COMPARISON OF THE EFFECT OF TMP PITCH CONTROL AGENTS WITH DIFFERENT MECHANISMS

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Abstract. The pitch contained in thermomechanical pulp (TMP) negatively affects paper quality, pulp, and the papermaking process. Serious pitch and stickies problems may occur in paper recycling processes. In this study, the effects of chemicals used to control the pitch in the TMP process were compared. The method used to analyze the pitch control effect was to perform image analysis after using a reagent that selectively stains only the hydrophobic pitch. Three different mechanisms, namely fixation, detackification, and dispersion, were applied to solve the pitch problem from TMP. All the control agents were effective in pitch control, and, in particular, the agents related to fixation and dispersion were found to be more effective in reducing the number and area of tacky particles per unit area in sheets and white water. However, it was difficult to clearly identify the effect of both the detackifiers and the dispersant agents through image analysis after staining except for the fixative agent.

Keywords: Pitch, stickies, TMP, fixing agent, detackifier, dispersing agent.

INTRODUCTION

In the pulp and paper industry, pitch problems often occur, primarily in the form of the precipitation of organic tacky material escaping from water suspensions as spots on papermaking equipment or in the paper web itself (Guéra et al 2005). A significant part of the pitch exists in a colloidally dispersed form. The tacky components originating from the resins and extractives of wood consist of a mixture of different components

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having similar physical characteristics. The low-molecular-weight substances they are practically insoluble in water under alkaline or acidic conditions (Putz 2000).

The pitches can bond with each other to become larger particles, or they can remain suspended in the process water (Gutiérrez et al 2004). When recycling postconsumer paper, stickies are tacky substances contained in the paper pulp and process water systems of paper machines. Contaminations of paper that are classified as tacky are also called stickies. The main sources for stickies are recycled paper, waxes, and soft adhesives. Stickies cause quality problems or other serious problems similar to pitch, and these problems result in loss of runnability and high costs for papermakers (Sarja 2007).

Conventional ways of controlling pitch from wood chips include seasoning of raw materials before pulping. However, seasoning of wood chips is often unacceptable because of yield loss, decreased brightness because of biological deterioration, and lack of storage space (Scheepers 2000). To deal with this problem, various methods have been adopted in paper mills, including chemical and enzymatic treatments (Hata et al 1996; Bobacka et al 1999; Sui et al 2015). Enzymatic control is a method of removing triglyceride, which is a pitch component present in wood, through enzymatic hydrolysis. However, it is sensitive to temperature and heat because of the nature of enzyme activity.

The general measure used to control or prevent tacky substances during papermaking is the use of additives, and the best way to deal with stickies include avoiding them by selecting the kind of pulp source. The additives used in a pulp suspension to reduce the negative effects of pitch or stickies can be organic or inorganic (Putz 2000; Vahasalo and Holmbom 2006). They can also be used to a certain degree directly at the paper machine, where they help to prevent problems with deposits (Putz 2000; Vahasalo and Holmbom 2006). One way to prevent anionic pitch or sticky particles from accumulating in process water is to use a cationic polymer to fix these particles to anionic fibers so that they come out together with the end products (Putz 2000). The effect of these fixing agents is highly dependent on how they interact with the surface of the tacky particles (Sarja 2007). Cationic polyacrylamide (C-PAM) is very commonly used as a flocculant for retention (Sarja 2007). Poly-diallyl-dimethyl ammonium chloride (poly-DADMAC) together with acrylic acid or acrylamide is patented for deposit control (Song et al 2006; Sarja 2007) High polymer dosages contribute not only to good retention of stickies, but also to good fiber fines and filler retention (Fogarty 1993; Putz 2000). Another common method to control pitches or stickies is the addition of inorganic minerals to the recycled pulp slurry or thermomechanical pulp (TMP) stock. Adsorption of the minerals to the surface of pitch or sticky particles can reduce the tackiness of these harmful substances. For detackification of pitches and stickies, talc has been most widely used since the 1960s (Putz 2000). Usually, surfactant-based dispersants with a hydrophilic head and a hydrophobic tail tend to direct the hydrophobic tail part toward the pitch deposits and the head toward the water phase, thereby imparting a repulsive force between the pitch deposits (Hanu 1993; Hubbe et al 2006). The most widely used dispersant is an anionic surfactant. There is also a concern that, because of poor control of dispersants, dispersed tacky particles may cause another deposit problem, but in some cases, it has helped papermakers to overcome certain problems from pitches and stickies (Allen 1980; Grönfors et al 1991; Carter and Hyder 1993; Wågberg 2000; Hubbe et al 2006).

