TAMPERE POLYTECHNIC
University of Applied Sciences
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Final thesis

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THE EFFECT OF DIFFERENT CONTROL METHODS ON COAT WEIGHT IN ON-LINE FILM TRANSFER COATING.

Supervisor	Dr. Tech. Ulla Häggblom-Ahnger
Commissioning Company	M-real Sittingbourne Paper Mill, Mr. Simon Tyler

Tampere 2006

FOREWORD

This thesis work was done in the M-real Sittingbourne Paper Mill in England during the summer of 2005. The work actually began just as a project for the mill but after a while the idea of writing the final thesis from the project evolved to my mind. The complete final thesis consisted of two parts, the literature and the experimental part. The experimental part was done in August 2005 and the literature part in January 2006. The work was complete in February 2006.

I would like to thank my girlfriend, Jenni, for all the support she has given to me during the writing process. Also Dr. Ulla Häggblom-Ahnger and Mr. Simon Tyler deserve a big thank you for helping me do this work. Ulla for helping me finish this work and Simon for helping me with the practical things at the mill and planning the trials.

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ABSTRACT

The purpose of this work was to find out how the coat weight’s machine and cross directional profiles of a SymSizer coating unit react to certain control strategies.

In the literature part the process in the M-real Sittingbourne Paper Mill is described specifically the film coating unit operations. The main requirements of the base paper are described, as well as properties of the coating colour and benefits and drawbacks of the film coating.

In the experimental part the goal was to find out why there is so much variation in the machine directional coat weight and then to test some control strategies and observe do they have an effect on the cross directional profiles.

In the trials some problems were found with the mill’s on-line measurement equipment and ways to correct that were thought. Also the main coat weight adjustment methods were tested. With the rod loading adjustment some difficulties with the cross directional profiles was found. Coating colour dilution in the preparation plant seemed to be very accurate, but quite slow way to change the coat weight. Finally the effect of application roll temperature on the coat weight was measured and a clear correlation was found.

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TIIVISTELMÄ

Tämän tutkintotyön tavoitteena oli selvittää tiettyjen päällystemäärän säätötapojen vaikutus kone- ja poikkisuuntaisiin profiileihin SymSizer on-line filminsiirtopäällystys yksiköllä.

Kirjallisuusosassa kerrotaan ensin M-realin Sittingbournen paperitehtaasta. Siinä tarkastellaan myös filmipäällystyksen toimintaa, sen ongelmia ja etuja. Lisäksi käydään läpi pohjapaperilta ja päällystyspastoilta vaadittavia ominaisuuksia filminsiirtopäällystyksessä.

Käytännön osassa tarkoituksena oli määrittää miksi päällystysprosessissa on erittäin paljon konesuuntaista päällystemäärän vaihtelua. Lisäksi testattiin joitain säätöjä sen parantamiseen ja tarkkailtiin säätöjen vaikutusta poikkisuuntaisiin profiileihin.

Koeajoissa löydettiin ongelmia paperikoneen on-line päällystemäärän mittauksessa ja sen kalibroinnissa. Lisäksi testattiin yleisempiä päällystemäärän säätömenetelmiä. Sauvapaineen säätö aiheutti jonkin verran vaihtelua poikkisuuntaisessa profiilissa. Päällystyspastan laimentaminen pastakeittiöllä havaittiin varsin tarkaksi, mutta hitaaksi tavaksi säätää päällystemäärää. Lopuksi testattiin vielä applikointitelan poikkisuuntaisen lämpötilavaihtelun merkitys päällysteprofiiliin ja selkeä korrelaatio löydettiin.

1. INTRODUCTION

This thesis work began when I got a student researcher position from M-real's Sittingbourne Paper Mill in summer 2005. I worked in the Research and Development department in a project concerning their on-line film coating station, which is Metso's SymSizer. The main reason why this project was started was because there were problems keeping the SymSizer machine direction (MD) coat weight between the control limits. The mill people had done previous work and tests where they had found out that the problem was how the operators were controlling the SymSizer. The conclusion was that new control strategies needed to be found.

1.1 Project objective

The main target was to reduce the MD variability of the coat weight. The possible improvement was to be measured with the mill's own system of percentage of reels reaching the control limits, which was for the coat weight +/- 1,5 g/m^2 from the target set to the operators. Initially it was about 75 % and the target was to reach up to 90 %. I had four months time to learn the systems, suggest trials and hopefully implement new control strategies.

1.2 Project plan

At first I began to review the existing work that had been done and further analysis as required. After that was time to get to know the mill people. With the workers across the five shifts began the investigations of their control strategies and how they experienced the behaviour of the process. One target was also to find out if the five shifts were doing something completely different compared with each other. After the investigations it was time to begin to plan trials and formulate new control strategies and also assess their practicality. One very important factor was to think about the impact the changes could have to other variables such as cross directional profiles. At this point the improvement of CD profiles was added as part of the project objective. And finally there would be time for trials and implementation of new control strategies.

2. SITTINGBOURNE PAPER MILL

The Sittingbourne Paper Mill is one of the two of M-Real's UK Paper Mills. The other mill is located just about 10 kilometres away from Sittingbourne in a town called Kemsley. Both mills are just 45 minutes away from the capital of England, London.

2.1 History of the mill

The Sittingbourne mill was founded in 1870 and by early 20th century it had become the world's largest producer of newsprint. At that time there was 10 to 15 paper machines to meet the demands of London's growing newspaper industry. The mill's location was ideal for paper making because of its vast water supplies and the proximity to the London markets. According to recent historical research, papermakers had used the site as early as 1703. The Lloyd family was the first to install a paper machine in Sittingbourne in 1877. Frank Lloyd from the family took control of the mill following his father's death and expanded the mill greatly until at one stage there were 14 machines in operation. The Berry Brothers ran the Edward Lloyd Ltd following Frank's death in 1927. In 1937 a company called the Bowater's took control. Following a management buy out the mill become known as UK Paper in 1986. In 1990 UK Paper was bought by a New Zealand group – Fletcher Challenge. In 1999, UK Paper was sold to Metsä Serla. In 2001 M-Real becomes the new name for the group and the mill is named M-Real Sittingbourne Paper Mill. The two mills are often called the M-Real UK Paper Mills. (1,2)

2.2 Mill and paper machines today

Nowadays the mill consists of two paper machines (after this PM) PM15 and PM16. PM15 was installed in 1990 and there has been some rebuilds after that. PM16 was installed in 1908 and it has been almost completely rebuilt. PM15 makes base paper for double-coated fine paper. PM16 makes uncoated paper and some base paper for coating purposes. The capacity for these two machines is about 200000 t/a and from that 60000 t/a is sheeted. The mill uses as raw material pulp bales, it has no own pulp production. After the paper machines there are two off-machine blade coaters, two supercalenders, two winders and a sheet cutter. From the packaging department the reels and sheets are transported to storage, which is at the Kemsley mill.

3. PAPER MACHINE 15

PM15 manufactures precoated base paper for coated fine paper. The machine operates at the average speed of 800 m/min and its maximum speed is 900 m/min. The machine is 4 metres wide and about 96 metres long. The production range is from 90 to 150 g/m^2. In the machine there is a Valmet’s (Metso’s) film press coating unit called the SymSizer. The production capacity is 160000 t/a.

3.1 Paper machine process description

The headbox is designed by Escher Wyss. It is so-called "step-diffuser headbox". In this special design there is no equalization chamber. In the tube bank from the CD distributor, area increases take place through sudden expansions of the pipe diameters. Along a pipe wall, a boundary layer of water develops, and vertical walls can then generate streaks in the paper if several pipes are located on top of each other. However, a sudden increase in flow cross section area means that the boundary layer is broken up. This reduces the problems of basis weight streaks when several units are stacked vertically. (3)

After the headbox there is a standard Foudrinier wire section. There are foils to help the water removal and the final dewatering element is the couch roll. The wet web is trimmed with trim squirts on both sides. The press section is a regular three-nip system. From the press section the paper web leaves to the drying section. It is double felted and there are five cylinder groups and five steam groups. There is an on-line film coating unit between the 4^{th} and 5^{th} cylinder group, but there are still two steam groups after the coating unit to adjust the final moisture content. Before the final two steam groups there are an air turn drier and an infrared drier to dry the liquid coating colour layer. After the drying section there is a machine calender with hard/hard rolls to adjust the calibre of the paper. Finally there is a Pope reeler.

3.2 The products

The main products are coated wood free 90, 100, 130, and 150 g/m^2 gloss, silk and matt grades. The double coating is made first on-machine with film coating and the final surface coating is made off-machine on blade coater. The matt and silk grades are calendered with soft calender and the glossy grades are supercalendered. The product brand is Nimrod.

4. WOOD FREE COATED PAPER

The main raw material for coated wood free paper is hardwood chemical pulp. Usually there is also some softwood chemical pulp used as reinforcement pulp. The main properties of these grades are the optical and printing properties and for the sheeted grades dimensional stability. Opacity is a bit of a problem in the base paper because the furnish is so chemical pulp dominated. Eucalyptus fibres give the best opacity of all hardwood pulps. The other main properties for coated fine papers are high brightness and whiteness values, both over 90 % ISO-standard values. These high values are achieved with high brightness of the pulps by bleaching and with using calcium carbonate ($CaCO_3$) as filler because it is naturally very white. Also the coating colour should contain a lot of $CaCO_3$ to get the top layer bright and white. With lower basis weights titanium dioxide can be used to reach the needed opacity and have optimum brightness and whiteness values. (4)

4.1 Main end products for wood free coated papers

Coated fine papers are used for advertising, books, annual reports, high-quality catalogues, direct mail and magazines. Sheeting has a large share of production with over 80 % of coated wood free papers being sheeted. Offset printing is the most common printing method for these kinds of products. Because the products are mainly printed with offset, it is required that the surface properties are good. The most important factor is the surface strength, because the usage of tacky inks in the offset process. (3)

4.2 Required base paper properties in on-line film coating

On-line coating sets requirements that have to be met before the paper web enters the coating unit. Traditional blade coating requires high strength properties from the base paper, because of the mechanical stress affected by the doctor blade. Film coating process, on the other hand, doesn’t demand so high tear and tensile strengths from the paper web, because it is much gentler. But there are some other properties that are highlighted in the film transfer process.

4.2.1 Smoothness

The base paper surface should be extremely smooth and basically flawless, because the film transfer coating method copies the faults and may even highlight the hills and valleys of the base paper. The difference between blade and film coating can be seen very well in figure 1, where the doctor blade has smoothened the surface of the paper, but the film coater has followed the profile of the base paper. This is especially important if the final product is printed with rotogravure and many times film coaters can’t be used for these grades because the lack of smoothness. For heat set web offset printed products this is very good, because the ink drying is uniform due the even coating coverage. The base paper smoothness doesn’t have an effect on the application of the coating colour layer, because the coat weight adjusting is not dependent on the smoothness (5).

