CORRELATION BETWEEN DPA AND EMERSON METHOD AS WELL AS BETWEEN DPA AND PAPER MACHINE PROCESS VARIABLES

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ABSTRACT

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Dusting Propensity Analyzer (DPA) is an online measuring device developed by ACA Systems which measures the dusting of paper. It is known to work well on a newsprint machine and the results are shown to correlate well with Emerson black cloth method, which is another way of measuring dust. In this thesis DPA was tested on a paper machine producing woodfree uncoated paper. Dust collected from a newsprint machine is mostly fiber and it is also called linting. In woodfree uncoated paper the dust is all filler and because of the different environment DPA needed more testing to see if it works with filler dust as well as it does with fiber dust. In this thesis DPA measurements are compared with Emerson black cloth measurements to see if there is a correlation between these methods. Results are also compared with different process variables to see if the reasons for dusting could be spotted.

This is the public version of the thesis which does not include confidential information.

Key words: dusting, linting, woodfree uncoated, filler

TIIVISTELMÄ

Tampereen ammattikorkeakoulu
Paperi-, Tekstiili-, ja Kemiantekniikan koulutusohjelma
International Pulp and Paper Technology

Tuomas Tatti:
DPA:n korrelaatio Emerson-mentelmän ja paperikoneen prosessimuuttujien kanssa

Opinnäytetyö 16 sivua, joista liitteitä 0 sivua
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Dusting Propensity Analyzer (DPA) on ACA Systemsin kehittämä paperin pölyävyyttä mittaava online-mittari. DPA:n tiedetään toimivan hyvin sanomalehtikoneella ja tulosten siellä on todettu korreloivan hyvin Emerson mustakangasmenetelmän kanssa, joka myös mittaa paperin pölyävyyttä. Tässä työssä DPA:ta testattiin päällystämätöntä puuvapaata paperia valmistavalla koneella. Sanomalehtikoneelta kerätty pöly sisältää pääasiassa kuitua kun taas päällystämättömän puuvapaan paperin pöly koostuu enimmäkseen täyteaineesta. Tässä työssä tutkittiin, toimiiko DPA hyvin myös filleripölyn kanssa. Työssä verrattiin DPA mittauksia Emerson mustakangasmittauksien kanssa, jotta nähtäisiin onko näiden mittausten välillä korrelaatiota. Tuloksia verrattiin myös eri prosessimuuttujiin, jotta pölyämiseen liittyviä syitä voitaisiin paikantaa.

Tämä on opinnäytetyön julkinen versio, jossa ei ole esitetty työn sisältämää luottamuksellista tietoa.

Avainsanat: pölyäminen, puuvapaa päällystämätön, täyteaine

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1 INTRODUCTION

Dusting is a serious problem in papermaking. Dusting of woodfree uncoated paper can be relatively small but still cause problems in the printing process. In printing dusting causes deteriorating quality which leads to a need to wash the machinery which then leads to production losses. Dusting is a hard problem to approach as there are no clear reasons for it and it usually is the sum of many variables.

Dust Propensity Analyzer is an online-measuring device originally placed on a newsprint machine. After the shutdown of the newsprint machine DPA was moved to a machine producing woodfree uncoated paper. DPA was proven to work well on the newsprint machine but the circumstances on a WFU machine are different. The dust releasing from newsprint paper is mostly fiber. On WFU the released particles are only fillers which of course creates significantly different requirements for the measuring device as filler particles are much smaller in size. Measuring dusting takes time and is therefore run only once every day in the mill, this is why there is a clear need for an online device.

In addition to DPA, Emerson method was used to measure dusting of the paper. For the Emerson method a standard used in the mill was also used for this thesis. In the Emerson method dust is gathered on a black cloth that is pressed against an up-to-speed paper surface. Bothe methods are described later in this thesis.

The target of this thesis was to compare the DPA method with the Emerson method to see if there is a correlation between those methods. Another goal was to study if possible reasons for dusting could be found from the process variables. In previous studies done with DPA some clear reasons for dusting could be spotted from process variables and in this thesis the results were compared in a similar manner. Emerson method was also evaluated to see how well the results could be trusted.