It is not easy to evaluate the effect of several types of pitch- or stickies-control agents with different mechanisms. Most mills verify their effects through trouble analysis, which occurs during the process after adding the control agents. BASF has developed a device that can measure the number and size of resin particles by dispersing the resin particles contained in the process water, dyeing them with a fluorescent dye, and detecting the optical signal excited by a laser light (Champ et al 2006). As this device cannot detect particles smaller than 0.8 microns, they are counted after making fine resin particles into large aggregates with a polymer coagulant. Gupta and Hodgson (1998) used various dyes to quantify only the hydrophobic sticky particles among old corrugated containers, and confirmed that Sudan IV showed the best selective dyeing effect among them. Nam et al (2015) developed a method for measuring the number and area of pitch particles after selectively dyeing the hydrophobic and tacky particles in sheets and white water by applying Gupta and Hodgson's method.

In this study, the pitch control effect was compared using various pitch control agents having three mechanisms, namely dispersion, fixation, and detackification, to control the pitch particles contained in TMP. For this purpose, the pitch quantification method applied by Nam et al (2015) was used.

MATERIALS AND METHODS

Raw Materials

TMP stock collected in Jeonju Paper Co., Ltd. in Korea was used to evaluate the effect of the pitch control agents. TMP was manufactured from Korean red pine (*Pinus densiflora*).

Pitch Control Agents Used for Pitch Control

Pitch control agents currently supplied to pulp and paper mills in Korea were collected to investigate the effect of pitch control in TMP stock. The chemical suppliers were Kemira Co., Ltd., Nalco Co., Ltd., BASF Co., Ltd., Solenis Co., Ltd., and Buckman Co., Ltd. The exact product names of the chemicals provided by each supplier are not disclosed by the request of the company, and only the types of chemicals, defined by their mechanism of action, are described, as shown in Table 1. The amount added for each agent was based on the application range recommended by the suppliers.

Procedure of Pitch Analysis

The stepwise procedure of dyeing the transferred pitch particles on the paper sheet with the furnish is shown in Figure 1. This process has already been described in previously published papers (Nam et al 2015). First, a dye solution was prepared by dissolving 0.7 g of Sudan IV in 100 mL of ethylene glycol. It was dissolved using a magnetic stirrer at 100°C for several minutes. The hot dye solution was filtered twice through Whatman No. 2 filter paper. The handsheet with a basis weight of 50 g/m^2 was immersed into the dye solution at about 40°C and was stained for about 5 min. The dyed handsheet was transferred to 85% propylene or ethylene glycol in water and gently agitated for about 30 s to wash away the excess stain. The stained handsheet was briefly rinsed with distilled water and mounted on a slide in 30% glycerin in water.

The stepwise procedure of preparing specimens for observing the pitches contained in white water is shown in Figure 2. First, TMP stock was decanted into a Büchner funnel in which 100 mesh wire was placed, and only white water was filtered out. White water was filtered again through

Table 1. Addition amounts for different pitch control agents.

Chemical types	Symbol	Supplier's recommendation (ppm)	Applied amount for each agent (ppm)		
Fixative (polyamine type)	F1	500-1000	500	750	1000
Fixative (poly-DADMAC type)	F2	500-1000	500	750	1000
Fixative (poly-DADMAC type)	F3	1000	1000		2000
Fixative (aliphatic polyamine type)	F4	1000↑	1000		2000
Fixative (PEI type)	F5	1000↑	1000		2000
Fixative (Polyvinylamine type)	F6	1000↑	1000		2000
Detackifier (Talc)	DT1	500-1500	500	1000	1500
Detackifier (Talc & bentonite)	DT2	1000-2000	1000	1500	2000
Dispersive (nonionic surfactant)	DP1	200-1000	200	600	1000
Dispersive (anionic surfactant)	DP2	200-1000	200	600	1000

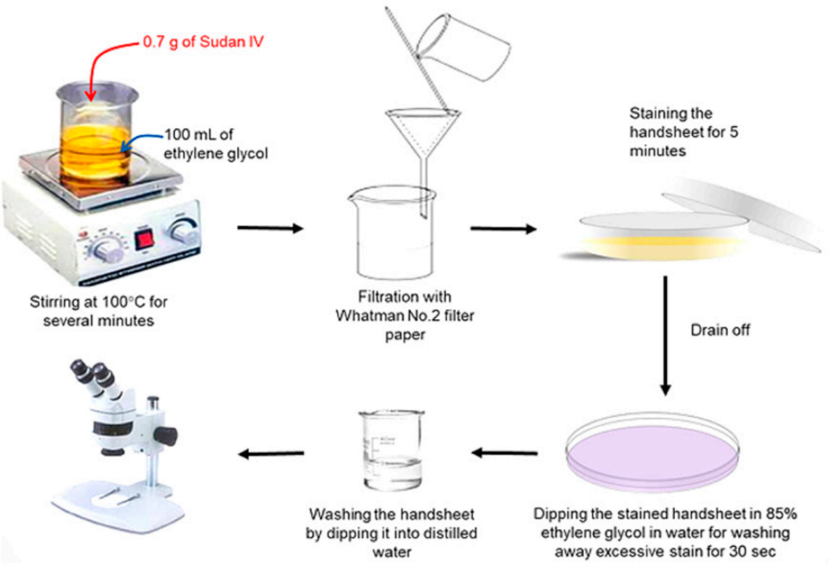

Figure 1. Stepwise procedure for staining paper specimens contaminated by pitch.

