitacuaro, this configuration has been installed in a similar sized plant in Australia. The top screens are 3.5 x 20mm producing overs, with core accepts passing through this and are held by the 1.27mm screen. Surface flake passes through this 1.27mm screen and is held above the 0.405mm bottom screen through which passes dust which is sent to the furnace and burnt. This is exactly what I am proposing for Rexcel. This will not only save on resin consumption, it will considerably increase the quality of the surface. In addition better quality screening of the core flake will considerably improve physical properties such as bending strength as described before. It is also interesting to note that the core flake is passed though an air classifier to remove stones and metal. With effective screening this will

prove unnecessary and this classifier can be used to remove large grit from the surface flake.

An examination of the screen analysis of the all the flake fractions showed that there was excessive fines in the core flake before blending (Figures 8), with 13% of flake below 1.3mm before blending. This small flake would be consuming a disproportionate amount of resin and affecting the physical properties of the board and shows there is considerable inefficiencies in the flake classification system. Surface flake before blending (Figure 9) has too much dusty material that should be removed (20%) (Figure 10). This dusty material also contains 90% of the grit.

When the flake screens are optimised as per recommendations above, it is important to get the surface to core balance correct. Thinner board needs more surface material and thicker board needs less. Thus it is important to be able to generate more surface material using the PSKM mill when making thin board and not generating too much surface material when making thick board. The balance of the screens should be set by determining the capacity of the PSKM mill and working out how much surface is needed to be screened when making the thickest board. Then as more surface is required for the manufacture of thinner board, material is bypassed to the PSKM mill prior to the flake classification screens to generate the extra surface material. This material is of course re-screened.

Given the very large proportion of sawdust that is used in the furnish mix (36%), there is a very high amount of cubic flake both in the surface and the core. This kind of flake consumes a disproportionate amount of resin and adds very little to the properties of the particleboard. It also contains a high percentage of grit and should be removed from the furnish mix entirely.

At present core flake is put through an air sifter to remove rocks and metal, however the capacity of the sifter is only 7 tonnes per hour. It is recommended that surface flake i.e. after classification be put through the sifter to remove any of the larger grit that screening did not remove. There is absolutely no need to air sift core material providing that the logyard is clean and furnish comes into the plant below the recommended grit level of 0.01%.

Regular sieve analysis should be done on surface and core flake, as well as regular surface grit tests.

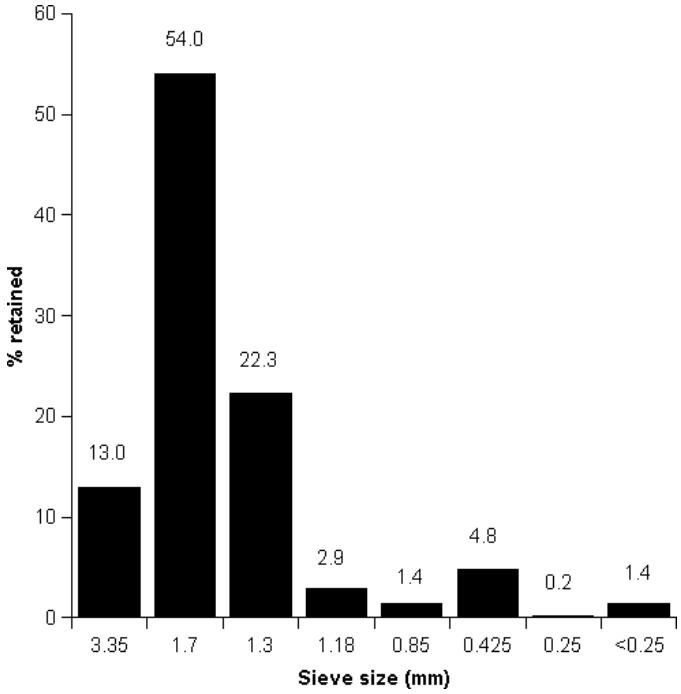

Figure 8. Analysis of core flake before blending

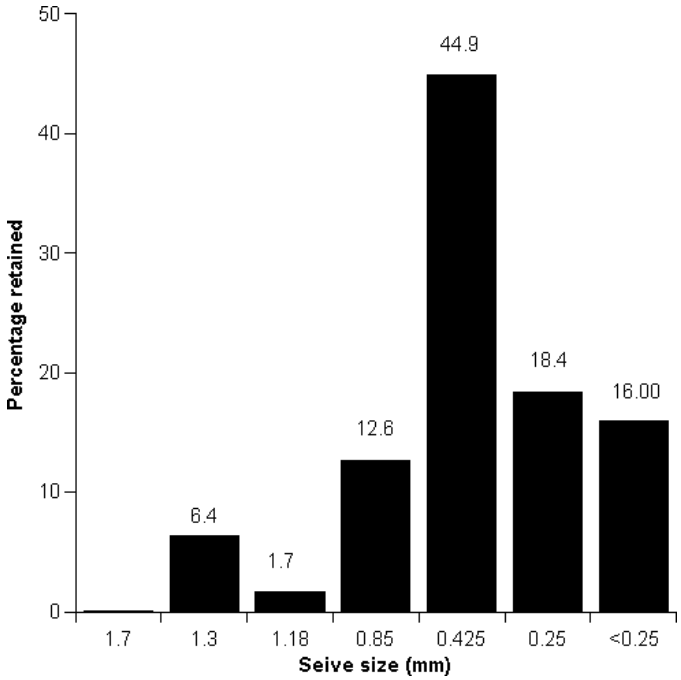

Figure 9. Analysis of surface flake before blending.

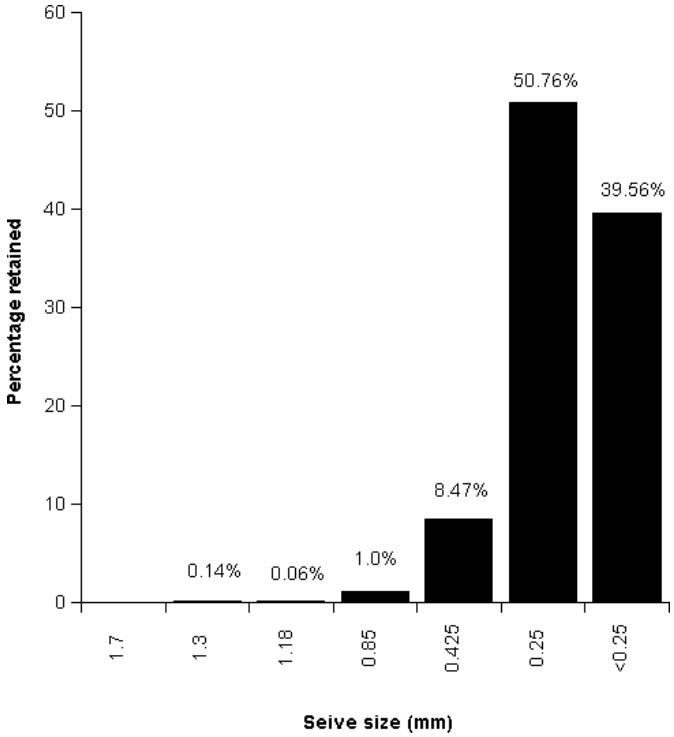

Figure 10. Analysis of surface fines before blending.

2.1.3. *Environmental dust causing Serious dust explosion and health issues*

It was noted around the weighbelt and blending areas there is a significant amount of dust escaping from various chutes creating a lot of dust in the atmosphere. This is hazardous from both an explosion perspective and also a health and safety perspective as people regularly have to clean the area. As a result of these dust escapes, there is a large build up of dust on surfaces which in the event of an explosion would create a much bigger secondary explosion with the potential of not only completely destroying the plant but also killing or seriously injuring many people. It is essential that these dust leaks are fixed up as soon as possible and that a system of dust monitoring be put into place to measure the hazard. The importance of this cannot be overstated and is probably the most serious issue seen in the plant.

2.2. Blending

For standard board the total resin usage is 86kgs per cubic metre. Core resin loading is 8.5% w/w on dry flake i.e. 8.5kgs of resin per 100kgs of dry flake and the surface resin loading is 9%. The core resin is catalysed by a 30% solution of ammonium sulphate at a rate of 7% w/w on resin

weight and the wax emulsion is added at a rate of 0.14% w/w per 100kgs of dry flake in the core and 0.28% in the surface. 12kgs of water are added to 100kgs of surface flake. The wax solids content is 74% and the oil content of the slack wax is below 4% which is considerably better than any wax emulsion currently available in Australia at the moment. The wax is supplied by a Brazilian company Isogama. All resins are made by Rexcel at their resin plant in Lerma.

For moisture resistant board the core resin loading is 7.5% and the surface resin loading is 10%. Wax consumption in core for MR board is 0.26% and in the surface is 0.32%.

The core blender is a PAL 1PL 6 60 which runs at 40 amps and a flap pressure of 2.1bar. The trip current is 70amps. There are two surface blenders the first is where the bulk of the surface flake goes, at the end of which the dust is added and the material gets re-blended in a second blender. This re-use of fines in the surface is highly problematic and leads to a number of problems, not the least of which is the removal of material from the surface during sanding, which is the major cause of white spots on laminated dark colors. The other issue it creates is the re-concentration of grit material in the surface which causes machinability issues which is a major problem at the Zitacuaro plant. The use of dust in the surface is also very demanding on resin and causes an over-use of surface resin.

Analyses of core and surface flake after blending can be seen in Figures 11 & 12 and obviously show that there are too much fine material in the core flake and too much dust material in the surface flake after blending. This will be rectified with proper flake classification.

An inspection of both the Core (PAL) blender and the surface (Imal) blender showed that there was considerable variance with the recommended setups of both injection nozzle position, horn/paddle clearance from edge of blender and horn/paddle angle. It is critical that blender setups be as per the published specifications from the manufacturers and they should be checked every second maintenance day.

For example on the PAL core blender the following was found:

- The injection nozzles were up to 25mm from the wall of the blender whereas they should be flush with the blender wall.

- In zone $\alpha 4$ some blender horns were found to be set up to -20°, whereas the recommended setting was 0° -5° +10°. This horn angle would considerably reduce the dwell time (blending efficiency) by pushing the flake too quickly through the blender.

- Most of the blender horns too close to the internal wall of the blender which would significantly reduce blender efficiency, some by as much as 10mm. The correct clearance is 22mm.

In the Imal surface blender the following was found:

- All of the injection nozzles were flush with the internal wall of the blender whereas they should start at 10mm depth from the wall at the infeed end and increment 10mm for each blender.

- The paddles in the particle inlet zone were up to -40° whereas they should be from -20 - + 30°.

- The gap between the internal wall of the blender and the horns and paddles should be 18mm. The actual measurements varied from 12 - 25mm.

It is essential for the optimal manufacture of particleboard that blender setups be correct. Blender setups need to be worked on especially positions of the injections nozzles, angles of paddles and horns.

It was also noted that in the core blender, wax is added to the drop chute, and resin is added in all of the injection nozzles with the exception of the last one (nearest the outfeed Figure 14). This one is the nozzle in which hardener is added i.e. all components of the resin mix are added separately and this needs to be changed in order to improve blender efficiency. Thus the effective addition of hardener and wax to the resin is done through blending action, and probably results in less than effectively catalysed resin. It is strongly recommended that static inline mixers be used to mix resin, wax and catalyst before injection into the blender as this assures adequate mixing of catalyst and wax to the resin.