2 WOODFREE UNCOATED PAPER

Woodfree uncoated papers are also known as fine papers. Among other things they include different kind of office papers, such as copy papers and writing papers. Also envelope and drawing papers are woodfree uncoated papers. (VTT 2004)

2.1 Raw Materials

Woodfree uncoated papers contain bleached hardwood and softwood chemical pulp. Softwood pulp is mostly used to strengthen the paper and hardwood is used for optical properties. Fillers are also used, the most popular choice being calcium carbonate which has a higher brightness compared with other kaolin or talc fillers. To achieve higher brightness optical brighteners are used in making woodfree uncoated paper. In addition to calcium carbonate and optical brighteners, highly bleached pulp is used to get a high brightness. (Häggblom-Ahnger & Komulainen 2006, 66-67)

Woodfree uncoated papers should be hydrophobic which means that they should not absorb water easily. This is achieved by using hydrophobic sizing such as AKD or ASA, which is added to the slurry in the paper machine approach piping. Most of the hydrophobic sized papers are also surface sized. Surface sizing is done in the drying section of the paper machine where starch is applied to the paper surface to improve stiffness and surface strength. (Häggblom-Ahnger & Komulainen 2006, 66-67)

2.2 Process

Characteristic treatments for the woodfree uncoated paper include surface sizing and on-line calendering. Surface sizing is done in the dryer section where starch is added on to the paper surface to get better surface strength and higher stiffness. Calendering can be done by using hard nip machine calender or soft calender. (VTT 2004)

The next step in the papermaking process for woodfree uncoated paper is winding to customer rolls or reels for the sheeting plant. Customer rolls or sheets are wrapped, stored and sent to printers or converters. Depending on the grade the printing can be web-offset, sheet-offset or digital printing as well as copying on a copy machine. (VTT 2004)

2.3 End product properties

Some key factors for the woodfree uncoated paper are runnability in printing, printability and end product usability. Paper should not cause any extra breaks during the printing process which means it should have a high enough strength level. Overall strength level can be measured by tensile strength. Any kind of small defects such as a hole or a spot can easily trigger a web break. That is why tearing strength is important because it tells more about the ability of the paper to tolerate defects in the paper web. (VTT 2004)

Surface strength is another important factor in the printing process. High surface strength decreases the amount of linting or dusting which is unwanted in printing as it deteriorates runnability in printing. Also curling deteriorates runnability but the probability for curling is small if paper is dimensionally stable. Dimensional stability is important for printability, as the moisture changes during the printing process the paper should keep its size. This is a result of a slow water absorption which is achieved by hydrophobic sizing. (VTT 2004)

For printability purposes the ink absorption should be at a suitable level. Ink absorption depends on the roughness, porosity and formation. Porosity should be at a relatively low level and the formation should stay even throughout the paper. Paper should also have good opacity and brightness. Brightness is important in order to achieve a high image density in printing. (VTT 2004)

For some woodfree uncoated papers, e.g. for copy paper, bulk is an important property. Bulk brings stiffness that is needed in the copy machine and also opacity that is one of the critical properties for copy paper. (Häggblom-Ahnger & Komulainen 2006, 67)

3 PROBLEMS WITH LINTING AND DUSTING OF PAPER

3.1 Linting and dusting

Linting and dusting are the removal of loose dust or weakly bound particles from the surface of paper web during the offset printing process. Excessive linting or dusting leads to a reduction in image quality and can reduce printing press productivity. Lint and dust particles are either wood or filler pigments. Dusting can refer to all the things happening on the paper machine or on the rewinder before printing whereas linting always happens after paper machine. (Komulainen, Mustalahti, Karinen & Launonen 2011; Komulainen 2013)

Another way to separate dusting from linting is the concept of how loose particles are released from the paper surface. In this definition linting refers to a phenomenon where fibre or pigment particles are released from the paper surface. Dusting is a related concept but means loose material on the paper which has been accumulated during the previous steps such as sheet or web cutting. (Oittinen & Saarelma 2009, 119)

3.2 Problems on the paper machine

Dusting causes bigger problems in printing but it can also cause harm on the paper machine. Dust containing small particles can easily find its way to the open structures of the paper machine. Especially dust consisting of fillers and pigments may cause erosion if it gets stuck between a cylinder and a doctor blade. Dust can also cause harm to drying fabrics if dust is stuck on a cylinder that is in touch with the fabric. (Kurra 2008)