Whatman filter paper No.2 to collect only pitch particles. The pitch particles filtered onto the paper were dyed according to the method described in Figure 1.

Image analysis. Pitch images (×15, total area 63.21 mm^2) were acquired using a stereomicroscope (Leica, Japan) to measure the number and area of pitches on the dyed specimens (refer to Figure 3[a]), which were automatically quantified using Axiovision software (ver. 4.4, Carl Zeiss, Germany) under certain conditions. The pixel value of the pitch image was converted to mm or µm to measure the actual area of the pitch through the captured image. As shown in Figure 3(b), after measuring the number and area of pitches, the pitch data were compared using MS Excel. The final analyzed sample image is shown in

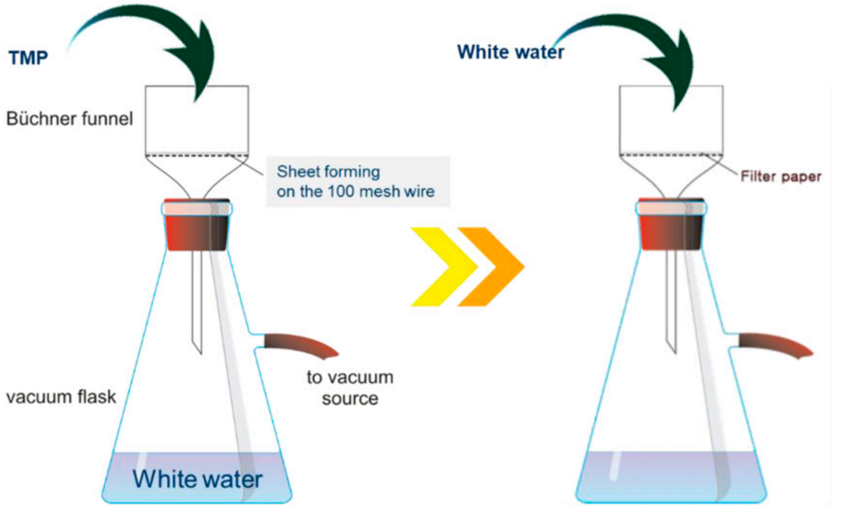

Figure 2. Stepwise procedure for staining pitches contained in white water.

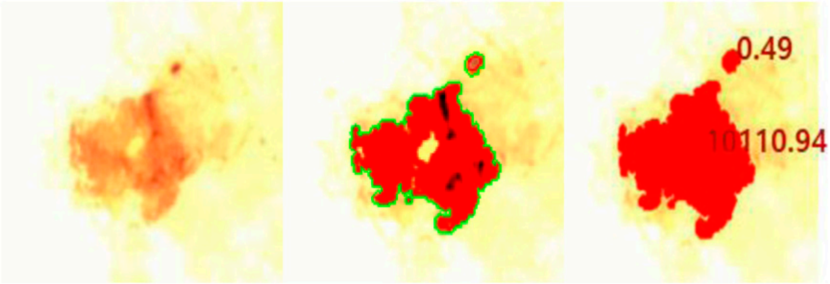

Figure 3. Stepwise procedure for analyzing pitch deposits.

Figure 3(c), the number of each pitch was counted and the area of each pitch was thus obtained. The images were automatically analyzed under certain settings during image analysis so that subjective judgment by any operator did not intervene.

RESULTS AND DISCUSSION

Pitch Controlling Effect by Fixation

Chemicals that remove pitches by fixation make colloidal substances into aggregates in the stock, adhere to fibers or fines, and come out with the final paper sheet (refer to Figure 4). Therefore, since very tiny pitch particles are aggregated and transferred into the sheet with the addition of the fixing agent, a large number of pitches should be detected on the sheet and the number of pitches included in the white water might decrease. Typical chemicals include polyDADMAC, polyethyleneimine (PEI), polyacrylamide, diamine polymer, and dicyanoamide polymers. Unlike retention aids, these polymers have a smaller molecular weight and are supplied in an aqueous solution (Hubbe et al 2006).