In the surface blender wax was added to the drop chute and the resins injected separately(Figure 13) . It is again recommended that static inline mixers be used to mix wax and resin prior to injection. It is also recommended that surface water makeup be added in the drop chute. This will become very important at the next visit when surfactants are going to be added in my patented method to improve machinability. An interesting feature which will be referred to later is the addition of dust (<0.356mm) back into the surface flake stream in a secondary surface blender (Figure 15). It will be recommended that water be added in the flake drop chute and that the wax and resin are mixed in a static inline mixer and added together.

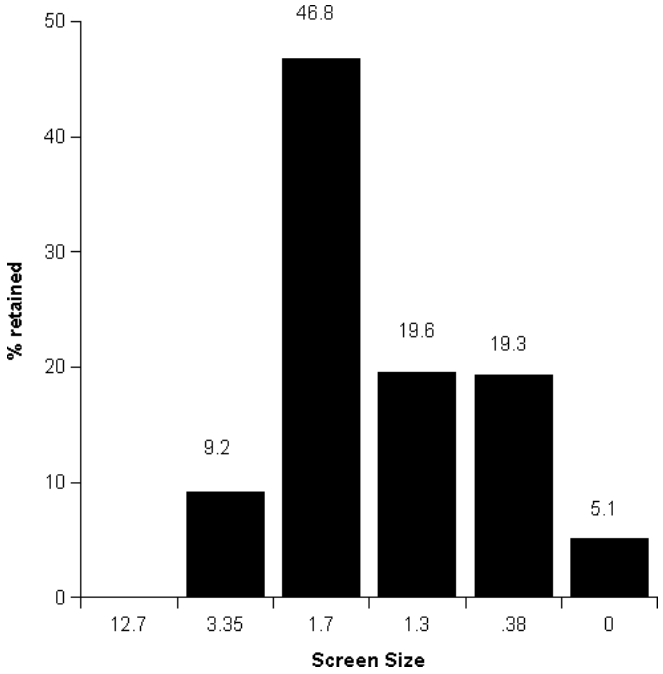

Figure 11. Analysis of core flake after blending

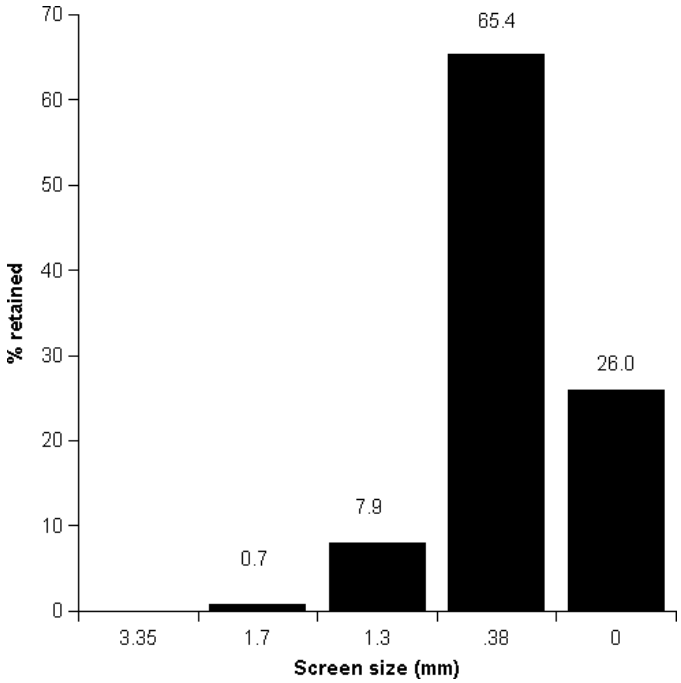

Figure 12. Analysis of surface flake after blending

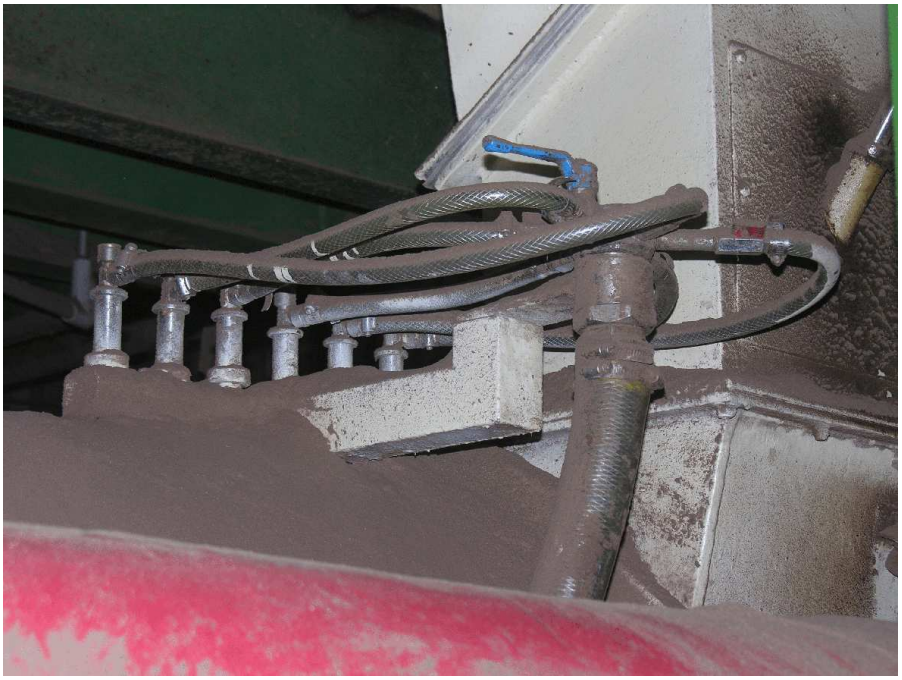

Figure 13. Configuration of the injection nozzles on the surface blender

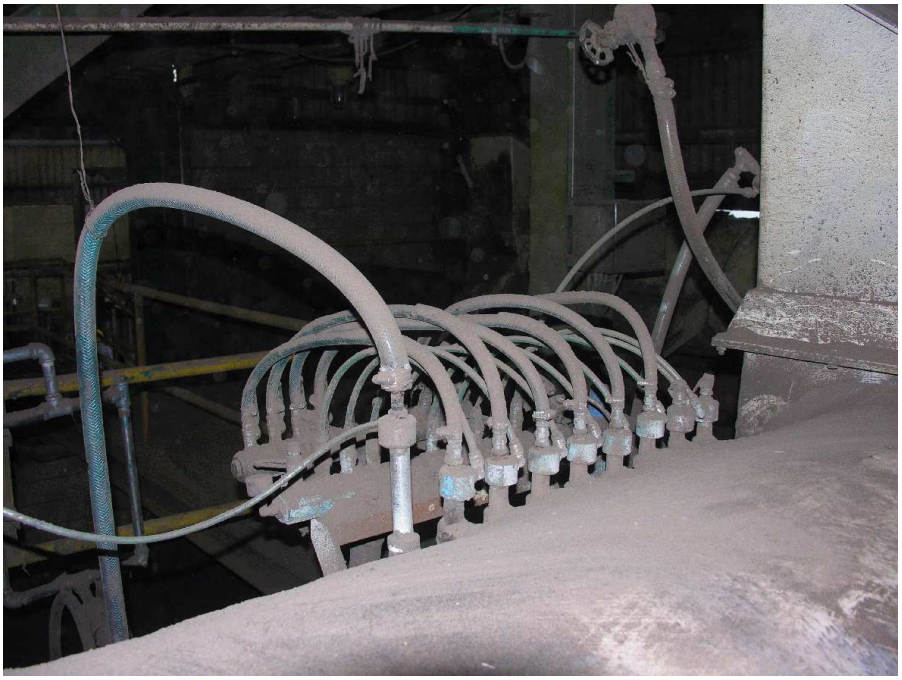

Figure 14. Configuration of the injection nozzles on the core blender

Figure 15. Configuration of the dust blender after the standard surface blender, note no injection nozzles.

2.3. Pressing

The press is a 16 x 6 Schenk 8 daylight press. Forming is done by mechanical spreaders, i.e. bottom surface first, then core and finally top surface. There is no classification in the spreaders at all. The press cycle is interesting where full pressure is achieved for less than ten seconds then main system pressure is reduced which appears to be compensated for by the jacking rams. I would recommend that a standard profile be implemented on a trial basis. The optimization of press cycles should be done on my next visit. The cycle for 28mm board was examined (Figure 16). The ex-press thickness is 31.7mm, the density of the board being 740kgs/m^3. This overall density is very high especially for thicker board and with improved blending efficiency could be reduced especially when the surface to core ratio is optimized. This is currently 60:40 which has to be reversed by removing dust from the surface flake by reorganizing the whole flake classification system. Press cycles are approximately 10s/mm.

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Figure 16. Press cycle showing pressure reduction after maximum pressure reached followed by a subsequent increase in pressure

2.4. Sanding/sawing

The three sanders are Steinemann with grit sizes of 38, 60 and 100 (per inch). The sanded board has a large amount of dust marks and very large surface flake. The problem of the dust marks has been identified and the reasons for the big flake is probably due to holes in the screens in the flake classifiers and the use of 16 x 16mm oversize screens in the flake classifiers allowing flake that is too large into the core of the board. [2] Board is then directed straight to the Schwabedissen saws to

[2] The solution for this as has been discussed is to use 3.5 x 20mm oversize screens in the flake classifiers with the oversize material going to the PSKM mill for re-machining.

be cut to the desired final size. The screens of the flake classification system should be checked monthly.

Testing of the surface of sanded boards should be done on a regular basis. There are two potential test methods;

1. A low gramage (40gsm) colored paper should be laid across the full board width, this would involve a number of sheets of the paper. The paper is then rubbed with a large crayon at least 75mm in length. The sheets of paper should be examined in the light for any sanding or surface defects.

2. A large piece of chalk again 75mm in length should be rubbed across the board. This chalk mark is removable and it is a good method to check for pinholes in the surface or any sanding defects. This method is more discriminating than the paper/crayon method.

On testing sanded boards with chalk, a number of holes in the surface was apparent, as was the large amount of bark. The holes would be caused by sander chipout due to the poor quality of the surface flake which would leave the holes in the surface causing white spots. It is essential the test methods above be introduced at the sander grading station and conducted on a regular basis. This will uncover sanding faults as well as pinholes. The crayon test is for the quality of the sanded finish i.e. looking for tramlines, grit, dust holes etc. and should be done across the full width of the sander. The chalk test is done to test the effectiveness of the pressure bars, i.e. once they start to wear a wave pattern appears after the sander which the chalk test will pick up. These tests should be done twice per 8 hour shift and records of the crayon test should be kept.

Sanded board was observed where there was a significant imbalance of the amount of surface on each side. This is a major cause of warp especially after laminating. As such it is also important to determine that the board is sanded equally on both sides. This is especially important when the amount of surface is reduced as I hope will be the case in this plant. The method is simple, with a router rout to a depth of approximately 4 - 5mm every 300mm across the board for a length of approximately one meter. Do this on both sides of the board. Measure the depth of the router exactly using Vernier calipers. Sand the board and again using vernier calipers measure the depth of the routed lines ***in exactly the same spots*** as before sanding. The difference between the two is the amount of material removed by the sander. To adjust the sanding depth on both sides, it is the first sander that needs adjustment. The method is to raise or lower the calibrating

rollers immediately before the sanding head to ensure even sanding on both sides of the board.

3. Impregnation and coating of decor papers

3.1. First (impregnation) stage

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The first stage is a standard impregnation stage with a pre-wetting roller and smoothing rollers as opposed to doctor blades. Surprisingly the paper is trimmed to final size prior to impregnation. This is costly in terms of both paying for paper that is not used as well as the transport of the paper and it's subsequent disposal. It is strongly recommended that the paper companies trim to the correct width ex factory, as they can re-pulp it and use it again whereas Rexcel cannot. If the suppliers of printed paper cannot trim off the calibration marks, then the weight of this should be calculated and taken off the price of the raw paper.