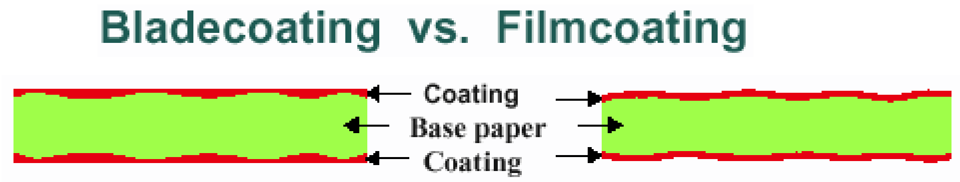

Figure 1 The difference between blade and film coating. (6)

4.2.2 Strength

The strength properties (excluding the surface strength) are not so important as in the blade coating method, because there is not so much mechanical stress against the paper. Figure 2 shows how the blade and film coaters work, without the doctor blade the film coater is much gentler than the blade coater. The two sides simultaneously coating method sets some strength limits for the paper web, because it moistens the base paper quite much in the press nip. It is still very important that the tensile, tear and z-directional strengths are stable all the time for achieving good runnability.

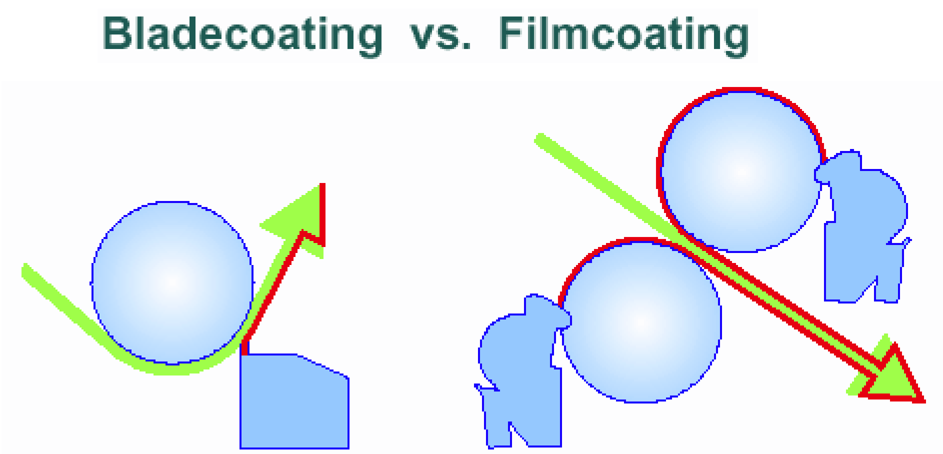

Figure 2 The biggest difference between blade and film coating is the doctoring in the blade coater, which affect high mechanical stress on the base paper. (6)

4.2.3 Formation

In fine paper products the print quality is very important, so the base paper must have good formation. It is also important, because there is no doctoring element to smoothen and hide the faults caused by poor formation. These faults can be for example streaks in machine direction affected by cross directional formation variation. Poor base paper formation can cause surface unevenness in the final product because the film coating method may multiply the variations.

4.2.4 Filler distribution and two-sidedness

Filler distribution is never equal in the z-direction, the amount of the variation depends on filtration circumstances. In one-sided dewatering, such as Foudrinier, the bottom side of the paper contains less fillers than the topside. That is because the fillers drain through the wire with water in the beginning of the dewatering. The side that contains more fillers is smoother and denser, but the surface strength is poorer so it dusts easier. The smaller filler amount on bottom of the paper causes poorer coverage of the coating, because the coating colour penetrates deeper in to the structure. The other main part of the paper machine to create two-sidedness is the press section. Traditional press section consists of three nips, this kind of system leaves the bottom side porous, because the paper web is in two nips against smooth roll and not against the felt. The paper web is pressed more from the side that is against felt. More porous structure absorbs more coating colour. (4)

4.2.5 Moisture

Moisture profile of the base paper is very important, because the coat weight profile follows the moisture profile. If there are places in cross direction that are moister or dryer than average, those places absorb coating colour differently. The moister spots absorb more coating colour than dryer ones. Also the machine direction moisture control is very important to get stable coat weight in the final product. Because if there are moisture variations during runs they appear as coat weight variations in the product. CD profiles can be adjusted before the on-line coating with steam box in the wire section or more preferably after the first press nip. Other possibility is to have press nips that are controllable in cross direction. After the coating station the moisture profile can be changed with an infrared drier, but it is too late in coating wise, because the coat weight profile may be poor already. In machine direction the moisture can be adjusted with drier cylinders steam pressures. This is slow, because the cylinders have big temperature, which is hard to change. That is why it would be preferable to have an air drier or an infrared drier in the process to adjust the machine directional moisture also (4). This is common in the on-line coating processes, because the coating colour is usually dried with these two methods. They are quicker to adjust and so they would help in the web breaks, basis weight changes and grade changes to achieve the target moisture faster and more accurate.

5. FILM COATING IN GENERAL

The film transfer units that are based on the short-dwell application first came into the paper making processes in the 1980’s. First they were used in the surface sizing and later they became also useful in pigment coating. The development of these machines began because of the growing need of the simultaneous coating of both sides of the paper and by that less needed space. Also the penetration of the coating colour and the water it is carrying into the paper web was advantageous. Because of the good penetration the need of non-contact drying reduced and with that the use of energy decreased. (4)

5.1 On-line pigment coating with film transfer unit

The coating colour is first pumped from the feed tanks into the application chamber. In there is the specially perforated sealing blade that eliminates harmful flow disturbances and air. From the application chamber the coating colour goes in to the application nip between application roll and metering rod. There are many kinds of different rod types such as grooved and smooth rods and different sizes from both of those. Figure 3 shows what kind of an effect the rod diameter has on coat weight. The coating colour film thickness that is attached on to the application roll is metered with rod pressure. Figure 4 shows how the paper web goes through the station and how the metering rod works. From the application roll the coating colour is attached on to the paper web in the press nip. The pigment forms a uniform layer on the surface of the paper web.

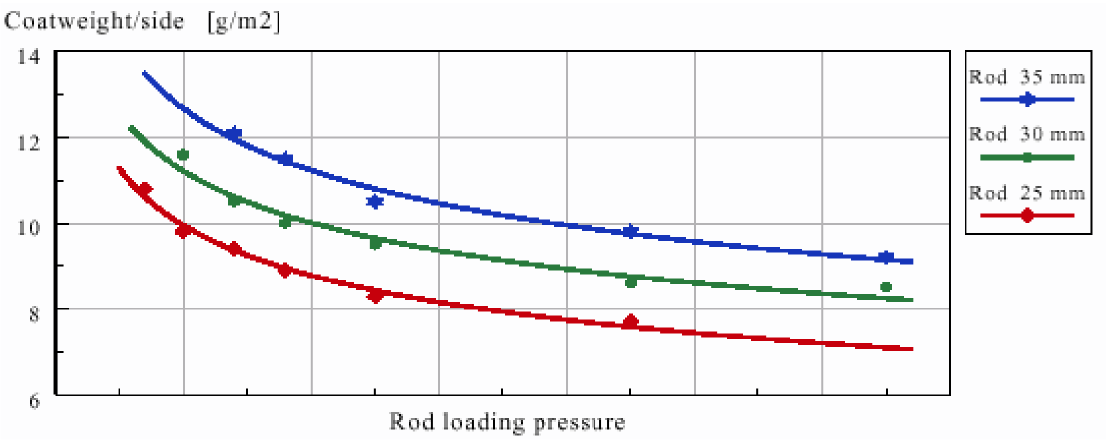

Figure 3 Large diameter smooth rods give the highest coat weight. (6)

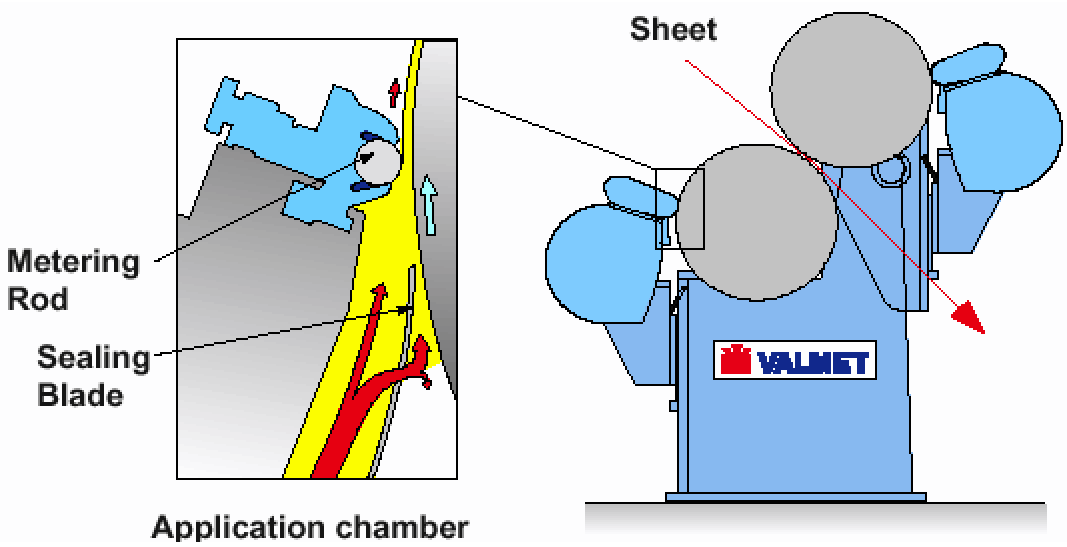

Figure 4 Film coating unit (right) that coats both sides at the same time and the application chamber with the metering rod and the sealing blade. (6)

After the press nip the pigment layer splits into two different layers. The other part stays on the surface of the application roll and the major part (70-80 %) sticks on the paper web. The part that is attached onto the paper surface can be divided to two different layers, immobilized and liquid layers. The immobilized layer is attached on to the paper web's surface and the liquid one is on top, it is close the same as the part that stays on the application roll. The splitting of coating colour after the nip happens in the liquid layer, the thinner the layer is the smoother surface is achieved. Viscosity and surface tension of the coating colour are important factors considering the splitting. The pigments should be chosen so that the solids content is as high and viscosity as low as possible. Also the machine speed affects film splitting. The press nip pressure determines together with the coating colour properties the coat weight. The higher the pressure the more coating is attaching on the paper web. (4) The operation range is mainly determined with the solids content of the coating colour but fine adjusting can be made with rod pressure. In the figure 5 is one example of operation range, where above the range there is a risk of orange peeling and below is a risk of poor coverage.