Before the addition of a fixing agent, the colloidal tacky particles were dispersed in a very small size in pulp suspension. As shown in Figure 4, when the fixing agent is added, the tacky particles are coagulated to form large particles and fixed onto the fiber surface. If the pitches are not properly controlled, these tacky particles can agglomerate and form very large deposits, causing problems with sheets and dryer felts.

Figure 5 shows the red-stained images of the pitch deposits detected in the sheet and white water before the fixing agent was treated. The pitch particles were coagulated and a large area of the deposits was detected in both the sheet and

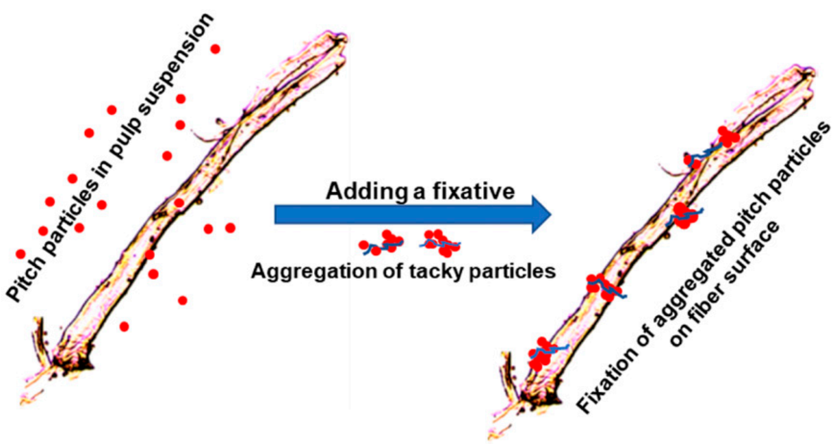

Figure 4. Conceptual diagram of a fixative that fix tacky particles onto a fiber.

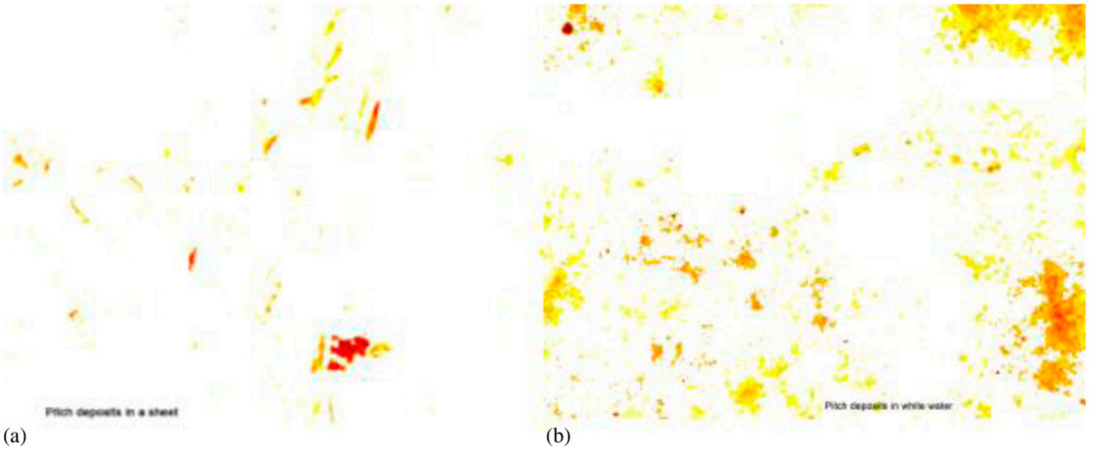

Figure 5. Images of stained pitch deposits transferred to a sheet and white water before a fixative treatment. (a) Pitch deposits in a sheet and (b) Pitch deposits in white water.

the white water. If the fixative was not added, the pitch particles were easily aggregated and deposited during the drying process of the sheet, and then transferred to the sheet or came out with white water and stuck to the pipe.

Before the fixatives were added, the number of pitches that escaped with the white water as the sheet was formed was detected much more than in the sheet (refer to Figure 6). However, the number of pitches per unit area on the sheet and in white water was remarkably reduced with the addition of the fixatives compared with the control. It was believed that the number of tacky particles in TMP suspension and white water was sharply reduced because the fixatives to coagulate the colloidal particles were bound to the fibers. In the end, since the fixatives caught many tacky