There are two resin systems, one for difficult dark colors involving saturation and coating with the same MF resin 6801 (53% solids). The second resin system is for easier and lighter colors and involves saturating with a UF resin R-829 (58% solids) and coating with a MF resin 6827 (52% solids). No water is added to either which means that they are in advance of Australian treaters especially with UF resin at 58% solids. It is very interesting and to be commended that there is no water addition with any of the resin mixes used on the treater. The first stage catalyst used is a 20% solution of ammonium chloride. The release agent is a proprietary product from Fusoni believed to contain fatty acids and ethylene oxide. Wetting agents are not normally used for the UF resin which is surprising i.e. only used for the MF resin which one would normally expect to impregnate faster due to lower viscosities. The gel time set for the UF resin system is 3.15 - 4.00 minutes which is ideal. The gel time set for the MF resins is 5.30 - 6.30 minutes which I believe is too slow. Wetting agents and not release agents should be used in UF resins for impregnation as release agents contain fatty acids and can actually impede impregnation. The wetting agent for the UF resin mix in Australia is based on Teric N9, a Nonylphenol ethoxylate and I would recommend this for use in Rexcel. Below are details of the impregnation resin systems;

Table I. 1st stage impregnation mix for easier colors using UF resin

Item	**Amount (kgs)**
UF resin 829	200
Release agent	0.7
Catalyst	1.45

Table II. 1st stage impregnation mix for difficult colors using MF resin

Item	**Amount (kgs)**
MF resin 6801	185
Release agent	0.9
Catalyst	0.7
Wetting agent	0.1

For all colors in an Australian plant a 55% UF impregnating bath solids mix is used where the following is the recipe;

Table III. 1st stage impregnation mix for all colors using UF resin at CHH Tumut Australia

Item	**Amount (kgs)**
UF resin BR200	207
Wetting agent F25T	1.2
Catalyst CT12	1.0
Water	11

When first seen there was inadequate tension of the paper on the pre-wetting roller as evidenced by the paper flapping on the roller, however this appeared better the following day. When the paper chatters when going over the pre-wetting roller it results in inadequate saturation as evidenced by dry spots going up the sky roller. When this happens the water solvent of the resin penetrates first and the resins solids do not resulting in voids in the paper after the first stage ovens which mean the MF resin migrates into the paper resulting in blotch and white spots. This was evidenced even on light colored papers which due to their higher filler content are usually much easier to fill. With dark colors this would be a more serious problem and certainly would be adding to the white spot problem. Sky rollers should be set at maximum height as a matter of course.The pre-wetting roller should also be set at such a speed to ensure that a film of resin remains on the roller after contact with the paper. A film of resin should be visible under the full length of contact of the paper on the pre-wetting roller. The problem is that there is insufficient UF resin being transferred to the paper at from the pre-wetting roller. The first stage bath temperature was $27°C$ and I would recommend that this be increased to $30°C$.

The paper ex the first stage ovens appears a little sticky. Volatiles should be between 11 & 13%. They are controlled by fan speed and the extent of cure of the resin by oven temperatures and the degree of catalysation of the resin. It is essential that volatiles are checked after the first stage and this should be done as a matter of course when there is a paper break. UF resin loadings should also be checked at this time. After testing it was found with volatiles at 13% the paper felt a bit sticky so either the catalyst levels have to be increased or the oven temperatures in the first stage need to be increased.

There is no edge scraping after the first stage which is important to stop the edge of the paper sticking. Rods are used to stop excessive paper curl on the sky roller indicating poor saturation.

Table IV. Oven settings for 1st stage ovens

Oven	**Temperature ($°C$)**	**Fan speed (rpm)**
1	155	1000
2	155	1000

3.2. 2nd (Coating) stage

There are two coating recipes depending on the 1st stage resin mix. With UF resin used in the 1st stage, the MF resin 6827 is used which has a solids content of 52%. The recipe is as follows;

Table V. 2nd stage coating mix for easier colors using MF 6827 resin

Item	**Amount (kgs)**
MF resin 6827	175
Release agent	1.2
Catalyst	2.0
Wetting agent	0.25

The recipe for the coating resin when MF resin 6801 is used in the first bath is as follows;

Table VI. 1st stage impregnation mix for difficult colors using MF resin

Item	**Amount (kgs)**
MF resin 6801	185
Release agent	1.2
Catalyst	0.7

It is interesting to note that using the coating resin mix with 6801, no wetting agent is used. I would strongly recommend that a wetting agent be used for this system similar to that for MF resin 6827. The catalyst is based on equal molar proportions of para-toluene sulfonic acid and morphylene.

It was also noted that there were dry spots on the MF coating rollers. These will be printed onto the paper and will cause dry spots. It is essential that there is a smooth coating of MF resin on the roller. This is solved by the use of wetting agents in the MF coating resin and by

Table VII. 2nd coating stage mix for all colors using MF resin at CHH Tumut Australia

Item	**Amount (kgs)**
UF resin BD829	230
Wetting agent MR306	1.0
Catalyst CT218	1.0
Water	5

keeping the coating rollers absolutely clean by using such solvents as acetone or a soluble alcohol/water mix.

The following table shows an MF resin mix for Australian conditions, in terms of overall coat weights, in Australia for a 75gsm paper, 55gsm of UF and 45gsm of MF resin is added. There was a lot of dust generated due to excessive temperatures in the first oven. I recommended that it be reduced by $5°C$ and the second oven be increased by $5°C$. This resulted in a noticeable reduction in dust.

3.3. General observations of treating of decor papers

A significant issue is that operators make large changes to treater operational conditions, i.e. reducing first stage oven temperatures by $20°C$. Treater conditions for each paper type must be set and not changed without express approval of senior technical or operations staff. The lower temperatures are supposedly set for difficult to treat papers including a low quality kraft paper and a cheap Chinese blue paper and is done to stop flapping in the first stage. I increased the temps to $150°C$

Table VIII. Original oven settings for 2nd stage ovens

Oven	**Temperature ($°C$)**	**Fan speed (rpm)**
1	155	1100
2	155	1100
3	150	1400
4	140	1200

and there was no flapping. Overall there needs to be a greater effort to get full cure in the first stage ovens. In addition oven doors are opened up during treating. It takes at least 20 minutes for oven temperatures to stabilise and during this time sub-optimal paper is produced.

It is interesting to note that on these low value papers, MF is used as the impregnating resin due to poor scheduling. This must be changed as these papers tend to have a high resin demand and should be impregnated with UF. The kraft is used on single sided LPM to stop bowing. Another method i.e. much greater temperature differential needs to be looked at.

It was noted that treated paper samples are cut by guillotine to be $100cm^2$. This could be a significant source of error so it is strongly recommended that the company purchase of paper sample cutter of $100cm^2$ be done so as to minimise any errors during sampling and measuring of treated paper.

3.3.1. *Decor paper specifications*
The following are Decorative Paper Specifications I instituted with Carter Holt Harvey in Australia. They have proven to be very successful and are still used today.

In order to minimise the defects in decorative LPM product to be produced at Tumut the following specification is for dcor papers used in the production of LPM.

1. Under no circumstances should common LPL/HPL papers be used. This was seen at the factory.
2. Minimum paper weight should be 75 - 80 gsm maximum 110 gsm.
3. Minimum wet tensile strength should be >7N.
4. Ash content <38
5. Klemm value <25mm (10 minutes).
6. Gurley porosity 20-30 seconds with a total variation across the web of <2 seconds.
7. Papers should not be calendared as small pores in the surface and large pores in the core can lead to saturation and defect problems such as with Black and the 70 gsm Beech.
8. Density >0.85 with total variation across the web being less than 0.02.
9. The distribution of filler should be homogeneous ie not concentrated just below the surfaces of the paper.

10. Any change to a manufacturing site must be notified to Rexcel before a change is made.

11. Fillers in the paper should be hydrophilic such as calcium carbonate and titanium dioxide. Kaolin clays and talc are to be avoided as they are hydrophobic and impede impregnation.

12. Paper must be finally trimmed from the supplier. If this cannot be done possibly with printed papers, then a credit is to be sort for the paper that is trimmed before treating.

It was noticed that Chinese paper had been rewound at the factory poorly and this gave bad tension problems when the roll was nearly full. This resulted in streak marks in the treated paper. It improved somewhat when the roll was used up. It is false economy to buy cheap paper as it eventually increases fully absorbed costs. In fact tension problems were noted on a number of colors particularly tension variation from side to side which is supposed to be automatic is not working effectively.

3.4. Testing of decor papers prior to treating

One of the most widely used measures to test the efficacy of decor papers is Gurley porosity (air permeability). It is a measure of air resistance of paper and can be used as an indirect measure of absorbency by liquids such as oils and water, but is most useful as a control test for machine production [3]. The air permeability measured by Gurley was found by [2] to be closely related to density and ash content however it was only weakly related to the generation of defects in pressed LPM panels. Specifically Gurley porosity was found to be inversely related to average unfilled pore area. This is still consistent with the relationship of density to defects. However while useful for paper making it is not a useful test for determining the impregnation of liquids into paper i.e. how effective a paper would perform on a resin treater.

[1] related air permeability to fluid flow and introduced the concept of the counter pressure of air on fluid uptake by paper. They suggested that air trapped in the pore system of paper could cause a high counter pressure that would restrict penetration of liquids into paper over short time scales. Furthermore they suggested that the counter pressure was so high that water penetration at low pressures must take place as a result of other mechanisms other than that caused by surface tension forces. As the Gurley value is a measure of specific air resistance thus at higher Gurley values (lower air permeability) one would expect reduced rates of fluid imbibition. This was found to be the case by [2]. The

wicking of both water and DEG measured with the Klemm method with the results followed the same trend. Higher density papers had lower wicking distances which appears to accord with the findings of [1]. [2] also found using a technique measuring time to 50% saturation when looking at flow in the z direction, increasing density resulted in an *increased* rate of imbibition. Thus the Klemm test method described below is a simple method to estimate how effectively a paper will saturate and perform in a treater given the significant doubts about the value of using air permeability to predict fluid flow in the z direction.

Similar trends were observed for the overall resin demand of a paper *i.e.* the total capacity of decor papers to absorb a liquid. Papers that absorbed more liquid were the ones that developed higher levels of unfilled pores after pressing and also were the ones that had lower densities.

Another widely used method to determine the efficacy of decor papers is the Klemm test [3] which measures fluid flow (water) in the x *&* y directions (notwithstanding the fact that impregnation of resins occurs in the z direction). This was found by [2] to show a consistent relationship between the wicking of water and DEG in the machine direction and it was shown that papers with increased rates of fluid flow in the x *&* y directions showed greater total area and greater numbers of unfilled pores in decor papers after pressing. Imbibition rates in the x *&* y directions measured using the Klemm test were also shown to be related to density. Higher density papers wicked up less water and DEG and tended to be the ones with the fewest unfilled pores. Thus the Klemm test is a simple and useful test to determine how effectively a paper will perform on a treater.

It is very important to determine the resin demand of raw papers so that papers with similar resin demand can be scheduled to be run in the same time block on the treater. The following section describes a method I developed for determining resin demand on decor papers. It should be used on all papers to assist in scheduling papers with similar resin demand together on the treater.