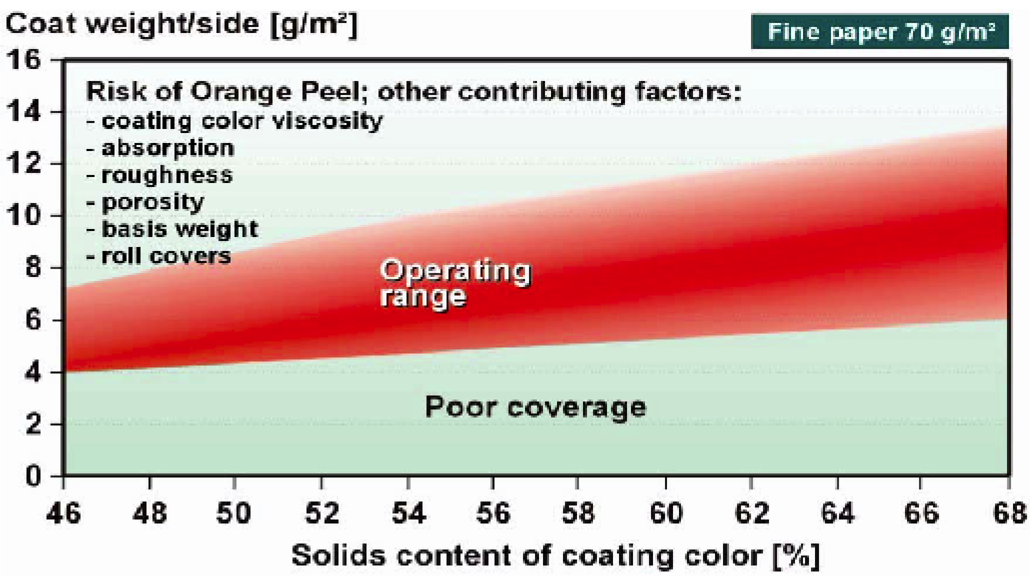

Figure 5 Operation range of the coat weight as a function of solids content. (6)

5.2 Drying of coating colour in on-line film coating process

After the paper web exits the press nip the liquid layer has to be dried quickly to prevent the water penetrating in to the fibres. It is not good for quality if the fibres start to swell. So drying begins before the first drier element by penetrating. The first drying unit is usually an air turn drier in the film coating on-line process (7). It is a non-contact drying that simultaneously steers the paper web in to the next drying phase, which is an infrared (IR) drier. In these two phases there is usually very high temperature to reach the evaporation temperature as fast as possible. The IR unit is the last contactless drier before the final cylinder group. With the IR drier it is usually possible to adjust the cross directional moisture profiles if there is something to fix. After the IR drier the temperature can’t be extremely high any more, because the pigment layer is reaching its solidification point. High temperatures in this point could cause mottling. In the final cylinder group the moisture content of the paper is determined. In figure 6 there is a layout of typical film transfer coating station, where after the application there is an air turn drier and after that an infrared drier. Nowadays there is also very typical to have a second air drier after the air turn instead of IR (8).

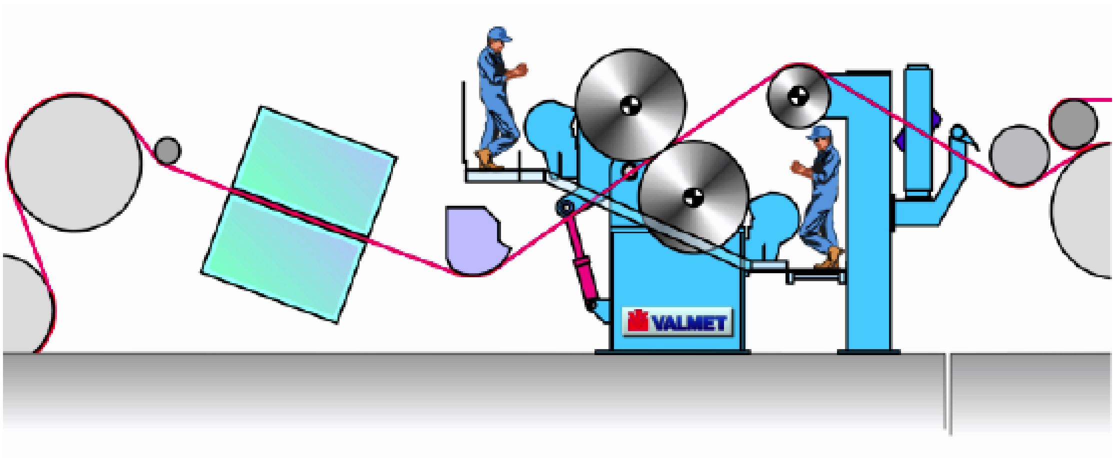

Figure 6 Layout of a typical on-line film coater, where the drying begins with air turn drier and continues with infrared. Paper web runs from right to left. (6)

5.3 Benefits of film coating

When the development of film coating units started the basic idea was to increase speed that had started to limit the process speed with pond size presses. After the pigment coating started with film transfer coaters the main benefit was that both sides could be coated simultaneously and less space was needed.

5.3.1 Mechanical benefits

In film coating there is no doctoring after the application so there is only a little mechanical stress to the wet paper web. With less stress fewer web breaks are achieved so the runnability of the process is better, also tail threading has become easier and downtime after web break is shorter. The metering element lasts longer than in the blade coaters, as rod lifetime is much longer than that of the blade. The investment costs are lower than with the blade coaters, because one unit can coat both sides at the same time (9). Also the need of drying is decreased, because some water penetrates in to the paper web in the press nip.

5.3.2 Quality benefits

The most important benefits qualitywise are the even coating colour layer and excellent base paper coverage. Because there is no hard doctoring after the application the coating layer follows closely the base paper surface’s figure. Therefore the even layer is achieved and the base paper coverage is high, as the small hills in the base paper can’t be seen in the final product as coating colourless spots and valleys as thick coating colour places. This helps especially in the offset printing process, because the paper surface and the coating layer are uniform. There are also no scratches, which occur with the blade coating method. With film coating there can be high de-inked pulp content, because the process is much gentler than with the blade coater. (9)

5.4 Problems of the film coating

The main problems in the film transfer process are related to coating colour behaviour in different areas of the station. Other big factor is the base paper quality that has to be in very high level as mentioned before.

5.4.1 Misting in the press nip

The misting phenomenon occurs especially with high coat weights and with low solids contents. Too high running speed also affects misting. If the base paper is very smooth and has low oil absorbency ability the risk of misting increases even with the lower coat weights. Misting is a problem with the spherical shape pigments, because they have low shape factor (surface ratio to thickness of the pigment particle). Plate like pigments prevent the misting so the usage of talc or clay should help if misting problems occurs. Misting phenomenon is seen in figure 7. (6)

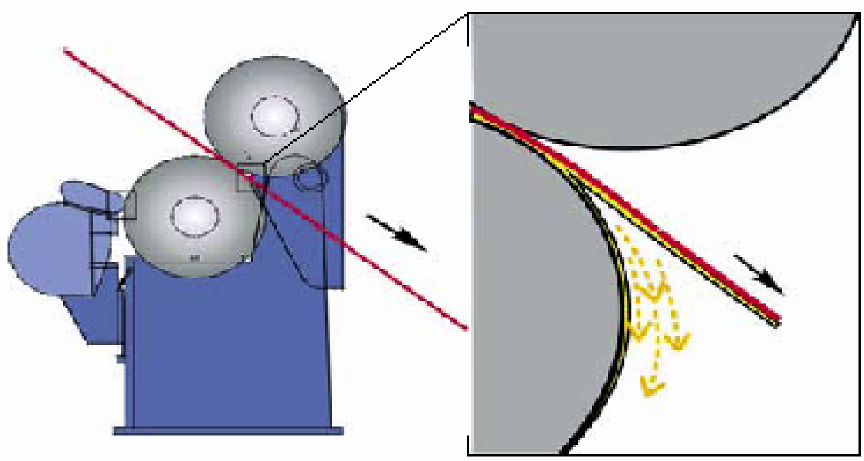

Figure 7 Misting in the transfer nip is a problem with spherical pigments such as $CaCO_3$. (6)

5.4.2 Coating colour spitting in the application nip

Sometimes the coating colour starts to mist in the application nip, that is called the rod spit. Too high rod pressure or too hard application roll cover may cause it. Rod spit can also occur if the station is not cleaned properly. The rod and rod bed should be kept clean always to prevent any kind of problems especially misting in the application nip. The coating colour should be effectively screened before pumping it in to the application chamber, because dirt particles and other impurities that reach the rod surface can cause rod spit. It can be prevented with increasing the rod rotation speed. Also changing the rod to a larger diameter can help. (6)

5.4.3 Drying of the coating colour on the transfer roll surface

This can be a problem if the solids content of the coating colour in the process is high. Figure 8 shows two different kinds of coating colour drying on the transfer roll surface. Main reasons affecting this are as follows:

- The solids content is close to solidification point of the formulation
- The water retention is low
- Too low CMC/insoluble binder amount
- Pigments are more plate like

The drying can be prevented with diluting the coating colour, decreasing the rod pressure to gain more wet film or increasing the CMC amount. (3)

Figure 8 On left is a wide immobilized layer coating colour dried on the surface of the transfer roll and on the right side is streaks caused by drying. (6)

5.4.4 Orange peel

Orange peel becomes sometimes a problem if the coat weight gets too high or the solids content too low and the film splitting in the application phase is disturbed. It decreases the surface quality dramatically, because the surface is not any more smooth but bumpy. Orange peel has become one of the limiting factors in the film transfer processes, because the machine speed is one of the variables that cause it if the speed gets too high (4). And the both sides simultaneously coating units are especially vulnerable when the speeds are increased. In figure 9 there is the operational area as a function of solids content, it shows how the orange peel is a problem with the high coat weights and how it becomes more possible when the solids content is decreased.

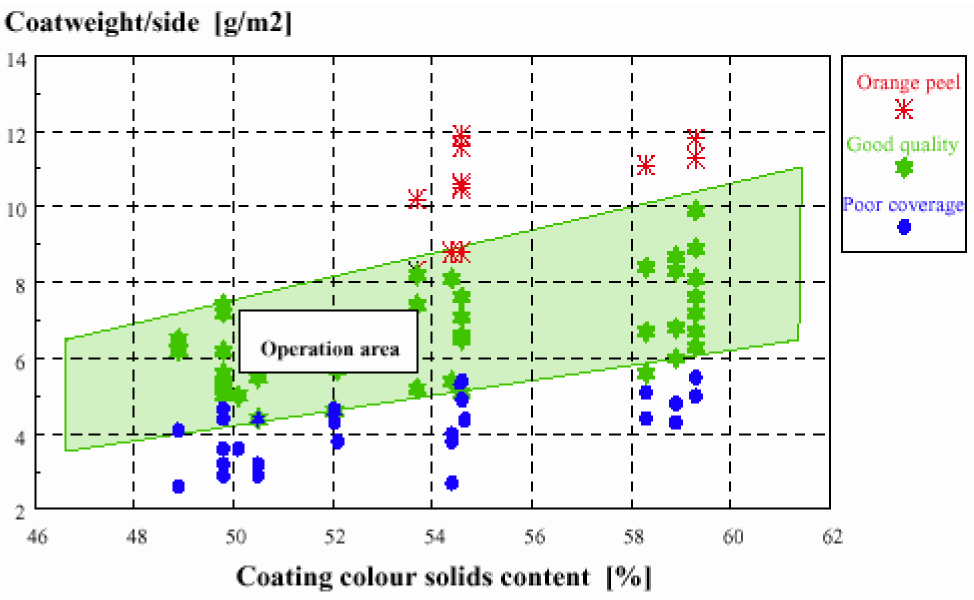

Figure 9 Orange peel is a problem with high coat weights and gets more usual if the solids content is decreasing. (6)

5.4.5 Web stealing

Web stealing means that the paper web is attached uncontrolled to bottom or top roll when it exits the press nip. This can happen if there is high wet film amount after the nip or the machine speed is too high. This makes the paper web alternate between the top and the bottom rolls, which has an effect on the surface quality. Web stealing is demonstrated in figure 10. The higher the speed or the bigger the amount of wet film the longer the distance that the paper web follows the applicator rolls. (5) The web stealing can appear either on the whole web width or just on the edges. It immediately causes streaks or pattern in the coated surface. The streaks are usually 10-20 mm wide or wider and oriented in the machine direction (3).