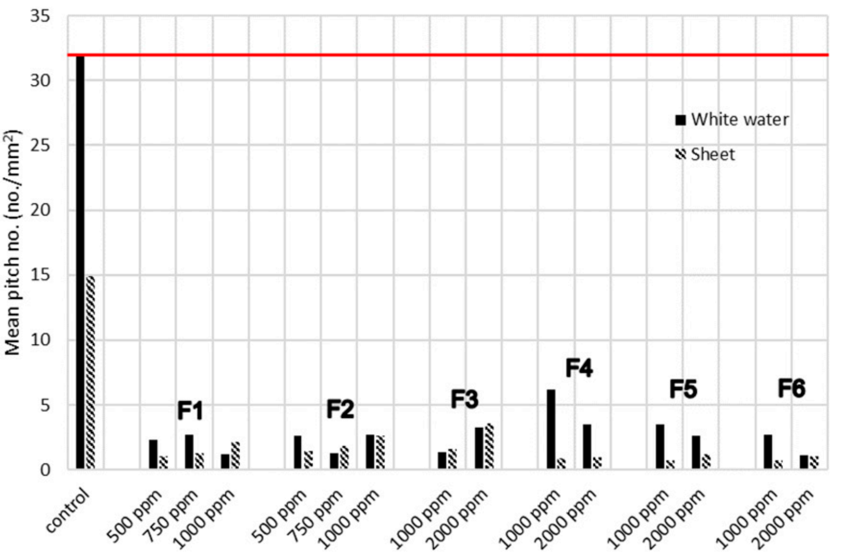

Figure 6. Change of pitch numbers per unit area by different fixing agents.

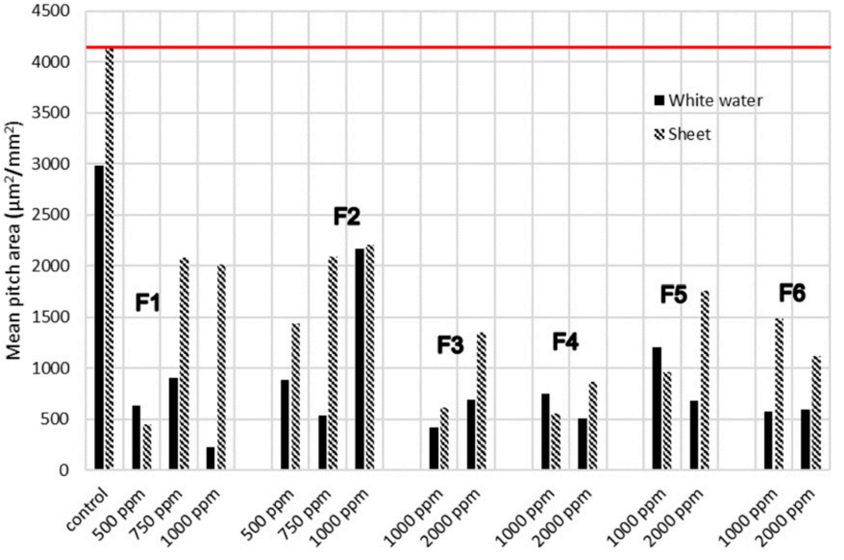

Figure 7. Change of pitch area per unit area by different fixing agents.

particles and caused them to be discharged together with the fibers, it also contributed to the reduction of the mean area of pitch deposits detected in sheets and white water (see Figure 7). When the amount of the adhesive was increased, the number of pitches detected in the sheet increased as the number of tacky particles transferred to the sheet increased. In particular, there were significant differences in F1, F2, and F3, which were polyamine- and poly-DADMAC-type agents. Figures 8 and 9 are diagrams showing the mechanism of action of the detackifier on tacky particles.

In conclusion, it was confirmed that polyamine-, poly-DADMAC-, and PEI-based fixatives had a positive effect on reducing the number and area of pitch deposits in both sheets and white water.

Pitch Controlling Effect by Detackifier

In Figure 10 and 11, when detackifiers were added, the number and the area of pitches per unit area in white water and on the sheet were compared. Both DT1 and DT2 significantly reduced the number of pitches compared with the control. Before the detackifier is added, tacky materials are dispersed in the furnish and are converted into large and small deposits as they combine themselves during the papermaking process. Contaminants that are not transferred to the dryer felt or sheet are discharged into white water and cause another problem. However, the addition of the detackifiers (DT1 and DT2) contributed to reducing the number of deposits by attaching tiny tacky particles to the surface of the detackifying particles or enclosing large tacky particles. Figures 12

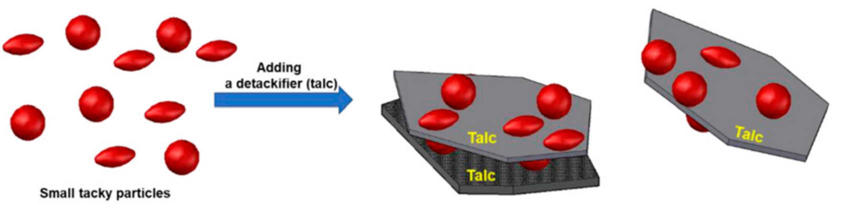

Figure 8. Conceptual diagram of a detackifier that collects tiny tacky particles.