Dusting is bad for fire safety. Especially dust that contains fibrous material flashes easily in a paper mill where there are a lot of high temperatures. Dust can also impair the function of some measuring devices or detective eyes, this can cause bad measurements or false alarms which can cause loss of production. Cleaning the measurement heads or detective eyes causes also extra work. Another place where dust may cause problems is coating. In coating dust can accumulate on and under the coating blade and this will cause marks or streaks on the paper. (Kurra 2008)

3.3 Problems in printing

Dusting is a big problem in offset printing because dust accumulates on the printing blankets and impairs the printing quality. As quality deteriorates the printing press has to be cleaned at regular intervals causing production losses. Linting is typically a problem with wood containing, non-surface-sized, uncoated offset papers, but problems occur with woodfree uncoated paper too. (Oittinen & Saarelma 2009, 119)

Dust and lint are also causing problems in photocopiers and domestic or office printers, where the output of paper is high. Dust in the inking system necessitates short service intervals throughout the service life and leads to the sort of problems familiar in offset printing. (Brandt & Herrig & Krolle & Ramcke 1991)

4 FACTORS AFFECTING ON THE DUSTING TENDENCY OF THE PAPER WEB

4.1 Refining

Refining is a pre-treatment done for chemical fibres. Without refining fibres will have a poor bonding ability which results in insufficient strength properties. Refining is done to activate the bonding ability of the fibres. In refining fibres are put under load between blades and several changes in fiber structure are achieved. These changes include internal and external fibrillation of fibres. Fibrils released enhance the bonding ability of the fibres as well as increased flexibility which is a result of internal fibrillation. (Häggblom-Ahnger & Komulainen 2006, 113)

Dust or lint generated in the offset printing is most likely to have poorly fibrillated and very stiff fibres. To eliminate fibre dusting the fibres should be sufficiently flexible for a maximum surface contact area and strongly fibrillated to exhibit a high bonding potential. These qualities can be achieved by refining. Studies done for mechanical papers show, that specific refining energy seems to correlate well with dusting tendency of the paper. Specific refining energy tells the amount of energy put per ton of paper. (Brandt et al. 1991; Amiri & Begin & Deshaies & Mozaffari 2004, 25)

4.2 Forming section

Forming section consists of a headbox and its approach piping as well as the wire section. The headbox distributes the fiber slurry evenly in the cross direction to a wire. On the wire section water is removed through a fabric to either one or two ways, depending on the former type. Fourdrinier removes water only one way the entire time whereas hybrid former combines both removing water in one direction in the beginning and later to both directions. Gap former is a pure twin wire where water is removed to two ways the entire time. Many important paper properties are determined on the forming section, z-directional filler distribution being one of them. It has a great impact on the dusting tendency of the paper. (VTT 2004)

Optimal filler distribution varies between different paper grades. For woodfree inkjet papers it would be better to have more filler closer to the surface than in the middle, this is called the U-shape filler distribution. The U-shape is good for printing quality. For offset grades it is better to have more filler in the middle and less in the surface to minimize dusting tendency. As fillers are more likely to dust it is better to keep them away from the paper surface, this of course is not as good for printing as the U-shape. (VTT 2004)

The former type has a big influence to filler distribution in z-direction. In Fourdrinier former water is removed only downwards. When water is removed downwards also a lot of filler is washed away with the water. Because filler is not washed away from the top side of the paper there will be more filler on the top side of the paper. A more symmetrical distribution can be achieved on a hybrid former where water is removed two ways. With a hybrid former there will be a bit more filler in the middle than on each side of the paper. (VTT 2004)

4.3 Press section

In the press section the water is removed from the paper web by mechanical compression. Web is compressed in a nip formed by two rolls or a roll and a shoe. Heat can also be used to assist water removal. Press section influences product quality among other things through the distribution of sheet density in z-direction. (Paulapuro 2007, 344)

The structure of the paper can change during wet pressing. In the press section water is flowing from the web and the water flow can separate particles and transport them into new positions or straight out of the web. Separation happens because under wet conditions the bonds are not yet too strong. This can cause very small z-directional structure changes. Particles move to the direction of the flow so the density of the sheet changes the same way also. Press section configuration can be used to control z-directional density profile and slightly also filler distribution. (Paulapuro 2007, 344, 348, 350)

The main effect of the press section is formation of fibre bonding on the felt side. More bonding on the felt side than on the press roll side means higher density and less linting on the felt side. However, in several concepts the last felt is on the bottom side and more filler on the top side. Both of these increase linting on the top side. (Komulainen, 2013)