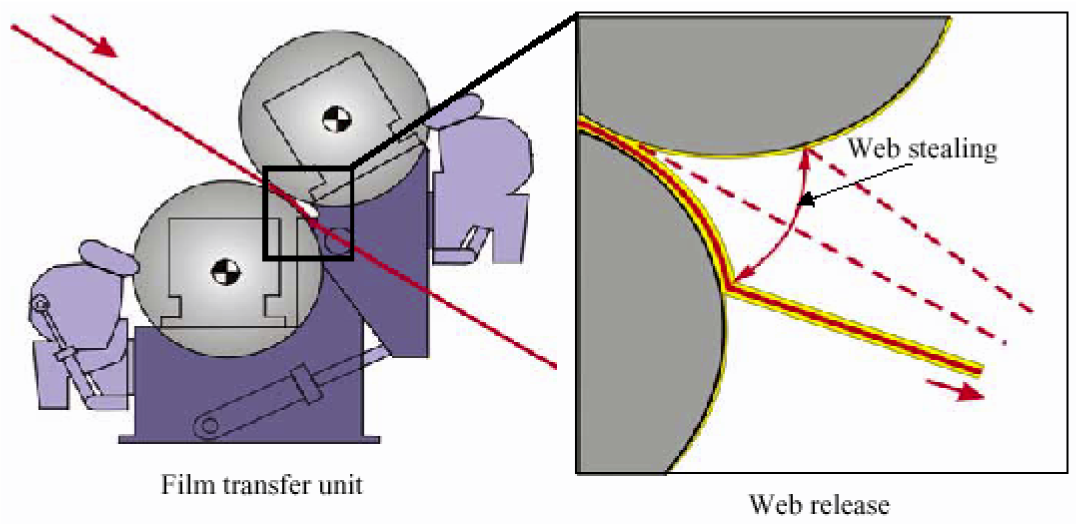

Figure 10 Web stealing after the press nip may become a problem with high speeds and big wet film amounts. (6)

5.5 Film coating usage

In the beginning the film transfer units were only used for surface sizing to replace old pond size presses and that is still very usual. Nowadays film transfer processes are also commonly used as a precoating unit for double or triple coated grades. Sometimes they are used for final coating, but then rarely both sides at the same time type of systems. It is very useful as a standard LWC offset grade coater, still there are some problems with the rotogravure grades, because the lack of smoothness, but it can be used with low grammages (4). The future seems quite bright with the film coaters, because the lack of space in rebuilds, so very often the film coating unit is the only possible solution. Growing usage of recycled fibres demands more and more gentler coating processes and that is where film coaters are needed.

6. COATING COLOUR RAW MATERIALS

The target in Sittingbourne is to make a precoat for double coated wood free paper for offset printing. The most important thing is to get the precoating attach tightly to the base paper and afterwards to get the surface layer smoothly on the precoating layer. In the Sittingbourne mill the coating colour is mixed in the coating preparation plant and from there it is pumped to the coating unit's feed tanks. The used raw materials are calcium carbonate, latex, starch, NaOH, Optical brightener agent (OBA) and blue pigment. Usually the shares of these raw materials is about 75-95 % of dry coat weight is pigment (calcium carbonate) and the rest is mostly binders (lateces and starch), leaving the share of additives (NaOH, OBA and blue pigment) to about 1 % (4). Next is introduced the raw materials that were used in the Sittingbourne Paper Mill.

6.1 Ground calcium carbonate (GCC)

The ground $CaCO_3$ is a great pigment for precoating of WFC-papers. It is quite a cheap pigment. The need of binders is low with the GCC, because of its shape, which has a large characteristic area. In the precoating process GCC improves the attaching of the surface layer, which is important for offset grades. Other reasons for using calcium carbonate as pigment are as follows**:** (4)

- High brightness
- High whiteness
- Betters opacity and porosity
- Good printing ink absorption
- Less blistering in the offset printing
- GCC lowers viscosity
- Can be used in high solids contents
- Good OBA efficiency

6.2 Binders

The binders are used for binding pigment particles together and more importantly attaching the pigments tightly to the paper web surface. Binders have also other important properties that influence on the final coating colour mixture. Hoped properties are for example high binding ability, colourless or high whiteness, good water retention and good rheological properties. (4)

6.2.1 Latex

Latex is a synthetic polymer water mixture, so it is basically plastic particles in water (4). Lateces have very high binding ability, good wet strength and low viscosity. Latex gives the possibility to use high solids contents in the coating colour formulations and they give the paper good calenerabilty and printability (10). However the lateces can’t be used as the only binder, because they have so poor water retention. So they must be used with for example starch or CMC. Lateces are also very temperature- and pH dependent, also foaming and sensitivity for shear forces can be a problem (4).

6.2.2 Starch

Starch is the most commonly used water-soluble binder. Starch can be produced from potatoes, maize and wheat. It is not ready for use straight from these plants. The structure chains have to be broken first to smaller pieces and some chemicals added to these structures. Then it is ready for use with good solubility and viscosity properties. Starch has alone poor binding ability and it is mainly used with latex and in these mixtures it works to make higher viscosity and to enhance the water retention. When starch is dried it forms a hard non-flexible surface. It is very cheap raw material and it has good runnabilty properties. (4)

6.3 Additives

NaOH, OBA and blue pigment are used in the coating colour as additives. Each one of them has a special function making the mixture work better. NaOH is used for adjusting the pH of the coating colour to optimal and also to get certain surface pH that is required by the printing process. OBA is used to get higher brightness, it works by reflecting the UV-radiation back as bluish visible light to get the image that the paper is actually brighter than it is (10). Blue pigment is used to get the feeling that the paper is whiter than it is, because human eye sees bluish as whiter.

6.4 Measured properties from coating colour

There are some very important variables that are observed many times in one shift (12 hours). Viscosity, solids content, pH, and temperature are the four most observed variables. They are all big factors in the rheological behaviour of the coating colour. Values for these four are measured in a laboratory straight from fresh samples. In some mills there are also on-line measurement units that can give estimations and directions for the variables.

6.4.1 Solids content

Solids content has an effect on the dry coat weight so it is very important to keep stable. The higher the solids content is the higher the coat weight is. In film transfer coating it is important not to let the solids rise too high because high coat weights may cause orange peeling in the paper surface. Too high solids content may also cause increasing wearying in the machinery. It should be kept constant also because it has an effect on viscosity, lower solids decrease viscosity. The coat weight can be adjusted by changing the solids content from the coating preparation plant by putting more or less water in the coating colour mix and the fine adjusting is made with the rod pressure. Figure 11 shows how the solids content and the rod pressure change coat weight. This is very accurate way to adjust it but quite slow, because it takes a couple of hours to have an effect on coating colour circulation, where is tons of coating colour circulating.

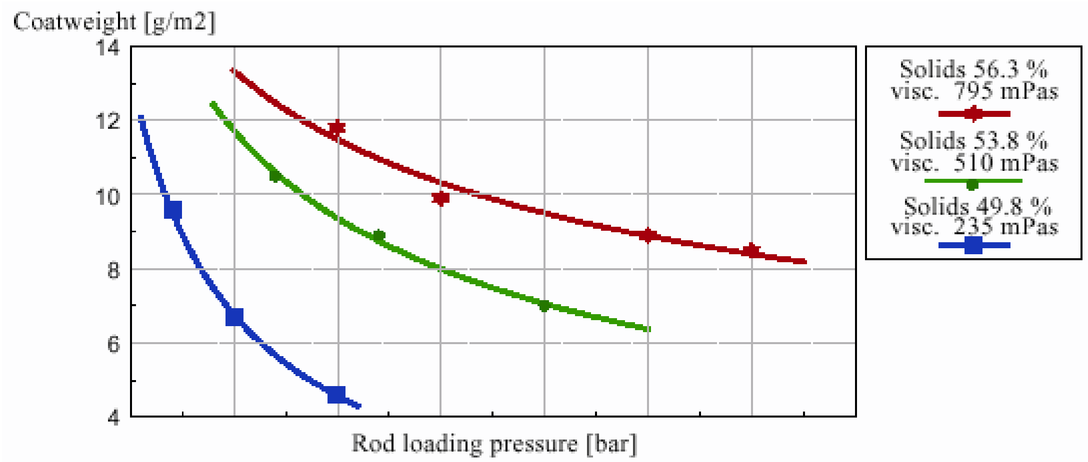

Figure 11 The effect of solids content and rod pressure on coat weight. (6)

6.4.2 Viscosity and temperature

Viscosity is the most important variable in the rheological behaviour of the coating colour. Viscosity is strongly depended on temperature. So the process temperature should be kept as constant as possible to reduce viscosity changes. This is important both in the preparation plant and in the coating machinery. Coating colour viscosity usually decreases when temperature increases. Viscosity is also very sensitive for particle size, particle shape and particle size distribution changes. It decreases when particle shape changes closer to spherical, because the non-regular shaped particles have difficulties to arrange in order. If the particle size is decreased the viscosity will increase, because the space between particles gets smaller in the same solids content. When the particle size distribution is narrowed the viscosity will decrease, because there are more similar size particles and they can move more freely together and by each other. Air removal is also very important in the coating processes, because air bubbles increase the viscosity strongly and they may also cause streaking. (4)

6.4.3 Water retention

Water retention indicates the coating colour's ability to hold water in itself after application. If the water retention is good, the solids content of the coating colour is stable. If the solids content increases during coating, the water of the coating colour penetrates into the paper, which can cause uneven binder distribution on coated paper. Water retention has an effect on runnability in the coater. (3)

6.4.4 pH

The pH must be adjusted to prevent unwanted chemical reactions to happen and on the other hand to get the wanted reactions to happen. The coating colour pH must be adjusted on the level that is required by the printing process. Otherwise the printing inks will not act as they are supposed to. Foaming is a common problem when the pH gets too low and when calcium carbonate is used in coating colour. It is sensitive for temperature variations so the measurements should be performed in accurate conditions. (3)

7. REVIEW OF THE LITERATURE PART

M-real Sittingbourne Paper Mill has long history in papermaking. The first signs of papermaking are as early as 1703 and the actual mill was founded in 1870’s. Since that there has been 10 to 15 paper machines and nowadays there are two machines. The mill itself has been strongly re-built in many process areas during recent years.