3.4.1. *Resin demand*

The following is the method to determine resin demand on raw papers:

1. Obtain paper samples and weigh to nearest 0.001g, a guillotine can be used for this purpose.

2. Dip each sample into clean tap water at $25°C$ for 30 seconds

3. Remove samples from water carefully using tongs and wipe off excess water using a steel ruler or a glass rod

4. Reweigh each sample

5. The test is performed in triplicate

Resin pickup =
(Wet weight - Dry weight) x 120
Resin Content = 100 x ((Wet weight x 1.2) - Dry weight + 0.35)/ Wet weight x 1.2
All weights are in grams.

3.4.2. *Klemm test*
This test was based on TAPPI T441 om-90 [3] and measures the distance a liquid (usually water) wicks up a strip of paper in 10 minutes. It is a test of liquid imbibition of paper that is still commonly used by both paper makers and end users. The sample size for the Klemm test method is 200 mm x 15 mm (TAPPI T402 om-88). Samples are placed in a beaker of water as shown in Figure 23. They are left in the test solution for 10 minutes, removed and the distance the water moves up the strip of paper was measured in millimetres (mm).

thesis files/Chapter4/Figures/klemmtestapp.eps

Figure 17. Klemm testing apparatus

3.4.3. *Paper stacking ex the treater*

Stacking of the treated paper ex the treater was very poor, and would result in a large amount of paper chips occurring during lay-up. It is critically important that operators monitor stacking for the first 50mm of the stack to ensure a bookend finish on all edges of the pallet. If this is not achieved the whole pallet will exhibit poor stacking which will result in paper chips and torn paper lay-up. In fact paper chips caused by poor paper stacking are in the top five paper defects. Figure 18 clearly show the problem of poor stacking. The new Mt Gambier type of book end should be used which is fully earthed to the body of the treater (Figure 19). Another reason stacking ex the treater is so poor is that operators are using the internet rather than adjusting the stacking.

Another serious problem with paper stacking is that there is too much handling of treated paper after the treater. Half of the pallets are turned as there is no paper turner nor is there any means at lay-

up to reverse the papers and this is done by hand. he way to solve this is to have a bottom pallet board and put down a large sheet of plastic that wraps the pallet of treated paper and can be reused. At the completion of the pallet, if the pallet is to be turned over put a top pallet board onto the treated paper after wrapping up the plastic and strap the pallet tightly. The pallet can then be turned over without ruining the quality of the stacking. Manual turning should not occur. In addition it appears as though rainbow packs are made by hand. When changing papers at laminating it is important not to make up mixed treated paper pallets but to change complete pallets i.e. handle the treated paper pallets as little as possible so as not to damage stacking. After the problem was demonstrated stacking improved significantly (Figure 20) however the problem of manual handling after treating must be dealt with. Bookends were produced locally and stacking is now acceptable however there is still too much manual handling of paper and this should be eliminated.

Figure 18. Images showing very poor stacking that will result in paper chips during lay-up

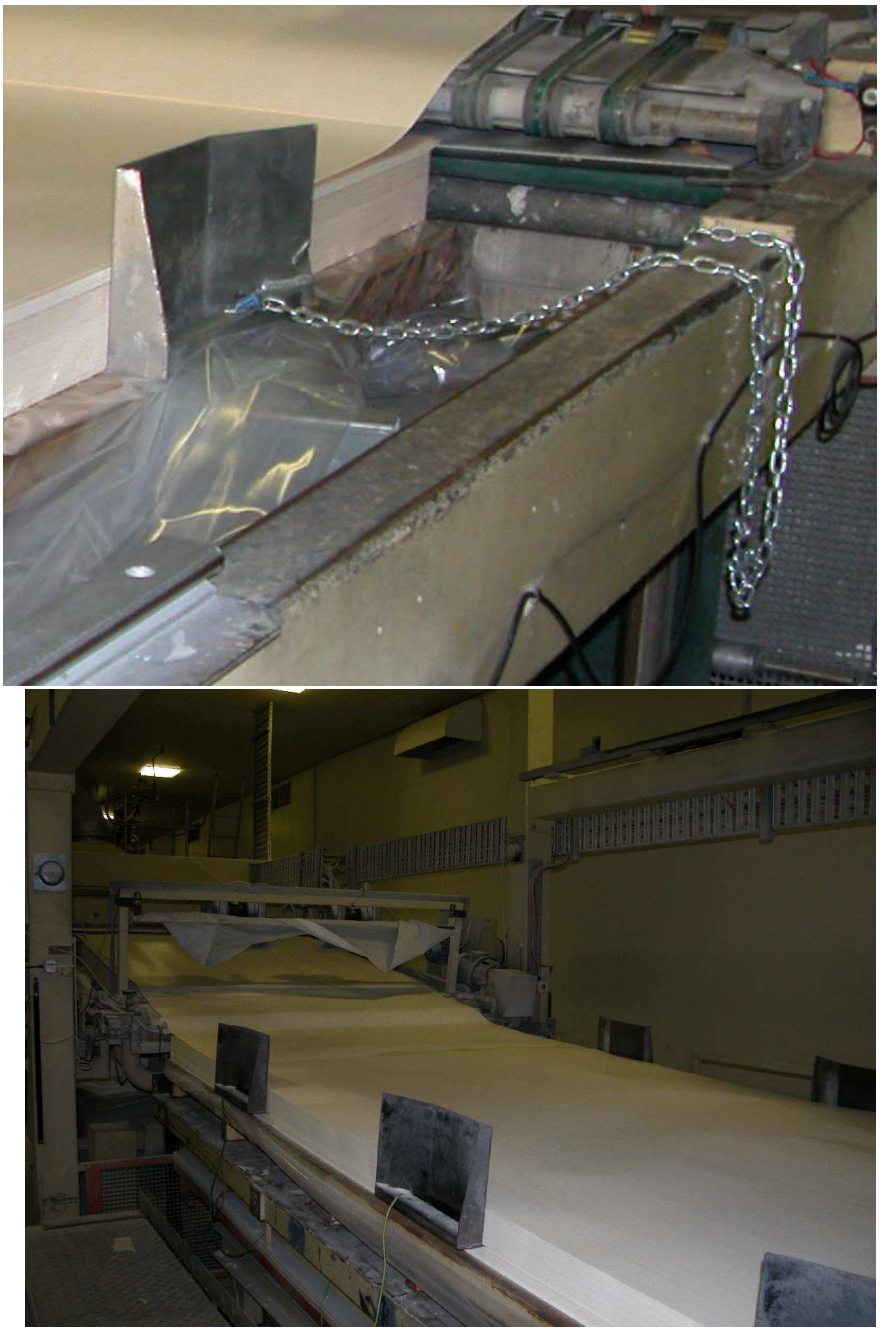

Figure 19. Images showing stops to improve stacking quality after the treater resulting in good stacking. This image is taken at the CHH Mt Gambier treater in Australia.

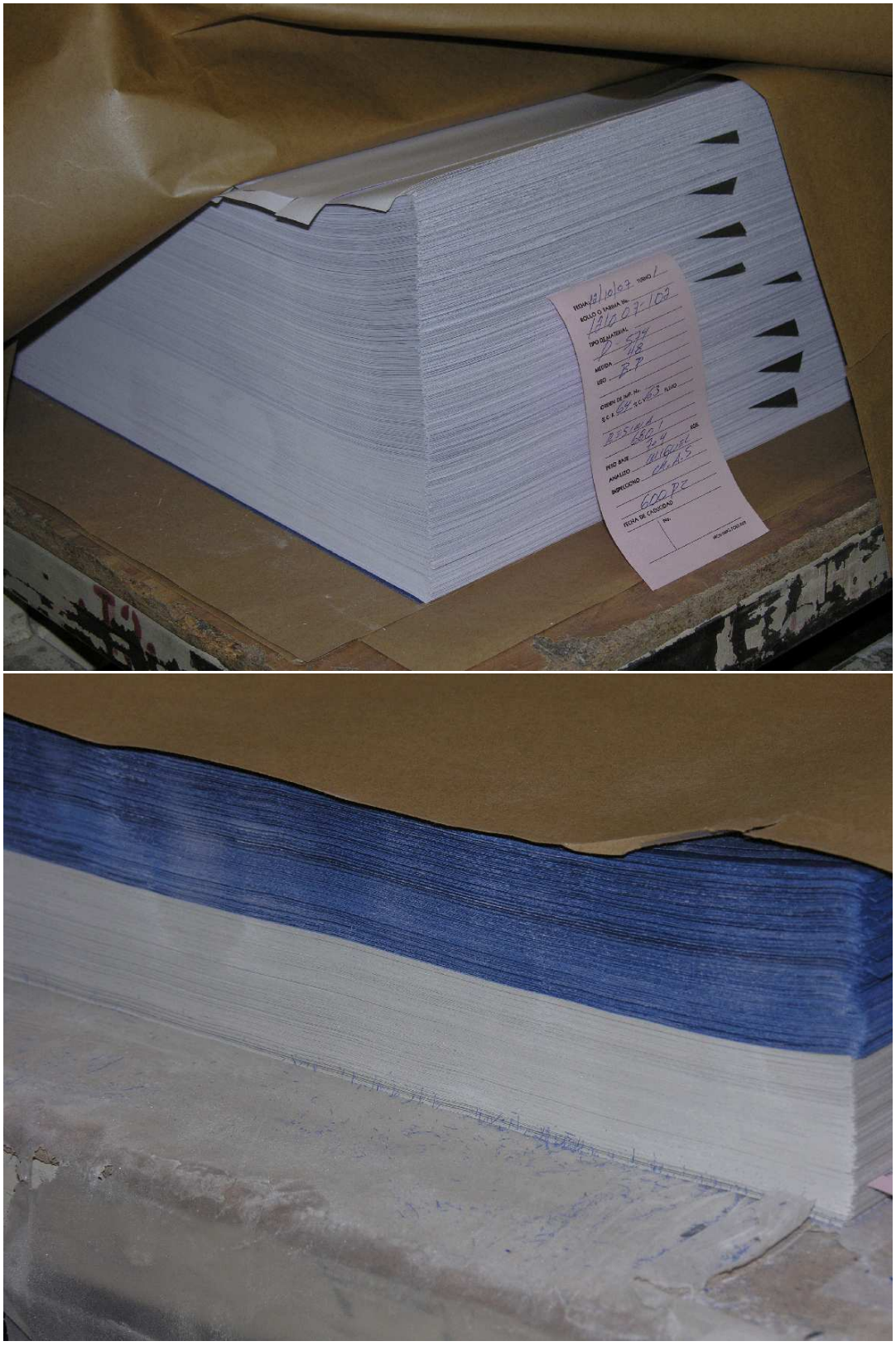

Figure 20. Examples of improved stacking at Rexcel Plant at Zitacuaro.

3.4.4. *Cleanliness around treater*
It is essential that the area around the treater be kept spotless as dirt in laminates is among the top five of the defects in LPM production. Hydraulic oil, tyre rubber paper chips and other dirt was common on the floor in the treating area. The treating area must be vacuumed daily.

3.5. Test methods used for treated paper

For testing paper after treating the standard methods are resin content, total coatweight and volatiles content. However there is a much more effective method to determine the efficacy of treating and this is the B stage cure test which gives all of the results described above as well as most importantly how far the MF resin has been cured in the treater and how much is left to be cured at laminating. In general the greater the level of B stage cure the faster the paper will run at laminating i.e. higher pressures and temperatures and lower cycle times. However with difficult to treat papers B stage cure might be limited resulting in more time for the resin to plasticize without pre-curing while using lower press temperatures and pressures and longer cycle times. Optimizing pressing parameters are discussed elsewhere in this report.

Other tests such as resin content, Coat-weight variation and hand treating of paper for testing paper out-turn samples are detailed below. The main test for raw paper i.e. resin demand has been detailed previously in this report.

3.5.1. *B stage cure test*
This test should be carried out by operators whenever there is a major change in a paper type and at least once every 2 hours.