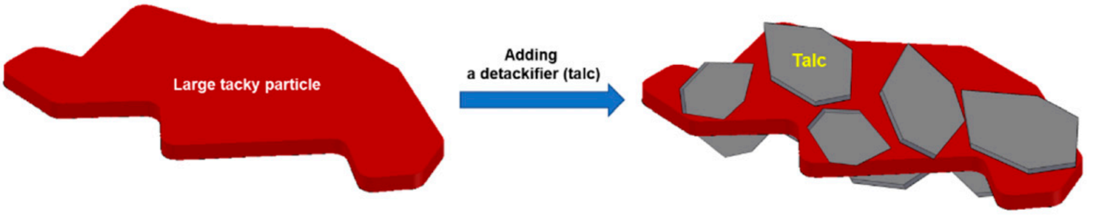

Figure 9. Conceptual diagram of a detackifier that collects large tacky particles.

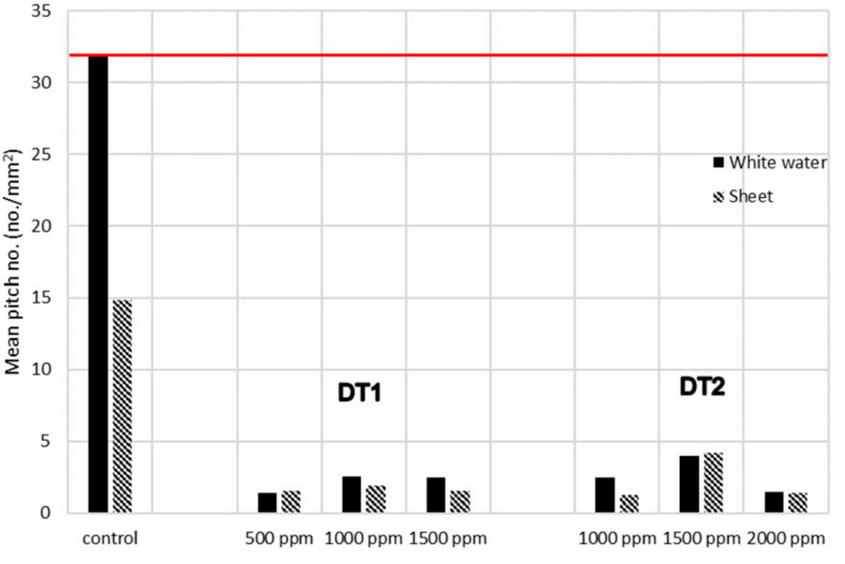

Figure 10. Change of pitch numbers per unit area by two different detackifiers.

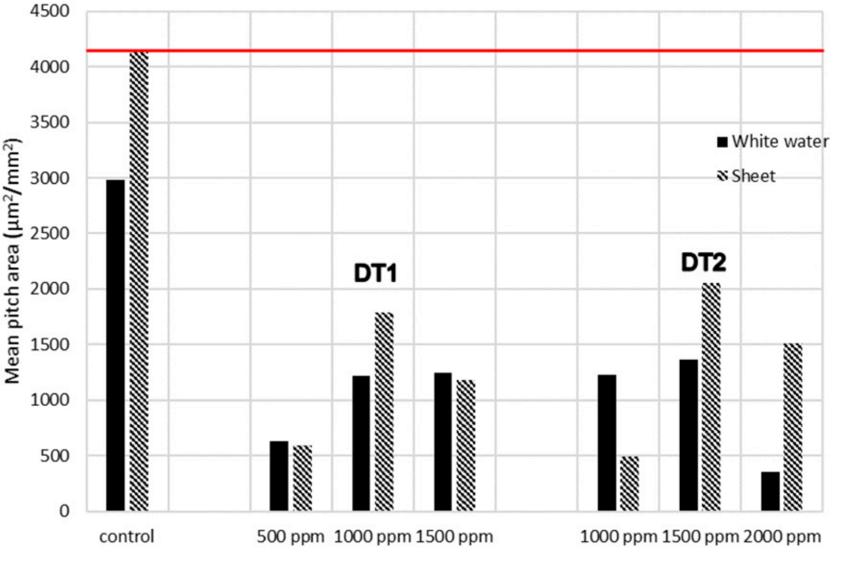

Figure 11. Change of pitch area per unit area by two different detackifiers.