The main product in the mill is double-coated fine paper. This grade demands high optical properties with over 90 % ISO standard brightness and whiteness. This is achieved by using calcium carbonate as fillers and in the coating layers. The coating layers are on-line film transfer coating as precoat and finally blade coating off machine.

The on-line film coating requires from the base paper certain things including good smoothness and very uniform cross and z-directional profiles. On the other hand, the tear and tensile strengths don’t have to be extremely high, because there is no doctoring element against the paper web. Surface strength still is very important for both the base paper and the coating layers, because the products are printed mainly with offset. Film coating method suites very well for the offset printing, because it has excellent coating coverage. The lack of smoothness is a problem for rotogravure printed grades.

The coating colour raw materials play a big role in coating. With ground calcium carbonate can be achieved high brightness and whiteness and good attaching between the two coating layers. Latex and starch are used together, because of their high binding strength and good water retention together. Some optical brighteners and blue pigments can be used to make the paper look whiter than it actually is. The coating colour has some critical properties that are observed on-line and a couple of times in a shift in laboratory, for example solids content, viscosity, temperature and pH.

EXPERIMENTAL PART

8. WORK BACKGROUND

After the investigations and assessing the situation in the PM15 and SymSizer it was time to think about the trials. In the beginning of my research the CD profile variations increased in the SymSizer so some development to that problem had to be done also. Trials were planned carefully with my boss Simon Tyler, Senior Product Development Engineer and with Production Manager and mill’s Technical Manager. After planning I implemented the trials with the workers in different shifts.

9. TRIALS

For the original project plan concerning the MD variations I had some suggestions for trials and those were first discussed with my boss and then accepted by mill personnel. Two trials were made for the MD variation. First checking the on-line measurement systems and their accuracy in showing the coating colour consumption and the coat weight. Second was to test how coat weight changes when water is added in the coating colour in the preparation plant. Same time with the second test was to be tested how the CD spread value reacts to rod pressure changes. For the CD profile problems the SymSizer roll and rod temperatures were measured and compared to coat weight profiles in the third trial.

9.1 Coating colour consumption

First step for this trial was to measure how much the SymSizer consumes coating colour by measuring the consumption from the preparation plant. Then compare it to the value that the on-line system shows. This was to be made a couple of times to get accurate results.

9.1.1 The trial

The preparation plant controller makes a mixture batch in a mixing tank, when it is ready the colour is dropped in to the precoat machine tank. From there goes a pipeline in to the SymSizer feed tank and back so there is a ring where the colour circulates. There is an automatic valve in the pipeline that is controlled by level indicator of the feed tank. So whenever the level drops to certain amount the valve opens and the tank is filled again. To get the consumption all that is needed is to drop a certain sized batch to the precoat machine tank and measure how long does it take for the SymSizer to consume it. Then calculate the amount that is used in an hour and compare it to the value that the on-line system shows. It had to be calculated from the average coat weight from the same hour that the measurement was made.

9.1.2 Results

The measurements went well and three results were achieved on three days. All of these results show that some improvement has to be done for the on-line measurement equipment. In the first trial the operator dropped six tons of coating colour in to the machine tank and it took 60 minutes to consume it. In table 1 are the results and calculations of the trial. The solids content was measured before and after the drop and an average was taken, but both of the values were the same, 68 %. Paper machine speed during this trial was 781 m/min and the trim was 3.90 metres. In table 1 there are three values highlighted they are the coat weight values. First there is the value that is measured from the actual coating colour consumption, second is the Measurex value that is seen in the operator room monitors on-line, the value is the average from the 60 minutes time. Third value is from the QIS-system that is the mill's surveillance system, it measures the average values from Measurex for every reel that is made in the mill and saves them in the database.

As seen from table 1 there is quite a big difference. Very problematic is that if the target that the SymSizer operator is trying to reach is 20 g/m^2 and the Measurex shows just 19 g/m^2 the operator tries to increase the coat weight. But the actual coat weight has been already over 22 g/m^2 so the result is that the quality is getting poorer all the time. The last three lines in the tables 1.2 and 3 are calculations of how much the mill would waste coating colour if the Measurex and QIS –values were correct. As seen from table 1 there would be over 20 tons waste every 24 hours, so that would be recognisable in the waste water department. So the on-line measurement values must be incorrect. The same error is seen in the other two trials also that are shown in the tables 2 and 3.

Table 1 The results of the first coating colour consumption measurement.

26.8.2005	
Machine speed m/min	781,00
Web width m	3,90
Kilos of coating colour	6000,00
Time of consumption	60,00
Solids content	0,68
Coating g/min	100000,00
Dry coating	68300,00
m2/min	3045,90
Measured CWt /m2	**22,42**
Measurex value	**19,00**
QIS value	**18,07**
kg/min wasted if true	10,43
kg/24h wasted if true	15016,18
kg of slurry wasted in 24h	21985,62

The process parameters are a little different in table 2, but it doesn't matter because the calculations still are correct and the results are the same. Again there is over four grams difference in the coat weight value between the trial and the Measurex and waste amount over 30 tons per day.

Table 2 Results from the second trial concerning the coating colour consumption.

30.8.2005	
Machine speed m/min	801,00
Web width m	3,90
Kilos of coating colour	7500,00
Time of consumption	67,00
Solids content	0,69
Coating g/min	111940,30
Dry coating	77014,93
m2/min	3123,90
Measured CWt /m2	**24,65**
Measurex value	**20,00**
QIS value	**18,96**
kg/min wasted if true	14,54
kg/24h wasted if true	20933,17
kg of slurry wasted in 24h	30426,12

Third trial was made to ensure that the results were correct. And again they show that there are problems with the calibration of the Measurex system. In table 3 is seen that still there is about four grams difference between the actual coat weight and the on-line measurement system.

Table 3 Results from the third trial concerning the coating colour consumption.

31.8.2005	
Machine speed m/min	831,00
Web width m	3,90
Kilos of coating colour	7500,00
Time of consumption	72,00
Solids content	0,69
Coating g/min	104166,67
Dry coating	71770,83
m2/min	3240,90
Measured CWt /m2	**22,15**
Measurex value	**18,50**
QIS value	**18,41**
kg/min wasted if true	11,81
kg/24h wasted if true	17012,42
kg of slurry wasted in 24h	24691,47

9.1.3 Analysing the results

This trial shows clearly one problem concerning the MD variability. When the crews in the shifts do not know the real coat weight that they are running it is impossible to control the coat weight. According to this trial the coat weight is all the time much too high and even worse the controllers are trying to increase it because they think that they are too low on coat weight. In the literature part was explained how too high coat weight may occur as serious quality problems and it could affect runnability problems too. There were no real quality problems this time but runnability was a little poor. There were quite much web breaks, which is unusual for the PM15, because normally they run a couple of days without any break at all. Figure 12 shows a bit clearer the problem. There can be seen the four grams difference in each trial between the actual coat weight and the Measurex value. The incorrect QIS-value compared to the actual coat weight is very challenging for the Research and Development people. They think that the coat weight is low all the time and try to do work to increase it. Same thing is for the people working on the quality, because the quality is probably something else than they are predicting.

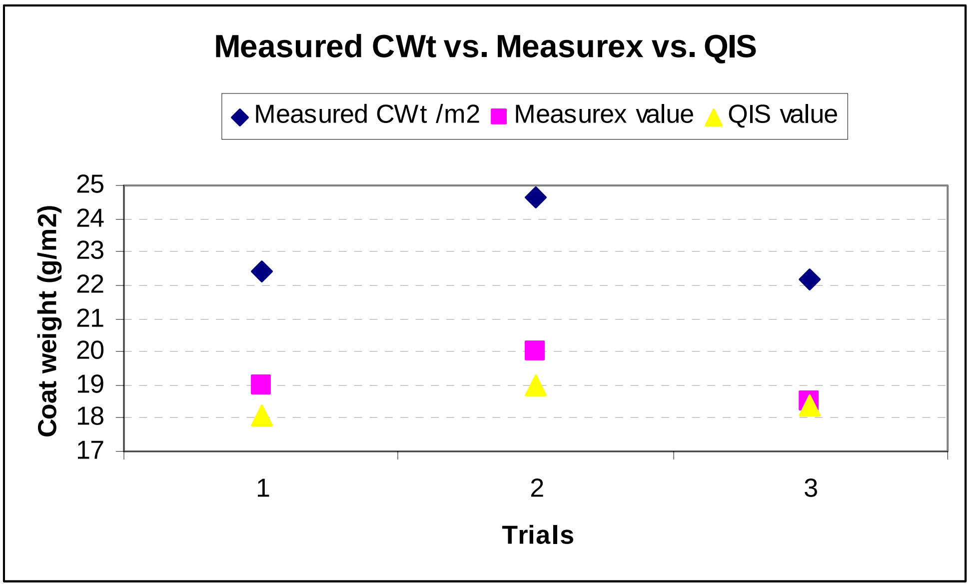

Figure 12 The actual coat weight is four grams more than the Measurex is showing and the QIS is even lower.

9.2 Coating colour dilution in the preparation plant

This trial included two parts. In the first part water was added to the coating colour mixture and then to the circulation ring. The purpose was to find out how long does it take to have an effect on the solids content in the SymSizer coating colour circulation and how long does it take to reach equilibrium in solids content and further how does it change the coat weight. When adding water to the mixture the solids content should decrease and with it the coat weight should drop too. After the part one begins immediately the second part where the purpose is to increase the coat weight by decreasing the rod loading gradually. When the rod loading is being decreased other objective is to observe does it have an effect on the CD spread value. The CD spread value gives the information how the rod pressure changes the CD profiles, basically it is the standard deviation value of the CD coat weight variation.

9.2.1 The trial

The first part of the trial began with adding two parts of water in to the coating colour mixture. The solids content was measured in the beginning of the trial. After an hour the first solids content samples were taken from the SymSizer feed tank. Samples were first taken every half an hour, but after two samples the decision was made to take one every hour, because the change was so slow. After the solids content began to reach equilibrium and the coat weight had dropped to a certain level started the part two of this trial. The rod loading was decreased gradually after every reel change so it was easy to get the average coat weight and CD spread results straight from the QIS-system. And finally the rod loading was put to a level that was the target for the grade that was running during trial.

9.2.2 Results

The first sample was taken at 10.40 o’clock from the original coating colour without the added water. The solids content was 69.7 %. The first drop of the mix with two parts of water was at 12.30, just before the drop the solids content was still 69.7 %.

The first sample with the two parts of water in the mixture was taken at 13.30 and the last one at 17.00. I started to take samples twice in an hour. Between 12.30 and 13.00 the dilution had affected a little and it kept decreasing the solids content quite steadily down to 14.00 o'clock when the solids content was 69.1 %. After that the value started to reach equilibrium by dropping only about 0.5 % per hour so the samples were decided to be taken once in an hour. By 17.00 o'clock the solids content had dropped to 68.93 % and no more samples were taken. The results are in table 4. During the time between 12.30 and 17.00 the coat weight dropped a little over 1 g/m^2. This follows very well the theory of film coating, because there is a rule of thump that +/- 1 % solids content equals +/- 1 g/m^2.