1. Obtain 6 samples of treated paper $100cm^2$, Number samples 1 - 6 using pencil,and Weigh each sample and record

2. Put 3 of the sample into an oven at $160°C$ for 5 minutes. Remove them from the oven and weigh each sample and record the weight.

3. Dip the other 3 samples into a water bath of $30°C$ for 1 minute ONE AT A TIME. Keep sample submerged and moving for the whole minute but do not rub it.

4. After dipping, lay the sample onto absorbent paper and press gently to remove surface water.

5. When oven temperature has returned to $160°C$, place the 3 dipped samples into the oven for 5 minutes.

6. When 5 minutes is over, remove the samples from the oven with care as they can stick to the oven trays. Weigh the samples and record.

To calculate ***Volatiles***, use the following equation:

Ex treater weight (1)-Dry weight (2) x 100)/Ex treater weight (1)

To calculate the ***B stage cure***, use the following equation: Dipped

dry weight (5) - Raw dry weight x 100 / Dry weight (2) - Raw dry weight)

3.5.2. *Resin content*
The resin content test carried out by Rexcel is as follows:
(Ex treater weight(1) - Raw dry weight)/Ex treater weight(1)*100

3.5.3. *Coat-weight variation*
An important measure of the effectiveness of the treater is to determine the differences in the amount of resin picked up by the paper both in a machine direction (MD) and cross direction (CD). This is called a measure of coat-weight variation.

Samples of treated paper of $100cm^2$ are obtained every 300mm across the web (CD) at a given point in time. These samples are weighed, numbered and recorded. Samples are taken in a similar way every 10 - 15 minutes. Samples collected as described must be collected for at least 6 separate times to have a statistically valid sample. Analysis of variance is used to determine the significance of any change in resin weight pickup either in the cross or machine direction. Normally CD variation is larger than MD variation, the former relating to the alignment of the smoothing rollers in the first stage or the alignment of the coating rollers in the second stage. MD variation is related to changing tension of the paper and is a serious problem causing fluttering of the paper over the pre-wetting roller causing poor saturation and also uneven pick up of resin from the coating rollers. Increasing tension usually fixes this problem however some cheap papers are rewound poorly at the factory and this is impossible to fix other than by obtaining paper from more reputable suppliers.

In the first measurement done on 8th October there was a significant difference in coatweights both in the cross and machine direction.

Variation in the cross direction was was up to 6gsm and in the machine direction it was 5gsm.

3.5.4. *Hand treating of paper for out-turn comparison with master samples*

The selected sample should be placed on a clean glossy surface such as a sheet of HPL or glass with the decorative (smooth) side of the paper facing down. The sheet should be brush coated with UF resin until it was completely saturated, *i.e.* when there are no visible dry spots in the paper, approximately 50 g/m^2. The paper is then turned over so that the decorative side faced up and the treatments were repeated. The sheet of HPL or glass should be cleaned and dried between each treatment.

The UF treated paper was then hung vertically in an oven at 125°C for 85 s. The paper is placed on a sheet of release paper to cool and given one brush coat of MF approximately 40 g/m^2 resin taking care to apply the same quantity of resin by using the same number of brush strokes to all of the sheet. All hand treating should be done along the machine direction of the paper. The fully treated paper should then placed in an oven (as above) and dried for 85 s.

The paper should then be pressed onto a sheet of MDF or particleboard for comparison purposes.

4. Laminating

There are large areas of improvement in Laminating that do not relate to the quality of the treated paper. The greatest area of concern are the basic running conditions of the presses. Laminating line 1 had a cold spot in the platen that means when running 5 foot board temperatures must be dropped nearly 30°C and cycles extended to 60s to ensure an adequate finish. Long and cooler pressing can accentuate MF resin migration. When running four foot boards, press temperatures are about 200°C. This must be fixed i.e. the cold spot on the platen has to be identified and rectified presumably by cleaning the hot oil galleries.

To fully optimize the laminating operation one must optimize the following fundamental variables which are:

1. **Pressure**
2. **Temperature**
3. **Cycle time**

The higher the first two can be set the lower cycle time can be set resulting in more productivity, and considerable cost savings.

The way to set up the three parameters are as follows:

Press pressures should be set up just below the point where crushing of the substrate occurs. In general, MDF crushes more readily than particle board. To measure crushing, measure the thickness of the board before pressing and the thickness of the board after pressing. Set the pressures to maximum and determine crushing, if crushing occurs, reduce the specific pressure by $5kgs/cm^2$.

Press Temperatures should be set up just below the point where pre-cure occurs. It is essential that the whole area of both press platens can achieve the same temperature and this is tested by the use of an infra-red heat gun, an essential tool. If this is not the case, then the hot oil galleries in the platens must be cleaned. Set the temperature to a point where pre-cure occurs. Then reduce the temperature by $5°C$. The more cure that can be achieved in the treater as measured by the B stage method, the faster the press cycles can be due to the higher press temperatures that can be achieved.

Press cycles should be set on the basis of achieving the necessary cure of the resin. This is best determined by the absence of blotch which indicates undercure and is confirmed by the steam resistance test. It is important not to overcure the MF resin as it would make it too brittle and impossible to post-form.

In a trial on Lam 1 pressures were increased from 34 - $40kgs/cm^2$ and temperatures increased to $203°C$ on the top platen and $205°C$ on the bottom platen. Cycles were reduced from 21 - 15 seconds a gain of 6 seconds i.e. nearly 30% which is a significant increase in productivity.

It was noticed that the quality of trimming after the laminating lines was very poor necessitating manual trimming during strapping of the packs. Not only is this very expensive but it is also an occupational health and safety risk to both the person who is manually trimming and to the customer as the trimming result is never very effective as it is done with a piece of wood. Both presses have trimmers and they need to have spring steel knives attached which will dramatically improve the standard of trimming.

A trial of Black paper made to a total coatweight of 190gsm and a B stage cure of 80%. It was run on Laminating Line 1 the Wemhoner Press on 12mm and 16mm board. Temperatures were $166°C$ and cycle times were extended to 80s. Press pressure was 34kgs/cm^2 and was reduced to 28kgs/cm^2 however white spots could not be eliminated, however the 16mm board performed better. MDF was run and white

spots were not seen. A trial run of black will be run with a much lower B stage cure with slow cycles and low pressures in order to see whether UF impregnated dark colors can be run on particleboard.

4.1. Laminating defects

Figure 21 shows the laminating defects. The graph is self explanatory however white spots in dark colored laminates caused by pinholes in the particleboard substrate are the major cause of defect followed by cracked paper, poor sanded surface, paper alignment, dirt, and paper chips caused by very poor stacking.

5. Major Problems and Areas for Improvement

5.1. Particleboard

1. The biggest problem by far is the level of grit in the surface flake. Grit levels are 1.3% when they should be below 0.01%, i.e they are over one hundred times what they should be. This is the major cause of machinability problems with board from Zitacuaro and causes machining tools to rapidly go blunt. The exact effect is the grit causes the cobalt alloy in the machining tool which binds the particles of tungsten carbide to wear away and so causing the removal of the particles of tungsten carbide thus causing the tool to wear. This happens rapidly and causes machinability problems. Figure 7 gives a size analysis of the fraction which will be very important for its removal which is essential. The subject of chipout is detailed below.

2. The second most significant problem is the amount of dust material in the surface flake. Figure 9 shows that an extraordinary 36.5% of the surface flake is $<$ 0.4mm and would be considered dust. This material is classified as being $<$0.4mm and does nothing for the strength of the surface. It in fact consumes most of the resin in the surface resulting in a poor resin distribution on the higher quality flake. This results in the surface of the board being of very low strength which results in removal of flake from the surface during sanding causing pinholes which leads to another major problem of the site, white-spots. It also means that as the surface has such low strength it has very poor machinability characteristics.

3. The overuse of surface material in the particleboard. For 16mm particleboard from the site the ratio of surface to core can be up

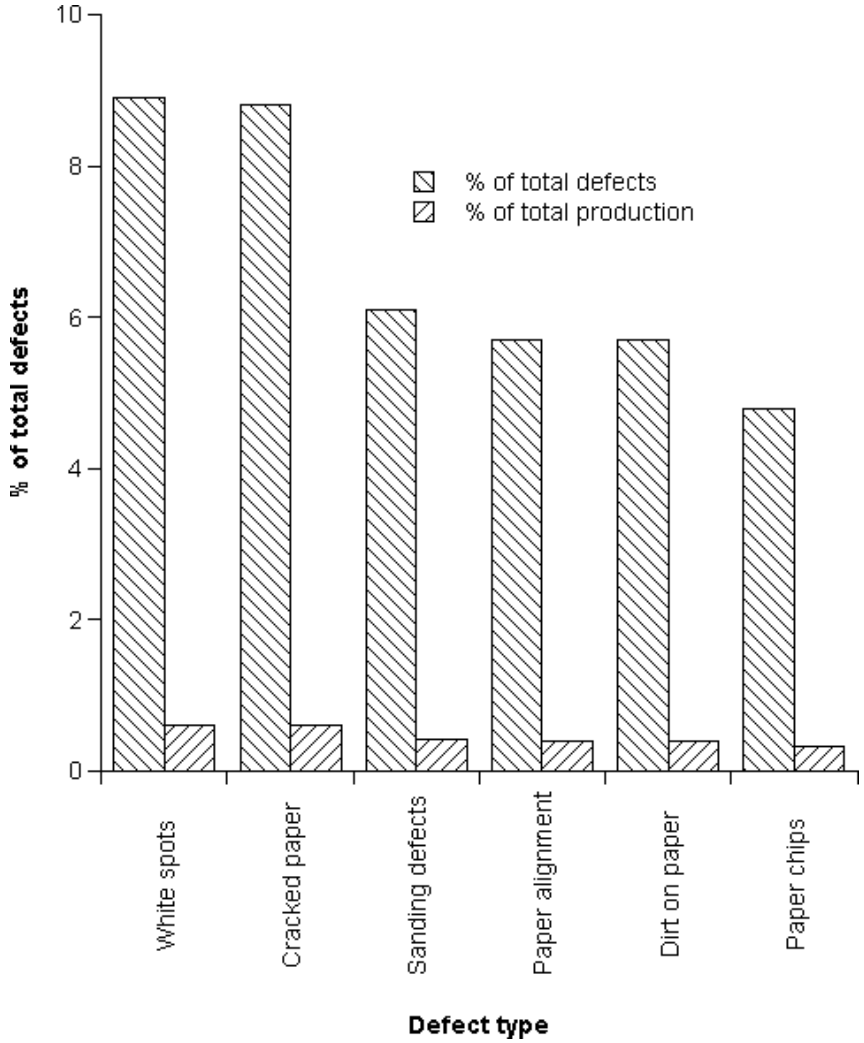

Figure 21. Chart of LPM defects at Rexcel showing defects as a proportion of total production and as related to total defects

to 65 : 35. This results in a board of low tensile strength and other properties. Extra surface material *does not* result in better tensile strength. The biggest determinant in increasing tensile strength is to achieve very good core particle geometry with high aspect ratios i.e. high surface to volume ratio. This enables the resins to effectively bond such particles together. The desired surface to core ratio is exactly the opposite, i.e. 35 : 65. Not only will this increase the strength properties of the board, it will also reduce

resin consumption as surface flake consumes more resin than does core flake.

4. There is too much bark in the furnish. Bark provides no strength whatsoever and in fact just consumes resin and is easily removed from the surface of the particleboard during sanding causing pinholes.

5. Overall the surface quality of the board is very poor with considerable amounts of pinholes and a very easily chipped out surface. In fact the surface is so soft it can be removed by a fingernail.