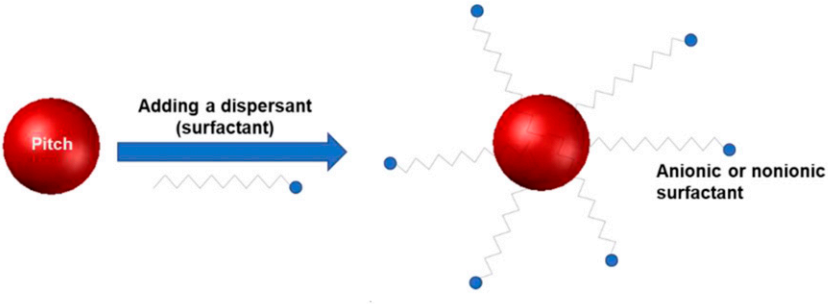

Figure 12. Conceptual diagram of a dispersant surrounding a tacky particle.

is a diagram showing the mechanism of action of the dispersant on tacky particles. It was difficult to find a meaningful difference because of the change in the amount of the detackifiers added.

Pitch Controlling Effect by Dispersant

Figure 13 shows the number of pitch particles per unit area before and after adding the dispersants. Since the addition of DT1 and DT2 left tacky particles as small particles in the furnish, the number of pitch particles detected in the sheet and the white water was remarkably reduced. Also, as shown in Figure 14, the area of tacky particles detected in the sheet and the white water was greatly reduced compared with the control because the dispersants prevented the formation of pitch deposits. As the addition amount of DT1 and DT2 increased, the number of pitch particles also tended to decrease, but the area of the pitch particles was not significantly affected by the change in the amount of dispersant added. Nevertheless, it was found that the dispersant showed a better effect in reducing the number or area of pitches observed in sheets and white water, unlike the fixatives and the detackifiers.

In the end, the pitch control effect of the dispersant could be confirmed through the application of the image analysis through dyeing, but it would

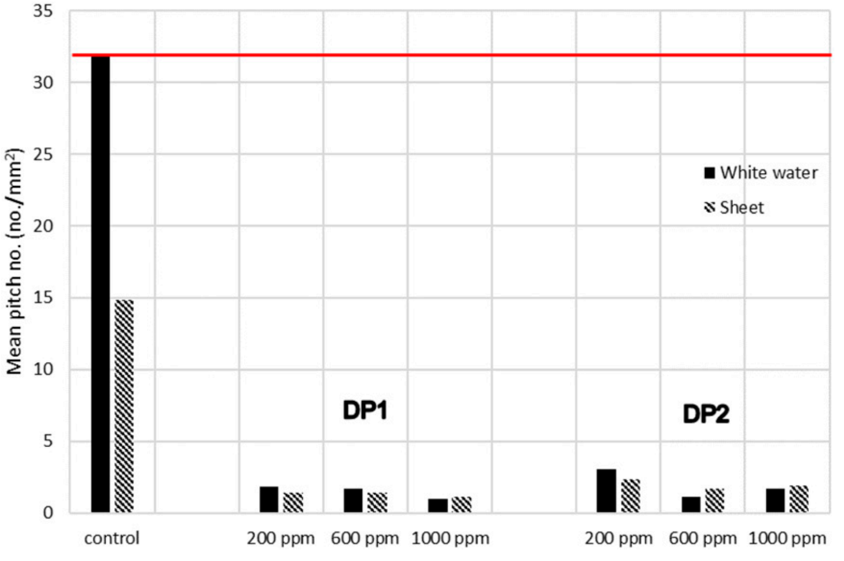

Figure 13. Change of pitch numbers per unit area by two different dispersants.

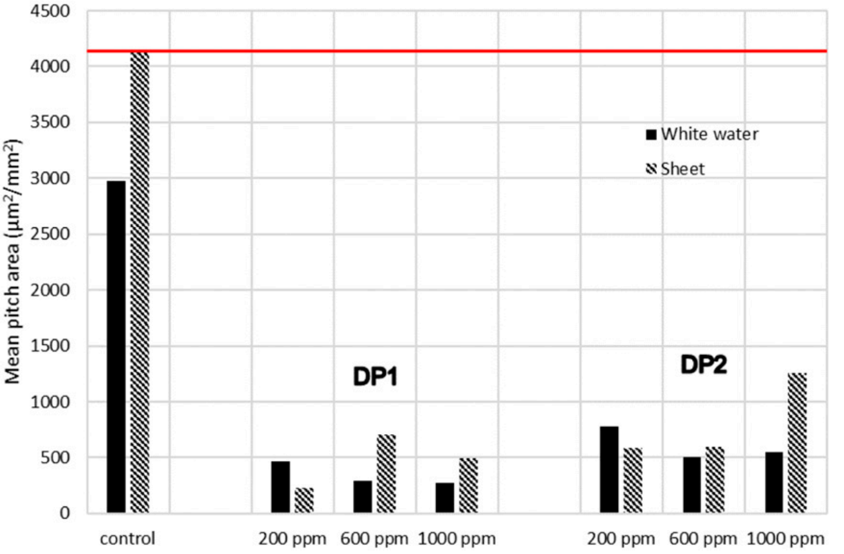

Figure 14. Change of pitch area per unit area by two different dispersive chemicals.

be difficult to find a significant difference in both sheets and white water based on the amount of the dispersants added.