Table 4 The effect of two parts added water to the solids content and to the coat weight as a function of time.

Time	Solids content	CWt (g/m2)
10,40	69,70	
12,30	69,70	19,5
13,00	69,60	
13,30	69,45	
14,00	69,10	
15,00	69,05	
16,00	69,00	
17,00	68,93	18,3

After the solids content had reached equilibrium began the part two from this trial. When the part two began the rod loading was 2.5 bars in both application heads. And the coat weight was 18.3 g/m^2. The test was started by decreasing the rod loading to 2.2 bars and then observing how long does it take to increase the coat weight and reach equilibrium. In table 5 is also the "time of change" column, which tells if the coat weight change was rapid or slow. Slow means a few minutes and quick is less than one minute. Changes carried on after every reel change down to 1.8 bars when the coat weight had increased to 19.2 g/m^2. This the maximum that could be changed, because during this time the coat weight CD spread got quite poor and there were quality limitations that had to be obeyed. In table 6 is shown how the CD spread responded to the decreasing of the rod loading. As the pressure was decreased the CD profile started to go worse from 1.81 to 2.26 and the mill personnel ordered the rod loading to be increased. First the rod pressure was increased to 2.1 bars and the coat weight dropped immediately to 17.8 g/m^2 and the CD spread values lowered to 2.21.

Improvement was still needed and the rod pressure was put to 2.3 bars. After this the coat weight changed to 17.5 g/m^2 and the CD spread dropped to satisfied level of 1.72.

Table 5 The effect of rod loading on coat weight and the response time of the change.

Reel number	Rod Load (bar)	CWt (g/m2)	Time of change
5798	2,5	18,3	slow
5799	2,2	18,5	slow
5800	2	18,8	slow
5801	1,8	19,2	slow
5802	2,1	17,8	very quick
5803	2,3	17,5	quick

Table 6 The effect of rod loading on the CD spread.

Reel number	Rod loading	CD spread
5798	2,5	1,81
5799	2,2	1,91
5800	2	1,91
5801	1,8	2,26
5802	2,1	2,21
5803	2,3	1,72

9.2.3 Analysing the results

Part 1

The results from the first part of the trial were just as predicted. When the extra water starts to affect the solids content decreases and so does the coat weight. The main target on the other hand was to define how long does it take to have an effect on the solids and how long to reach equilibrium. From figure 13 can be seen that it takes about 1.5 hours to the water to really have an effect on solids content. During that time the solids content had dropped from 69.70 % to 69.10 % and after that it took three hours to decrease 0.20 % so clearly the solids content began to reach equilibrium. In coat weight wise during the 1.5 hours the coat weight had dropped about 0.6 g/m^2, according to the rule of thump where 1 % change in solids means 1 g/m^2 in coat weight. In table 4 was mentioned that during the whole trial the coat weight had decreased from 19.5 g/m^2 to18.3 g/m^2 and at the same time the solids content dropped about 1 %.

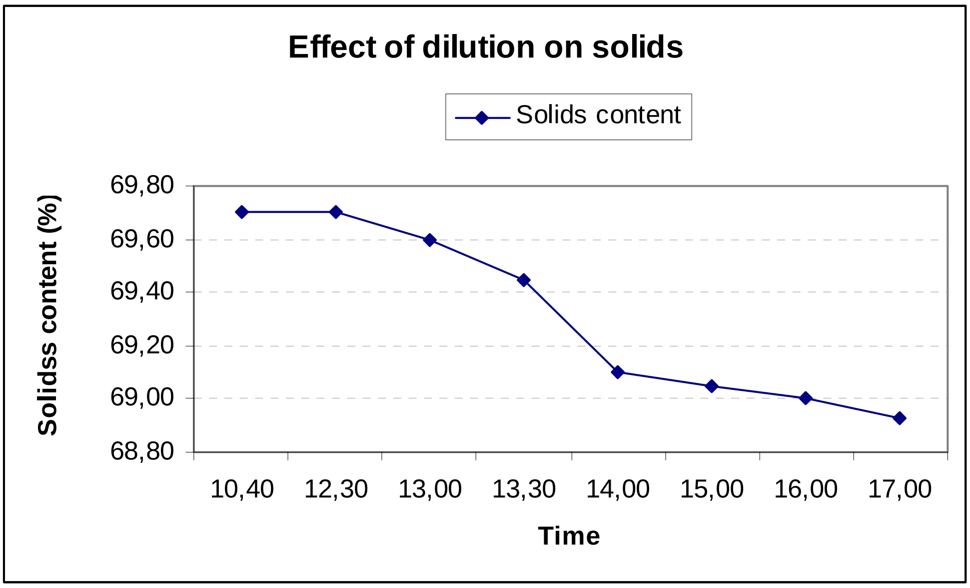

Figure 13 The effect of dilution on solids content when two parts of water is added in the preparation plant.

For controlling the MD coat weight in the SymSizer the dilution in the preparation plant is very accurate way of adjusting and it stays stable after the effect of the water. The most important thing is to be patient. If the operator wants to change the coat weight this way it can take over four hours to get the wanted change. During the trial the preparation plant operator was told to put two parts of water to the mix at 10.40 am and the first drop to the circulation was 12.30 pm and after 2 pm the solids content was still decreasing slowly. Still if the dilution is well planned and the two operators have good connection the wanted solids decrease can be achieved in 2 hours. As control strategy wise the two parts of added water changed the coat weight about 1 g/m^2 and further trials should be made to investigate how different water amounts change the coat weight. Now there was no time to test if the coat weight change is linear as a function of dilution water amount, but now it is tested that it is as a function of solids content.

Part 2

After the coat weight had decreased to 18.3 g/m^2 began the part two of the trial where the target was to test the effect of rod loading on coat weight and CD spread. In the beginning the rod pressure was 2.5 bars and the changes were made every time the reel was changed. The first change was to decrease the rod loading to 2.2 bars. The coat weight increased to 18.5 g/m^2 and it changed quite slowly as mentioned in table 5. Figure 14 shows how the rod loading changes the coat weight. The coat weight follows almost linearly the rod pressure changes, but in the opposite way. During the trial the rod pressure was changed gradually down to 1.8 bars and then the coat weight had increased to 19.2 g/m^2. At the same time the CD spread value had also changed and it had gone so poor that the rod pressure couldn't go any lower, because the paper quality would have been too poor then. The CD spread changes are seen in figure 15. The biggest change towards poor CD profile happened when the rod loading was changed from 2.0 bars to 1.8 bars. That time the CD spread changed from 1.9 to 2.26. After that the rod pressure was increased to 2.1 bars and finally put to 2.3 bars. This improved the CD spread and as predicted the coat weight dropped. With the 2.3 bars rod pressure was achieved quite good CD spread value as it dropped to 1.72, which was better than in the beginning when the pressure was 2.5 bars. Weird thing about the decreased coat weight was that it dropped lower than it had earlier been with similar rod pressures. For example with 2.2 bars the coat weight was 18.5 g/m^2 and with the 2.3 bars it was 17.5 g/m^2. This might indicate that the solids content was still decreasing a little and affecting the difference between the values. As table 5 shows the change in the coat weight was very quick when the rod pressure was increased unlike when it was decreased.

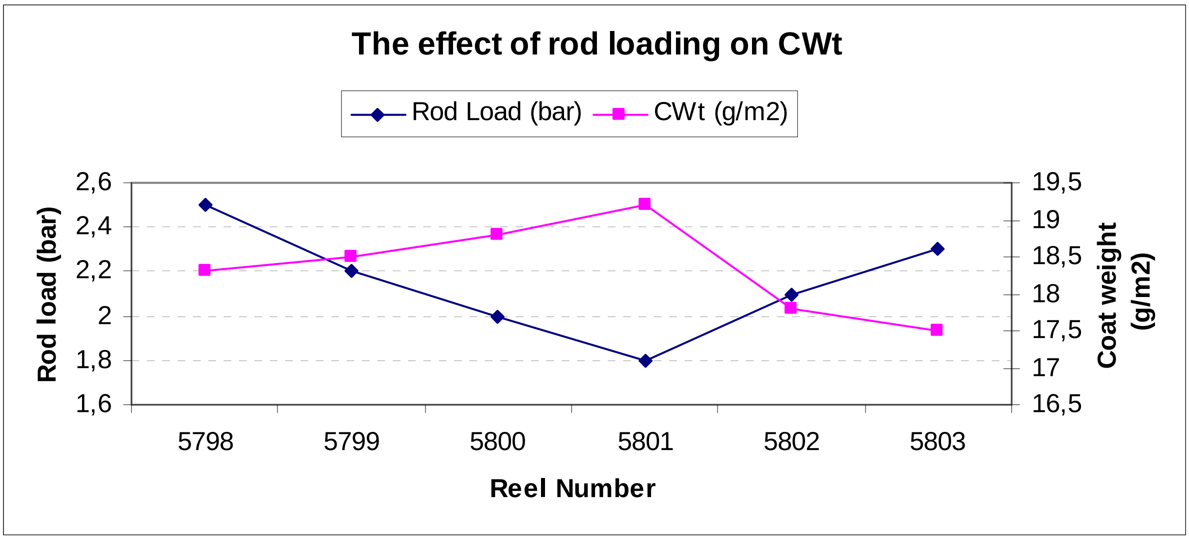

Figure 14 The effect of rod loading on coat weight.

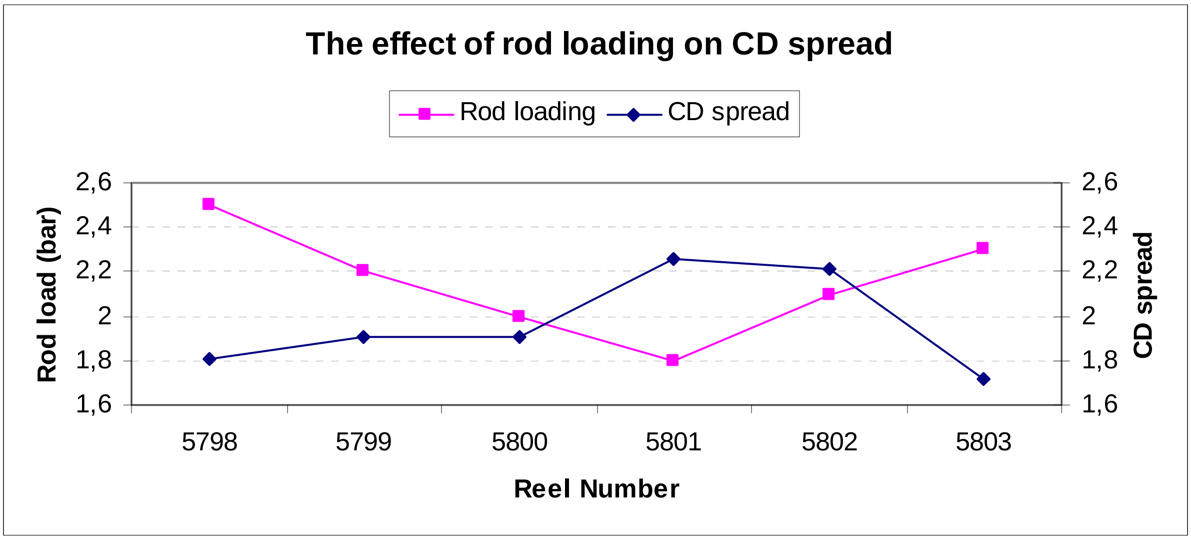

Figure 15 The effect of rod loading on the coat weight CD spread.