6. There is far too much dust leaking out during the process both after the drier and before the blender and between blending and forming. This poses an ***EXTREME*** explosion risk not to mention a serious occupational health and safety issue for employees. It also causes a buildup of dust that has to be regularly cleaned. However a lot of dust remains on horizontal surfaces for a very long time. In the event of an explosion from airborne dust, this dust that lays around would create a secondary explosion, propogating the explosion to a much greater area. For example an explosion at the beginning of the forming line would propogate back to the blenders and beyond and forward to well past the press. In fact dust had built up extraction ducts above the sanding area to a depth of over 100mm. During an explosion this would be dislodged and create an even bigger one.

7. There is too much fine material in the core flake. This results in the resin being unevenly distributed in the smaller flake at the expense of the larger flake which results in board of lower physical properties particularly bending strength. Figure 8 shows that 5% of the core flake is too small i.e. <0.85mm and approximately 1.5% is fine material that is even too small for surface flake.

8. There is too much large material in the core flake that sometimes shows through to the surface. This has a major impact on laminating. Figure 8 shows that 13% of core flake is >3.35mm which is significantly too much.

9. Because of the very high levels of surface in the board resulting in lower levels of high quality core flake, the physical properties, particularly bending strength is very low. The overuse of surface flake also means that resin use per cubic meter of board is very high as surface flake consumes more resin than core flake, thus the more surface flake used, the greater is the amount of resin used.

5.1.1. *Chipout and machinability problems*
As mentioned above the prime cause of chipout is the blunting of tools caused by grit in the surface flake of the particleboard blunting the machining tool by abrading away the cobalt alloy binder which holds the particles of tungsten carbide to the tool. This abrasion of the cobalt alloy causes the particles of tungsten carbide to be removed from the tool.

On another project SEM analysis was used to examine the phenomenon of chipout and showed only one sample showed any evidence of resination either on the chipout piece of chipout hole (Figure 25). Note in Figure 25 that where there is resin present, the detail on the surface of the flake appears somewhat blurred and where there is no resin on the flake the surface detail can be seen with high clarity. Figure 24 shows both the hole and particle caused by chipout. This image shows that the only resin evident is the saturating resin within the LPM paper. There is no resin on any of the flake either in the remaining hole or the chipout particle itself. What SEM analysis does not make clear however is whether the particles of flake are actually breaking as opposed to being chipped out whole, which would obviously result in little resin being apparent or whether there is very poor resin distribution. Figures 22 & 23 show details of the hole left by chipout and the particle that caused it.

Light microscopy was also used to examine chipout and Figure 26 shows a chipout particle showing that the area of paper is larger than the actual amount of wood particles removed. This was the case in every instance showing that even if a small particle is dislodged a resultant much larger section of laminated paper is removed leaving a bigger void caused by chipout. The paper actually delaminates i.e. the melamine coated layer splits from the UF impregnated core. This is more clearly shown by SEM. especially in backscattered mode. Figure 27 shows the corresponding void from the chipout particle in Figure 26. Figure 28 shows a chipout particle and corresponding void. It also shows that the chipout particle has evidence of sap-stain fungus and there is no corresponding sap-stain fungus on the chipout void. This suggests that the particles are chipping out whole i.e. they are not actually splitting up.

With both SEM and lightmicroscopy it was obvious that chipout involved the removal of particles of flake as well as paper from the surface during machining. It is not just the removal of the paper. The reasons for this phenomenon is poor blending efficiency of the surface blender that will be worked upon on my next visit.

Chipout/SEM/Image60.eps

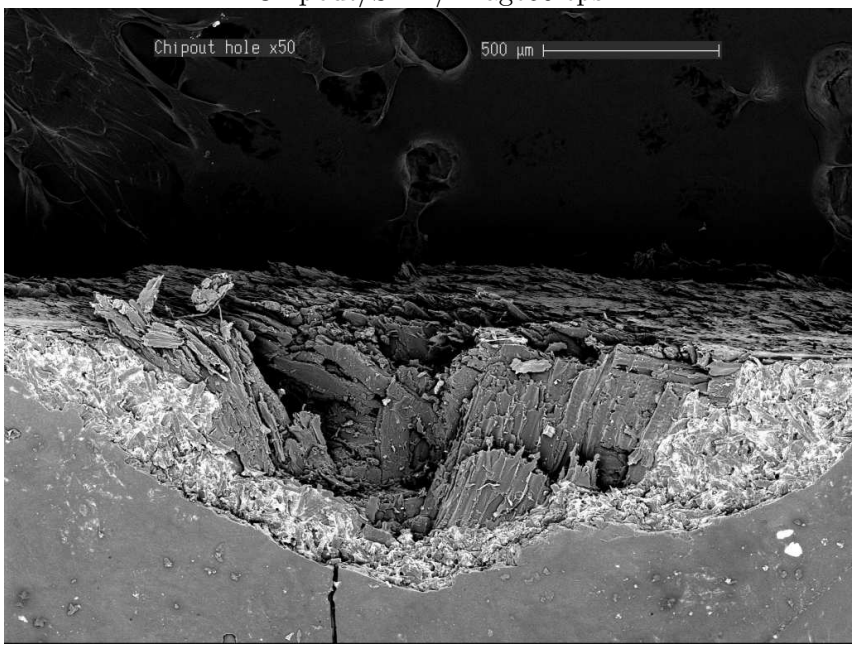

Figure 22. Scanning electron microscopy image x50 of the void caused by chipout.

Chipout/SEM/IMAGE62.eps

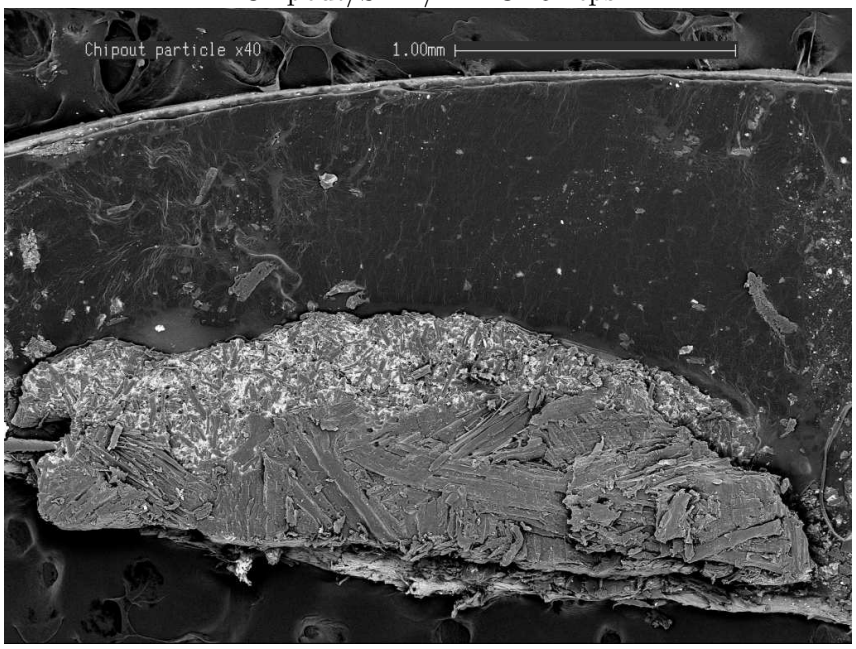

Figure 23. Scanning electron microscopy image x40 showing the particle that came out of the chipout hole in Figure 22.

Chipout/SEM/Image33.eps

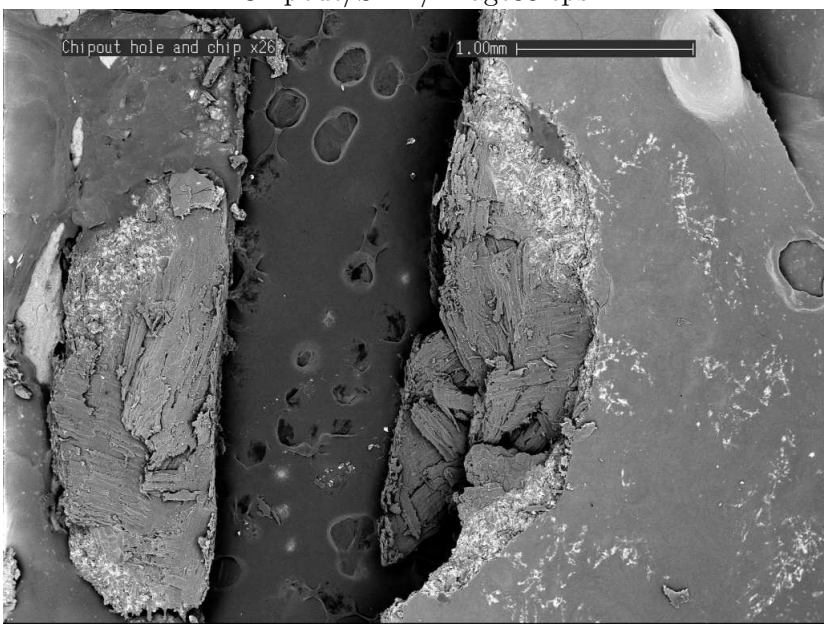

Figure 24. Scanning electron microscopy image x26 of the void (RHS) and particle (LHS) caused by chipout.

Chipout/SEM/IMAGE50mod.eps

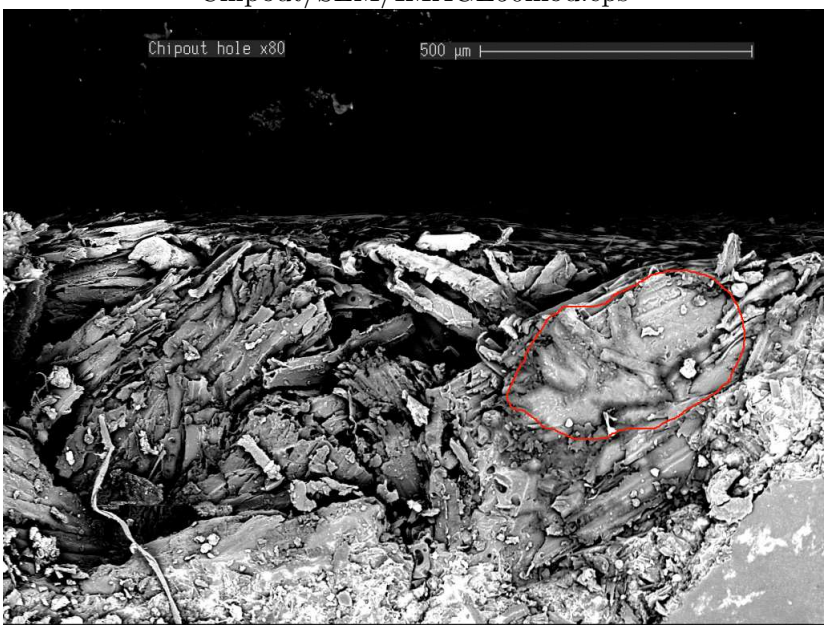

Figure 25. Scanning electron microscopy image x80 showing some resination of particles in the chipout hole.

Chipout/Lightmicroscopy/Image5compressed.eps

Figure 26. Light microscopy image x32 showing the particle removed during chipout.