CONCLUSIONS

Problems arising from pitches are known to be the most common issue in the pulp and paper-making process. In this study, the effect of pitch control was confirmed through image analysis after selectively dyeing hydrophobic pitch particles in red. The pitch control effects present in the TMP were compared using the pitch control agents acting through three different mechanisms, namely fixation, detackification, and dispersion. All pitch control agents contributed to the reduction of the number and area of pitch deposits in the sheet and white water when compared with the control. However, unlike fixatives, detackifiers and dispersants made it difficult to clearly distinguish the pitch control effect of changes in the amount of these chemicals through image analysis after staining.

In conclusion, it was confirmed that the use of a dispersant to control TMP pitches showed the most efficient effect in preventing the formation of pitch deposits in sheets or white water by reducing the coagulation of pitch particles.

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REFERENCES

Allen LH (1980) Mechanisms and control of pitch deposition in newsprint mills. TAPPI J 63(2):81.

Bobacka V, Kreutzman N, Eklund D (1999) The use of a fixative in combination with cationic starch in peroxide-bleached TMP. J Pulp Paper Sci 25(3):100-103.

Carter RD, Hyder J (1993) Treated kaolin combines effective pitch control with handling ease. Pulp & Paper 67(11):87-90.

Champ S, Hughes D, Lee WS, Esser A, Kaub HP (2006) The BASF laser optical pitch particle counter-current applications and future developments. Pages 73-78 *in* Proceedings of the Korea Technical Association of the Pulp and Paper Industry Conference, Korea Technical Association of the Pulp and Paper Industry.

Fogarty TJ (1993) Cost-effective, common sense approach to stickies control. TAPPI J 76(3):161-167.

Guéra N, Schoelkopf J, Gane PA, Rauatmaa I (2005) Comparing colloidal pitch adsorption on different talcs. Nord Pulp Paper Res J 20(2):156-163.

Gupta P, Hodgson KT (1998) Characterization of stickie contamination from OCC recycle mills. Pages 25-29 *in* TAPPI Pulping Conference, Montreal, Quebec, Canada, October.

Gutiérrez A, José C, Martínez ÁT (2004) Chemical analysis and biological removal of wood lipids forming pitch deposits in paper pulp manufacturing. Pages 189-202 *in* Environmental microbiology. Humana Press, Totowa, NJ.

Hanu WM (1993) Dispersants. Pages 293-311 *in* Kirk-Othmer Encyclopedia of Chemical Technol, 4th edition. Vol. 8, Wiley-Interscience, NY.

Hata K, Matsukura M, Taneda H, Fujita Y (1996) Mill-scale application of enzymatic pitch control during paper production. Pages 280-296 *in* Enzymes for Pulp and Paper Processing. Vol. 655, ACS Publications, Washington, DC.

Hubbe MA, Rojas OJ, Venditti RA (2006) Control of tacky deposits on paper machines: A review. Nord Pulp Paper Res J 21(2):154-171.

Nam H, Kim CH, Lee JY, Park H, Kwon S (2015) Optimization technology of thermomechanical pulp made from *Pinus densiflora* (II)-quantification of pitch contents in TMP. J Korea TAPPI 47(5):33-42.

Putz HJ (2000) Stickies in recycled fiber pulp. Papermaking Science and Technology Book 7. Recycled Fiber and Deinking. Fapet Oy, Helsinki, Finland. pp. 441-498.

Sarja T (2007) Measurement, nature, and removal of stickies in deinked pulp. PhD thesis, University of Oulu, Finland.

Scheepers GC (2000) Enzymatic pitch control in the kraft pulping and bleaching of *Eucalyptus* spp. PhD thesis, Stellenbosch University.

Song Z, Ford P, Roy V, Grimsley S, Satcher K, Blazey M, Pelbois R (2006) U.S. Patent Application No. 11/158,845.

Sui L, Zhao G, Li X (2015) Pitch control of recycled whitewater from papermaking by *Aspergillus oryzae*. BioResources 10(4):7232-7241.

Vahasalo LJ, Holmbom BR (2006) White pitch deposition and styrene-butadiene-rubber binder content in paper mill process waters. Appita: Technology, innovation, manufacturing. Environment 59(3):213-217.

Wågberg L (2000) Polyelectrolyte adsorption onto cellulose fibers: A review. Nord Pulp Paper Res J 15(5):586-597.