This trial indicates clearly the risks of adjusting the coat weight too much with the rod loading. First of all there can never be said beforehand what the coat weight is going to be with certain rod loadings, because there more dominating process variables such as the dilution water amount. Of course the MD coat weight fine tuning can be made with rod pressure, but it has to be observed all the time how it reacts to changes. For example if the coat weight is something with 2.0 bars rod pressure it can be completely different in three hours if something else has changed in the process as figure 14 shows. The other thing is the CD spread. The trial made it clear that the rod pressure has an effect on the CD profile. Especially the change between 2.0 and 1.8 bars was significant as seen in figure 15. This indicates that changing the rod loadings may cause quality problems if the CD profiles are not observed often enough. This may have an effect on the final product also if the top coating layer is not attaching the precoating uniformly, it may cause problems in the printing process.

9.3 Temperature profiles at the coating station

This trial was done to find out if the application rolls and the metering rods temperatures had any influence on the coat weight CD profiles. The temperatures were measured with an infrared hand thermometer from several spots along the rolls and rods then figures were drawn and compared with the QIS-system coat weight profiles. The temperature profile is important for the product for two main reasons. First the machinery alignment is strongly depended on the temperatures in the station. Second one is the moisture profile at the coating unit changes if the temperatures are considerably different between front and backside.

9.3.1 The trial

The trial was carried through in three days. During that time I made three temperature figures and compared them to QIS coat weight profiles. In the first measurement there were seven spots from the rolls and rods measured with the temperature measurement device. In the second and third ones I wanted to get more accurate results and took 16 spots and drew the figures from them. The first and the second test showed that the problem was in the bottom roll and rod so from the third test there is a figure only from them and not from the top ones.

9.3.2 Results

During the trial the top roll and rod temperatures did not have considerable variation, as seen in the figures 16 and 19. The rod temperature was lower than the roll’s in the top rod, but in the bottom the rod and the roll temperatures were quite similar. After two measurements the top temperatures were left, because they didn’t have the variation that the bottom ones did. The figures 17 and 18 indicate the correlation between the coat weight and the temperature. The coat weight profile clearly follows reversed the temperature profile. On the next day the test was repeated and the figures 20 and 21 show how the profiles are still very similar. During that day the results were shown to mill personnel and they tried to make corrections to the profiles by changing the cooling water flows at the SymSizer bottom application roll. Figure 22 shows how the roll temperature has levelled to around 51 ^{o}C and the coat weight profile has got a bit better. Still there is a two degrees temperature difference between the front and backside and that is seen in figure 23 where the coat weight profile is also a little higher in the front edge than the back edge.

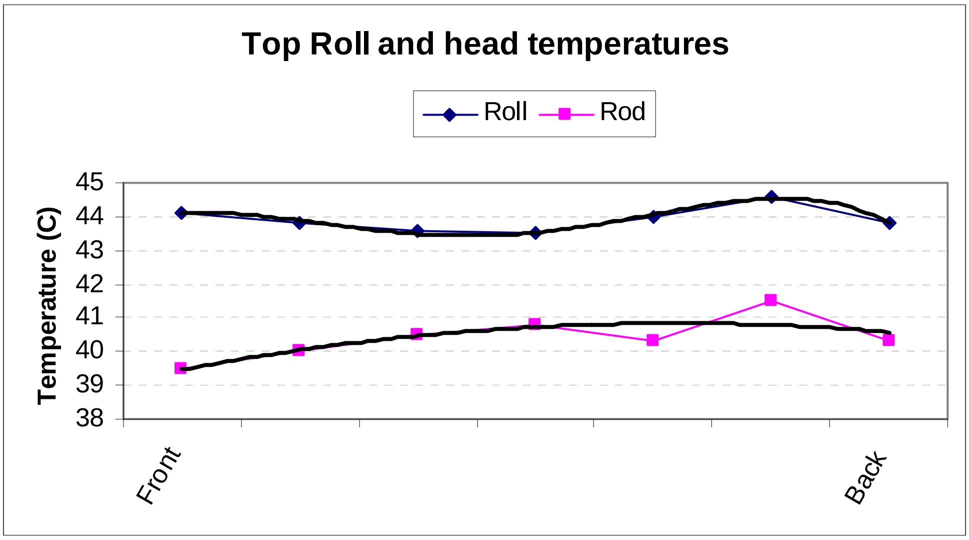

Figure 16 Temperature profiles of the top roll and rod in the first test.

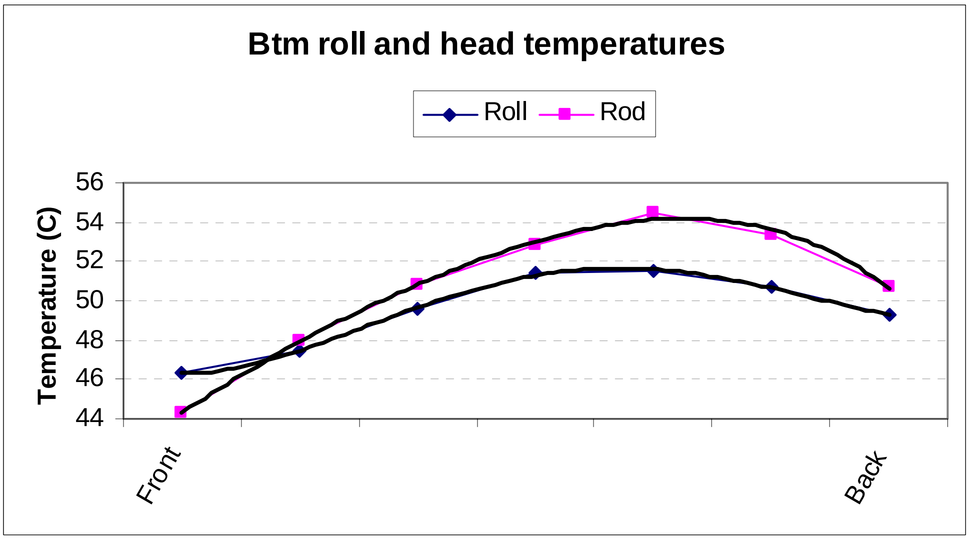

Figure 17 Temperature profiles of the bottom roll and rod in the first test.

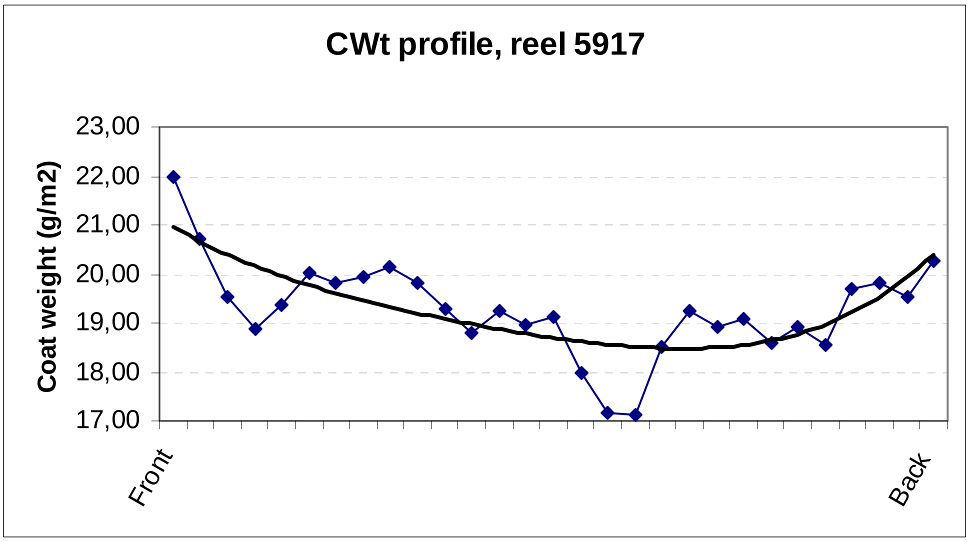

Figure 18 Coat weight profile during the first test.

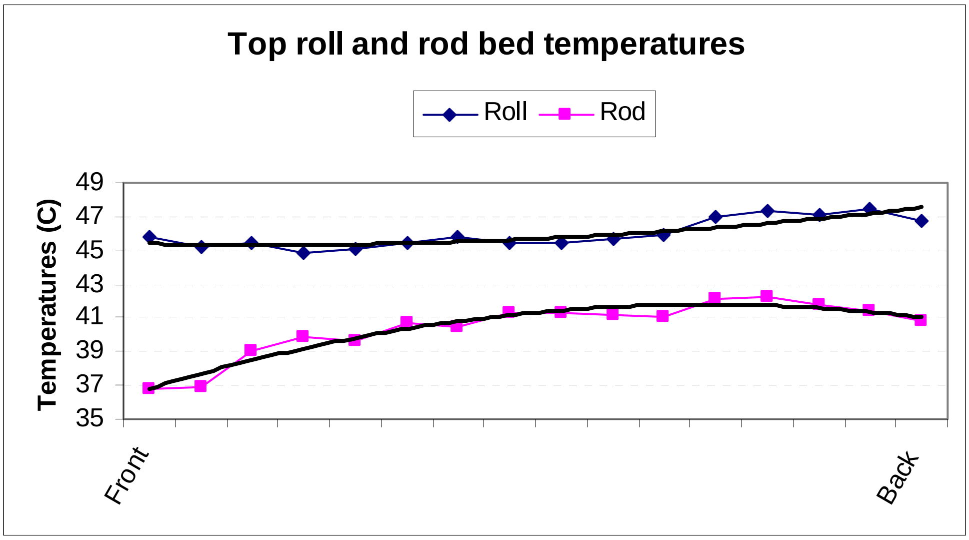

Figure 19 Temperature profiles of the top roll and rod in the second test.