Chipout/Lightmicroscopy/Image4hole.eps

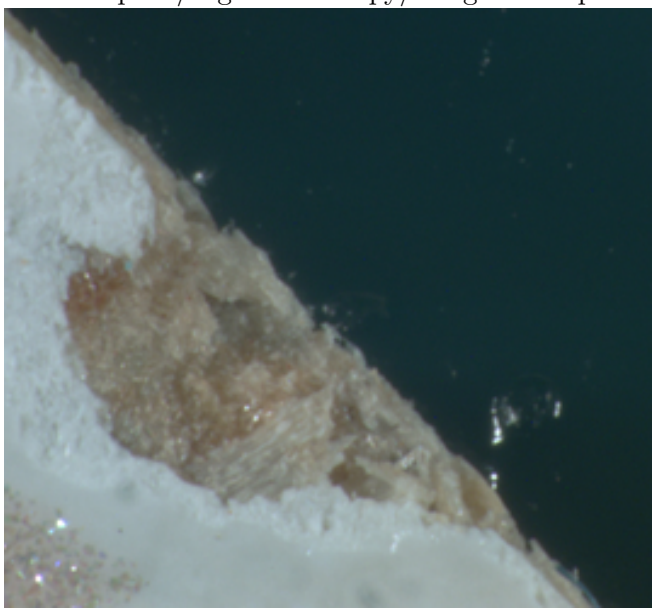

Figure 27. Light microscopy image x16 showing the void caused by the removal of the particle in Figure 26.

Chipout/Lightmicroscopy/Image17.eps

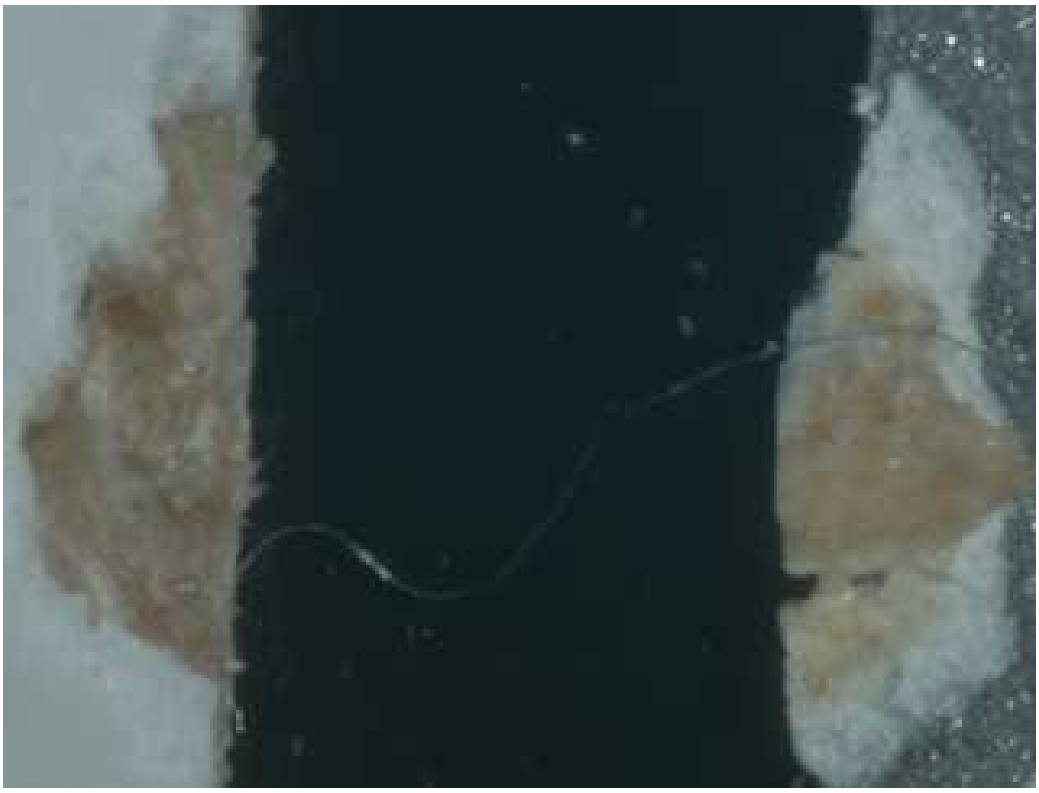

Figure 28. Light microscopy image x16 showing both the void and particle caused by chipout. Note that the evidence of sapstain in the hole is not evident in the removed particle, i.e. the particles which were removed were whole and not fractured.

5.1.2. *Summary of opportunities for improvement in Particleboard*

- Improve flake classification by removing dust from the surface flake, removing grit (ash) from the surface flake currently >1.0% should be <0.05%, and removing fine material from the core flake.

- Improve the management of the logyard especially rotation of stock, i.e. consume oldest stock first.

- Improve the quality of the raw wood inputs, i.e. don't buy dirty furnish and buy wood with bark off. It is false economy to use such material in the process with all the subsequent problems it causes.

- The logyard must be properly maintained with dirt and mud holes cemented over so that loaders and trucks do not spread mud.

- Surface flake be put through the air sifter currently used to remove metal and stones from the core flake which will be covered by more efficient flake classification. Air sifting will remove grit from the surface that is too big to be removed by the flake classification screens.
- The flake classification screens must be checked monthly for blockages and holes.
- Remove dust leaks and improve overall cleanliness in the particleboard area to reduce the serious risk of explosion.
- Improve the surface to core balance, currently 65% surface : 35% core, should be 35% surface : 65% core for an average size board such as 16mm.
- Regular sieve analysis should be done on surface and core flake, as well as regular surface grit tests.
- Improve blending efficiency through examining blender setups including way resin is injected into blenders without pre-mixing. This includes the use of inline static mixers to improve the mixing of the catalyst and the resin. Blenders must be setup according to the specifications. For the blending of surface flake, the water should be added in the drop chute before the blender.
- Investigate and improve rawboard properties, this to be done on subsequent visits by author.
- Improve quality of furnish, by reducing grit to <0.01% and bark content to <0.05%
- Improve the surface quality of the board to make it more suitable to laminate.
- Testing of sanded boards according to the methods above should be done twice each shift and at each product change.
- The amount of material removed during sanding should be equal on both sides and this should be checked with the method detailed above.

5.1.3. *Measures required to confirm problems and opportunities for improvement in Particleboard*

1. Flake classification measures (sieve analysis)

2. MOR, MOE & IB
3. Board profile measures
4. Resin distribution
5. Direction of warp and measure mm/m
6. Surface grit/ash content
7. Blender dwell time
8. CEN thickness swell and 1 hr boil
9. Amount of sand-off i.e.precure
10. Measure of post cure
11. Glue bond durability i.e. MOR A test 2 hr boil followed by MOR test
12. Resin consumption per 100kgs of flake.
13. Machinability based on spindle moulder test i.e. chipout per 100 lineal meters. A new tool should be used for each test and up to 500 lineal meters must be machined.

5.2. Impregnation

1. The biggest problem is the generation of white-spots when dark colors are laminated. It is believed that this is primarily due to pinholes in the surface of the board however poor treating can also have an impact on this.
2. The use of MF resin in the impregnation stage for critical papers is very expensive considering the very high quality of the UF impregnation resin which is one of the best I have ever come across.
3. There is a lack of standard operating conditions at the treater and these should be rectified. In fact in some cases the treater was set up in a way to create problems, such as oven temperature profiles creating excessive dust, poor bath temperature control, opening the treater during operations which creates havoc with controlling the oven temperatures among some of the issues. It seems different operators use their own interpretation of how the treater should run. This comes from a lack of knowledge of treating by key site personnel. Treating paper is a very technical operation and basic technical skills are lacking at the Zitacuaro site.

4. The quality of the raw paper in some cases is very poor and bought solely on price. However poor quality paper can actually cost more in terms of fully absorbed costs.

5. Every roll of paper that I saw treated was trimmed prior to impregnation. This paper has been paid for along with transport, and the disposal of the paper is also a cost to the company. This is extraordinarily wasteful and very costly with no advantage to Rexcel.

6. The purchase of cheap Chinese paper causes problems with tension control on the treater and this causes impregnation problems. The Chinese paper is not rewound correctly and even though cheap it is more expensive to treat in the longer term as it tends to require more MF resin as it does not saturate effectively due to tension problems over the pre-wetting roller.

7. It was noted that treated paper samples are cut by guillotine to be $100cm^2$. This could be a significant source of error so it is strongly recommended that the company purchase of paper sample cutter of $100cm^2$ be done so as to minimise any errors during sampling and measuring of treated paper.

8. The quality of stacking of the treated paper was very poor and this creates paper chip defects in laminating which is one of the plant's top five defects. After treating, the treated paper pallet should be wrapped in plastic and taken to the treated paper storage area. Under no circumstances should paper be manually handled for any reason after treating as this will created stacking problems resulting in paper chips during paper lay-up causing defects at laminating. The access to the internet at the treater outfeed should be banned as it is a distraction to operators who should be concentrating on running the treater and correctly stacking the paper.

9. The scheduling of the treater needs to be optimised by how much resins raw papers take up. Scheduling and running at the treater should be based on papers with similar resin demand.

10. Cleanliness of rollers in first stage is unacceptable, all rollers must be kept spotless as dirt or paper chips on the rollers especially before the pre-wetting roller will transfer to the paper and will create a dirt mark that is impossible to remove and as such will create a defect at laminating.

11. The area around the treater must be kept spotless to stop the contamination of the treated paper by dirt. Forklift movements around the treater should be minimized as this creates dust.

12. Sky rollers must be set to maximum height all the time.

13. The temperature of the first stage UF resin must be kept at $30°C$ not as I saw it varying between 24 - $36°C$.

14. The tension of the paper over the pre-wetting rollers must be very carefully examined and the pre-wetting roller speed must be such that there is resin on the roller *after* contact with the paper.

15. Oven temperatures must be set according to recipes as laid out above, and only rarely changed and only with permission. Operators change oven temperatures far too frequently and this has led to poor cure and dusting problems. The fist oven in the second stage must NEVER be higher than the second oven.

16. Edge scraping after smoothing rollers.

17. Overall cleanliness of operation is not acceptable, a lot more effort needs to be put in to keep the whole treating hall clean as this reduces the chance of airborne dust which again will find it's way onto the paper causing later defects in laminating.

18. Cleanliness of bath resin is not acceptable, all paper debris must be removed regularly from the bath as this attaches to paper and will create dirt rejects at laminating.

19. Too much paper trim after lay-up.

5.3. Laminating

1. There appears to be cold spots on the outside 300mm of the platens of both presses resulting in the running of 5 foot board at much lower temperatures than 4 foot board. This appears to be caused by blocked hot oil galleries and causes unnecessarily long cycle times.

2. There is very poor trimming after laminating pressing. This is an occupational health and safety problem for both employees and customers and is costly to manually remedy which is the case at the moment.

3. Cleaning of boards before the press is ineffective on Lam 1, with only a static brush being used. As dirt is one of the top five defects this needs to be rectified.

4. Operators are not maximising the capabilities of the press. There are many seconds to be gained in cycle times, especially for easier papers.

5. There are white spots when dark colored papers are being pressed. This however is primarily due to the quality of the surface of particleboard.

6. Multi colored paper pallets are common place whereby sheets of treated paper are removed from the pallet that was produced after the treater are made into rainbow pallets for the laminating presses. This adversely affects the quality of the stacking which adds to the defect levels caused by paper chips.

7. Torn paper and missing paper lay-up appear to be common problems and more effort needs to be made to optimise this by looking at paper lay-up arms and the alignment of the lasers as well as paper stacking

8. Cleanliness of lay-up areas at laminating is not acceptable. Dirt is readily transferred from this area to the laid up paper and hence the laminated board.

9. Scratch resistance is not a problem with the laminated board that I observed. There is adequate cure of the board as measured by acid cure and steam tests. LPM board is less scratch resistant than high pressure laminates and scratch problems are usually caused by mishandling by customers.