Research has shown that pressure in the nip has a significant effect on the dusting tendency of the paper. In press section poorly bonded particles are removed from the web and if this would not happen those particles would be more likely to dust in the future. Too high pressures cannot be used to avoid making the paper too thin or the fabric to leave a mark in the paper. To remove loose particles from both sides of the web it is important to remove water in both directions. (Ionides 1984, 304, according to Haaramo 2010)

4.4 Chemical treatment

In general fibres and filler particles in the papermaking process are both negatively charged. This means that they repulse each other and smaller particles of fibres and fillers go throught the wire. To solve this problem different kind of retention aids are used when making paper. Basic way to do this is to use a cationic polymer to bind the anionic particles together. It is also possible to use a retention strategy that involves both, cationic and anionic polymers. Among others these strategies can help in binding the filler particles to the fibres and thus reducing dusting. (Krogerus 2007, 77; Subramanian 2008, 17)

Research done by a chemical supplier has seen a significant reduction in newsprint dusting by using amphoteric polymer that has both cationic and anionic components. It especially improved dimensional stability of the paper which seems to have an impact on dusting tendency. (Hughes, 2013)

Chemical treatment can also be used not to reduce dusting but keep it at the same level while increasing the amount of filler. This of course saves money since filler is cheaper than fibre. In the trial done in for woodfree uncoated paper the amount of GCC used was increased from 18% to 28% while dusting was maintained at the same level by using a VFA (Vinylformamide) co-polymer. (Esser 2009)

4.5 Surface sizing

In the surface sizing process, low-consistency starch is applied on the paper surface. One of the main purposes for surface sizing is to increase surface strength. Increasing surface strength reduces dusting tendency of the paper. Other possible benefits from surface sizing include increased internal strength, increased water or oil resistance, improved dimensional stability, improved stiffness and decreased porosity. (Wilson 2005, 281; Paltakari & Lehtinen 2009, 310)

Surface strength can be maximized by minimizing starch penetration into the sheet. This can be achieved by using internal sizing, high solids and viscosity in the starch solution and a metering type press-application instead of a pond type press. (Wilson 2005, 281)

4.6 Calendering

The reason for calendering is to prepare it for the next part of the process, printing for example. Paper is flattened by compressing it between two rolls in a calender nip, heat is also used to help the process. Densification of the paper helps to get better smoothness and gloss among others. It also causes reductions in optical properties and bending stiffness. (Ehrola et. al. 2009, 18)

Too high pressure in calendering can break interfiber bonds which also results in more dusting. A research done for the woodfree uncoated paper showed a decrease in surface strength with no change in tensile strength and internal bonding. Paper made with PCC and GCC showed similar results but with PCC the reduction in picking resistance was larger. It shows that the surface of a highly filled PCC sheet is more prone to surface damage in calendering. The research used picking resistance testing which correlates well with surface strength but not necessarily with dusting. (VTT 2004, Gerli & Eigenbrood & Nurmi 2011, 17-24)

4.7 Fillers

The amount of fillers used has a great effect on dusting tendency of the paper. Filler particles settle between fibres and prevent a hydrogen bonding between fibres at this point. As the filler content increases the number of bonds consequently decreases. This results in more dusting. (Brandt et. al. 1991)

Filler size and shape has an impact on the dusting tendency. Aggregated fillers like scalenohedral or aragonitic PCC give higher light scatter at similar particle size than solid particles like rhombic PCC or GCC. For strength the situation is the other way around. Rhombic PCC and GCC are better for strength than aggregated fillers. A common rule is that what is good for the light scattering is bad for the strength. As dusting is connected to strength properties what is good for the strength should also be good for dusting. But this may not always be the case as a study done by Imerys states that increasing filler particle size improves tensile and internal bond strength, but may have negative effect on dusting. In some case studies done by Nalco pre-flocculated fillers were used to avoid small particles interfering with bonding. Filler particles interfere with interfiber bonds and the smaller the size of the filler particle, the greater the reduction in fiber bond area. In these studies ash content was raised up to 5 %-unit maintaining paper properties, including dusting. This would indicate that a larger particle size helped to reduce dusting. Different results just underline the complexity of dusting in general. (Imerys Paper 2010; Ancona, M & Broadus, K & Cheng, W 2011; Gerli et. al. 2011)

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