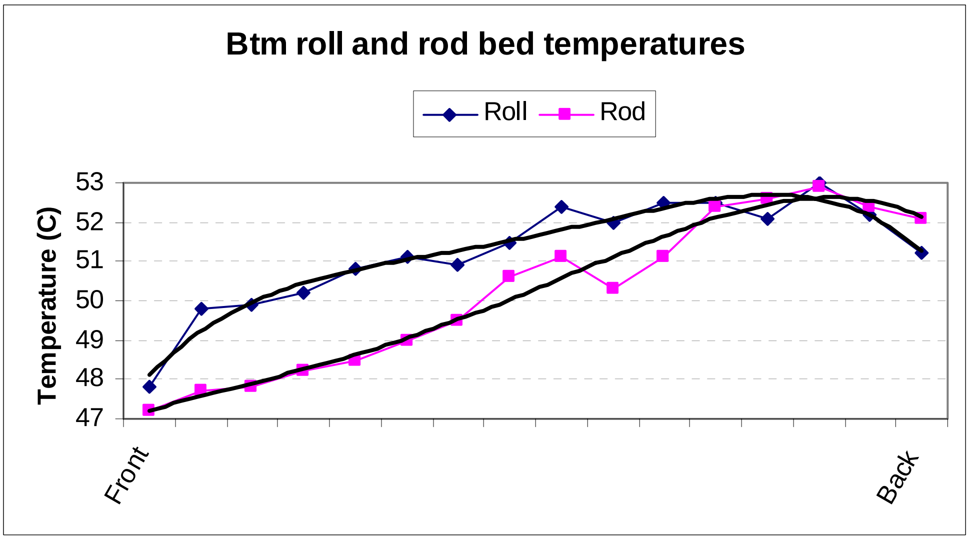

Figure 20 Temperature profiles of the bottom roll and rod in the second test.

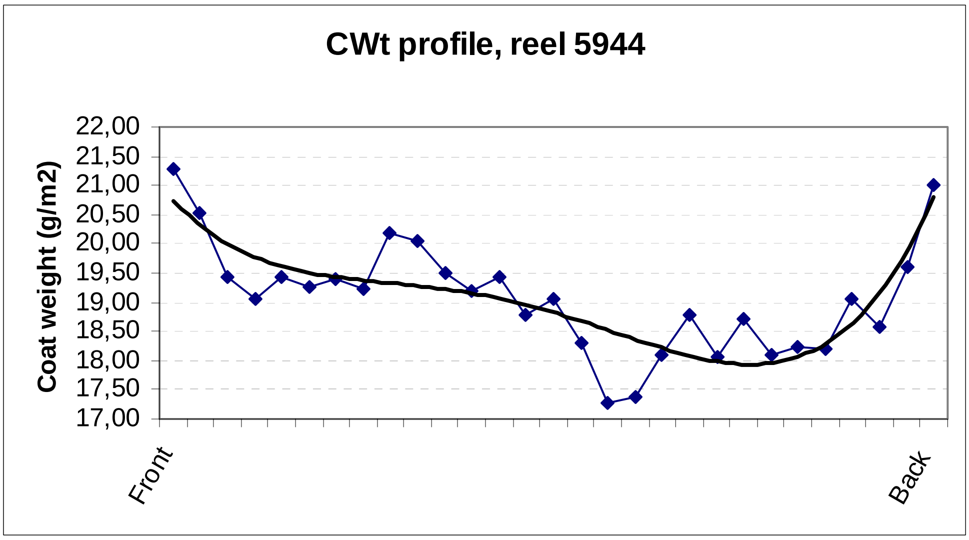

Figure 21 Coat weight profile during the second test.

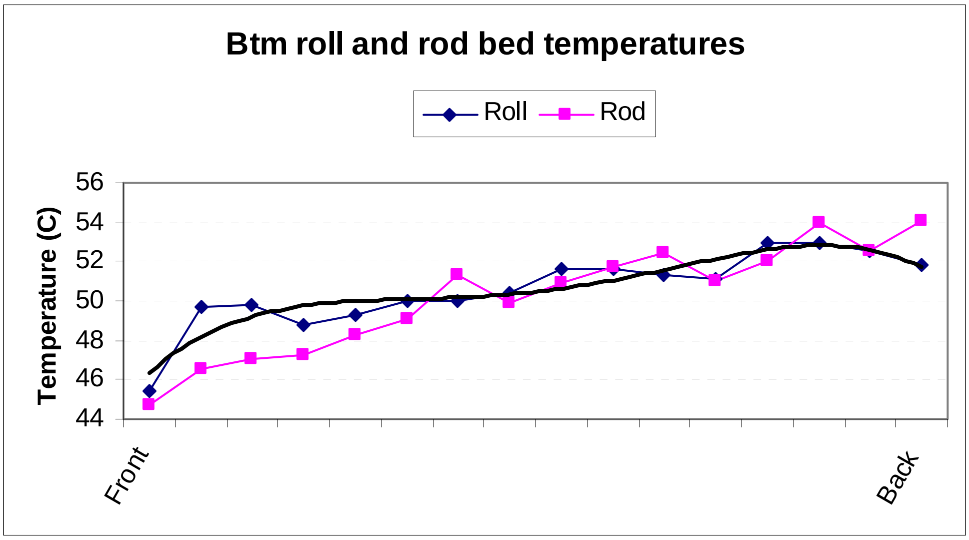

Figure 22 Temperature profiles of the bottom roll and rod in the third test.

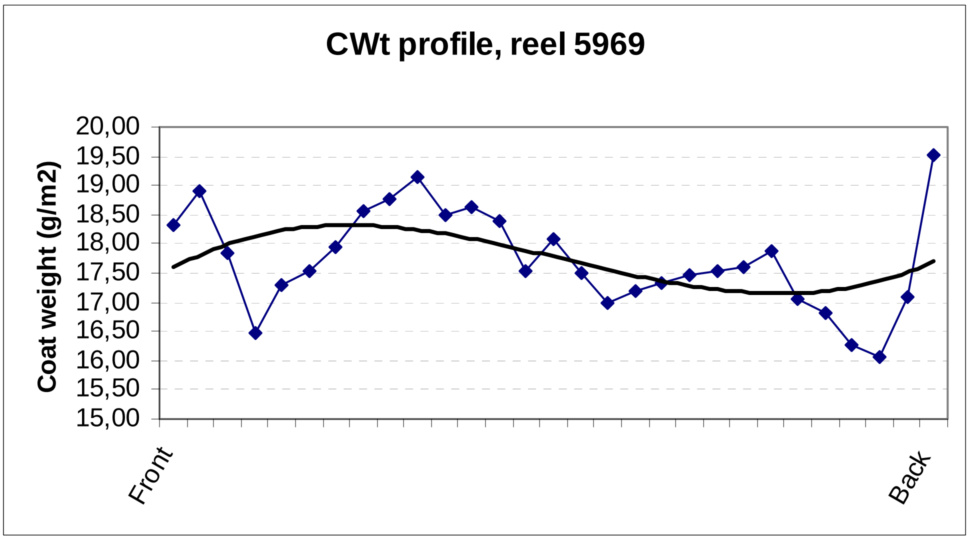

Figure 23 Coat weight profile during the third test.

9.3.3 Analysing the results

All three measurements show clearly what is the influence of temperature on the coat weight profile. The last test where the application roll cooling water flows had been adjusted shows that the roll temperatures are extremely important for the coat weight. The reason is that the coating colour dries faster on the surface of the applicator roll in the areas where it is hotter. The drier the coating colour is the less is attaching the paper web and more is sticking on the applicator roll surface. The temperature difference between the top and bottom can be explained with the lack of ventilation between the hot paper web and the SymSizer unit. That is why there is so much hotter than on the top roll, which is located freely in the machine hall air and is well ventilated.

There might be problems with the water circulation temperatures, because there are no heat exchangers to control the cooling waters for the application rolls and also for the application heads. The cooling is adjusted manually from the water feed tanks with putting more or less fresh water in there. This affects easily heavy fluctuation in the temperatures in the rolls and heads. A heat exchanger that could keep the waters in stable temperature would help the operators a lot and also decrease the CD variation.

10. CONCLUSION OF THE TRIAL RESULTS

These trials were run to decrease the machine direction coat weight variation and at the same time to observe how does the adjustments change the cross directional coat weight profiles. Some results were achieved that improved the process.

In the first trial the on-line measurement systems were checked and some problems were found. The coat weight was all the time about 4 g/m^2 higher than what it actually was according to the real coating colour consumption. This caused problems in adjusting the coat weight to targets and it may have caused some runnability issues. The high coat weight didn’t have an effect on quality yet, but certainly it is going out of the operation window of the SymSizer if the coat weight is still increased. After the Measurex-system calibration the problem should be solved.

The second trial gave the mill personnel information about the time that it takes to get an effect on the coating colour circulation’s solids content after adding water at the preparation plant. The results show that it took about two hours to reach equilibrium in the solids content and in the coat weight. During this time the two parts of added water decreased the solids content about 0.6 % and the coat weight had also decreased among the solids about half a g/m^2. It is quite a long time, but it is very effective and accurate. The important thing is to be patient and wait for the solids to drop to a stable condition before adjusting anything else such as rod loading. This trial continued after the dilution by changing the rod loading and observing its effect on the MD coat weight and CD spread. The MD coat weight acted just as predicted it increased when rod pressure was lowered and decreased when rod pressure was increased. The CD spread changed also quite linearly with the rod pressure by getting worse when rod loading was decreased and the other way around when putting more pressure on the rods. This indicated that when changing the rod loading during runs, the CD spread values should be observed regularly until it starts to be stable. And if the process is wanted to keep equilibrium the best way to change the coat weight is to add water in to the coating colour mix at the preparation plant.

The third trial was about the poor CD profiles and how they correlate with the SymSizer roll and rod temperature profiles. A straight correlation between these two was found and the explanation is quite simple. The hotter areas on the applicator roll surface dry the coating colour film more before the press nip so there is less coating attaching the paper web. In the measurements the bottom rod’s temperature profile was poor also, the applicator roll temperature most probably caused that. Solving the problem began with adjusting the cooling waters in the bottom applicator roll and the profile started to get better and the rod profile followed also. This trial shows clearly that the cooling water temperatures inside the applicator rolls have to be kept constant to keep the CD profiles acceptable.

11. SUGGESTIONS FOR IMPROVING THE PROCESS

The difference between the actual coating colour consumption and the on-line measurement equipment values should be taken seriously. The calibration of the devices should be observed more often and if needed to arrange similar trial that the trial one in this thesis work was. If these problems keep occurring the manufacturer must be contacted and improvement has to be done. The SymSizer is controlled based on these on-line measurement details and if they are so incorrect that they were the operator has an impossible task to keep the coat weight in targets and the quality may get poorer and runnability gets worse.

Temperature control in the coating process especially in the film transfer method is extremely important. A heat exchanger to control the cooling water temperatures would be a great investment. Now when the waters are controlled manually they fluctuate all the time. When operator wants to cool down the applicator rolls he manually puts more fresh water in to the supply tanks and waits for the rolls to cool. After cooling them enough the water is taken off, because the rolls would go to cool if not. Now the temperature starts to rise again and begins a vicious circle. A heat exchanger and automatic thermal indicators and controls would easily keep the temperature stable and by that keep the coating profile even.

It would be advantageous if the operators could see how much coating colour is going to either side of the paper. A system that measures both sides' coat weights separately would help to keep the paper's surfaces uniform. This is needed because the forming section is a Foudrinier type of wire section.

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