5.3.1. *Summary of opportunities for improvement in Impregnation and Laminating*

- Eliminate white spots
- Improve machinability of laminated particleboard
- Improve scratch resistance
- Incorporate UF resin impregnation on all colors including those considered critical
- Improve paper stacking ex the treater
- Reduce press cycles
- Develop a surface test to determine sanding quality and suitability for lamination of particleboard

- Develop raw paper specifications
- Develop resin demand test to enable better scheduling of papers at the treater
- Introduce B stage cure test for the treater
- Volatiles should be tested after the first stage of the treater, and should be in the range of 11 - 13%.
- Develop a machinability test
- Develop the ability to press poor quality particleboard using critical papers impregnated with UF resins

5.3.2. *Measures required to confirm problems and opportunities for improvement in Impregnation and Laminating*

1. UF :MF ratio
2. Volatiles ex the first stage
3. Coat weight variation, CD & MD
4. Stacking measurement i.e. variation in stacking in mm
5. B stage cure for all papers done by operators
6. Measure after first stage after paper breaks.

6. Appendix

6.1. Method for determining LPM Machinability using spindle moulder.

6.1.1. *SCOPE*

This procedure sets out the method for determining the machinability of low pressure melamine faced panels using spindle moulders.

6.1.2. *APPARATUS*

The following apparatus is required:

1. Spindle Moulder, capable of running at speed of 10,000rpm, and connected with dust collector.
2. Autofeeder, attached to spindle moulder, it shall have a feed speed of 15 meters per minutes.
3. Cutterhead, Model Leitz 024498, WW420-1, 125x50x30 and fitted with two new knifeblades.
4. Knifeblades, High wear resistance type tungsten Carbide turnblade knife size 50x12x1.5, model Leitz 005086.
5. Measuring tape and square.
6. Carnauba Wax or Food grade spray Lubricant RECOMMEND TR-102 Regular Mould Release Wax Supplier: Fibre Glass International or Food Grade Silicon Spray: Spraysafe Silicone, supplier: Molytec Australia.

6.1.3. *TEST SPECIMENS*

Two specimens size 1.02mx0.5m from the a same lot of production shall be collected and tested. Otherwise test specimens shall be large enough to feed safety to spindle moulder.

6.1.4. *MACHINE SET UP*

1. Clean spindle moulders table surface and spray a thin layer of lubricant on to table surface surface. Care shall be taken to avoid lubricant sprayed to feeder's rollers which could cause slip and chatter during machining.
2. Adjust Spindle Moulder's Fences Position
3. The cutterhead shall be between the infeed roller and the centre roller.

4. The gap between the infeed roller and the first (infeed) fence is APPROX 35 mm.

5. Set feeder at 15 meter per minutes (against spindle moulder's rotating direction) and switch on, feed test specimen and also adjust feeder pressure until feeding runs smoothly.

6. Switch off feeder.

7. Set spindle moulder at 10,000 rpm.

6.1.5. *PROCEDURE*

1. Measure the length of the test specimens.

2. Switch on dust collector, spindle moulder and feeder in sequence.

3. Wait 1 minute for machine to stabilise.

4. Feed test specimen through spindle moulder, the test specimen shall be firmly held to avoid vibration and chatter.

5. After passing the spindle moulder, count number of chipouts along edges in both top and bottom faces.

6. Record the number of machining passes and number of chipouts.

7. Repeat step (d) to (f) until a total of 100 meters is machined.

THE FOLLOWING INFORMATION SHALL BE REPORTED

6.1.6. *Full description of the test specimens*

– Source

– Surface colour

– Surface Finish

– Thickness

– Type of Substrate

– Production Code/Date

– Sample Dimensions

6.1.7. *Chipping Grade*

– Grade 0 No visible chips / 100 meters.

- Grade 1 Up to 10 chips / 100 meters.
- Grade 2 11-25 chips / 100 meters.
- Grade 3 26-60 chips / 100 meters.
- Grade 4 61-120 chips / 100 meters
- Grade 5 Maximum average 10 chips per metre.
- Grade 6 More than 10
- Grade 7 Chips cover more than 10

NB If chipping is poor, stop the test when number of chips is more than 200 and grade the LPM Machinability using proportion method.

EXAMPLE = 200 CHIPS AFTER MACHINING 65 METERS (200 X 100)/65 Equivalent 308 chips per 100 meters = Grade 5.

6.1.8. *Tool Wear Sensitivity (only for Grade 3 and above)*

- S1 = Number of meters machined to have the first 10 chips.
- S2 = Number of meters machined to have the second 10 chips.
- S3 = Number of meters machined to have the third 10 chips.
- S4 = Number of meters machined to have the fourth 10 chips
- S5 = Number of meters to have the fifth 10 chips
- Plot to S5 on a simple run chart and observe trend.

6.2. UF impregnating resin trials

A UF impregnating resin trial was run on 70gsm Technocel Black and a dark colored print both of which are normally very difficult to treat colors. The aim of the trial was to determine whether a UF impregnating resin could be used instead of a MF impregnating resin on critical colors in order to save costs.

The UF recipe was:

- 180kgs of UF 829 resin
- 1.8kgs (later increased to 2.0kgs) of wetting agent
- 1.25 kgs of catalyst.

Table IX. Oven settings for the 2nd stage ovens during UF resin impregnation trial

Oven	**Temperature** ($^{\circ}C$)	**Fan speed (rpm)**
1	138	1100
2	165	1100
3	150	1300
4	140	1250

– The release agent was removed from the UF bath resin.

The gel time was 3.15. The oven temps in the first stage were set to $150^{\circ}C$ and the fan speeds were 950 rpm. The MF recipe was:

– 180kgs of MF 6827 resin

– 0.8kgs (later increased to 2.0kgs) of wetting agent

– 1.2 kgs of catalyst.

– 1.92 kgs release agent

The second stage oven settings are set out in the following table:

Initial coatweights were 206.7 gsm which was reduced toward the aim of 190 gsm. Pressings were very good on MDF and showed a lot of white spots on particleboard however these were shown to be caused by pin holes in the board. Even when pressures were reduced from 34 - $28 kgs/cm^2$ no reduction in white spots was achieved. B stage cure of the dark print was measured at 76%. An interim method was found to mask the issue of the pinholes while impregnating with UF resin until pinholes in the board is solved by removal of the dust and grit from the surface and also through an increase in blending efficiency.

A subsequent trial was run to determine whether or not Black paper could be impregnated with UF resin and still achieve an acceptable quality on the current particleboard. The same UF bath resin mix (gel time 3.50) and MF coating mix was used however the coatweights were increased to 220gsm. The same first stage oven temperatures increasing to $155^{\circ}C$ fan speeds remaining at 950rpm. The aim being to significantly reduce B stage cure. The following table shows the final oven setting for the trial which achieved a B stage cure of 50% which was the aim and a volatiles of 6.4%. The total weight ex the treater was 220gsm.

Table X. Oven settings for the 2nd stage ovens during UF resin impregnation trial with low B stage cure for Black paper

Oven	**Temperature** ($^{\circ}C$)	**Fan speed (rpm)**
1	135	900
2	150	1050
3	145	1050
4	140	1050

During the trial 2nd stage oven temps in No. 2 was reduced from 160$^{\circ}C$ and No. 3 from 155$^{\circ}C$ both in 5$^{\circ}C$ increments achieving 82, 72, 63 and finally 50% B stage cure. Fan speeds in the last three ovens were reduced from 1100, 1100 & 1050 respectively. Note how easy it is to control B stage cure by manipulating ovens 2 & 3 in the second stage.

Pressings were carried out at 172$^{\circ}C$ starting at 80 seconds and going down to 60 seconds which had some press sticking. The setting was placed back to 65s. At 80 and 70 seconds there were no white spots and at the other settings not enough to reject the board which was a complete contrast to when paper with a B stage cure of over 70% was run.

Another Black treating trial was conducted on 16th October 2007 with the aim of repeating the results from the previous trial on poor quality particle with significant amounts of pinholes. The total weight of the paper was increased to 230-235gsm. The treater line speed started at 14.4m/min but was increased to 15.5m/min as the resin on the paper appeared too dry even though the volatiles were 7.2%. It was noted that the rollers just before the pre-wetting roller had a build up of paper debris and cured UF resin. This was transferred to the Black paper and obviously is highly visible. All rollers must be kept clean and if they are dirty the treater must be shut down and cleaned, however it is far better to clean them prior to starting treating operations.

After the line speed change the volatiles were 6.5% however the paper appeared slightly sticky after the first stage ovens. The UF resin must be fully cured thus the paper cannot feel sticky. It must be nice and flexible and the volatiles must be between 11 - 13%. A B stage cure was carried out and the result was 43% however this was in error and grossly underestimated B stage cure, as the paper was agitated too vigorously in the water bath and the paper was too aggressively dried out on paper towelling prior to placement in the oven. It is important to be very gentle with the paper after water immersion and only to

Table XI. Final oven settings for all of the ovens during UF resin impregnation trial with low B stage cure for Black paper.

Oven	**Temperature** ($^{\circ}C$)	**Fan speed (rpm)**
1	155	950
2	155	950
3	135	900
4	150	1050
5	145	1050
6	140	1050

remove excess water using the towelling being careful not to remove any loose or sticky MF resin. When the B stage cure test was redone the result was 65%. As a result reduced No. 1 oven in 2nd stage from 135-133$^{\circ}C$, No. 2 oven from 150-147$^{\circ}C$, No3 oven from 145-142$^{\circ}C$ and No. 4 oven from 140-138$^{\circ}C$. Another very serious issue is the opening of ovens in the second stage whilst the treater is running. As soon as the ovens are opened temperature is lost from virtually all of the second stage ovens. Thus the treater calls for more temperature in these ovens, therefore once the oven doors are closed temperatures overshoot and it takes at least 20 minutes for the oven temperatures to stabilise, during which time the cure of the MF resin is not optimised.

The final oven settings were as shown in the following table:

When the actual temps in ovens 3 - 6 were 134, 144, 140 & 140$^{\circ}C$, a B stage cure of 48% was achieved which is considered acceptable.

The paper was pressed on Chihuahua board which has a very low surface quality at a press temperature of 170$^{\circ}C$ and a cycle time of 90s. There were only very few white spots even though the board is acknowledged as being of poor quality, so much so that it chips out very badly when it is trimmed after LPM pressing. Zitacuaro board was also tried with similar results. It is recommended that Black be treated again with UF resin impregnation with an aim coatweight of 220-225gsm. During the impregnation trial the temperature of the UF resin in the bath got to 36$^{\circ}C$ and started to become quite viscous. It is fundamentally important when using UF resin in the impregnation stage to ensure the temperature of the bath is 30$^{\circ}C$ +-2$^{\circ}C$.

Another treating trial was carried out with white paper with the aim of extending the B stage cure so as to reduce press cycles. The

Table XII. Oven settings for all ovens during UF resin impregnation trial with white paper, these setting resulted in B stage cure of 56% and volatiles of 5.9%.

Oven	**Temperature** ($^{\circ}C$)	**Fan speed (rpm)**
1	150	950
2	150	950
3	135	900
4	150	1050
5	145	1050
6	140	1050

Table XIII. Oven settings for all ovens during UF resin impregnation trial with white paper, these setting resulted in B stage cure of 75% and volatiles of 5.5%.

Oven	**Temperature** ($^{\circ}C$)	**Fan speed (rpm)**
1	150	950
2	150	950
3	135	900
4	155	1050
5	150	1050
6	140	1050

following tables show oven temperatures throughout the trial and the resultant B stage cures.

It would be worthwhile to extend this trial to achieve B stage cures of around 80% to see if pressing cycles can be significantly reduced.

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