

Mitigating pitch-related deposits at a thermomechanical pulp-based specialty paper mill

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ABSTRACT: A mill in Eastern Canada experienced significant sticky deposit formation on one of the guide rolls of the supercalendering stack in its supercalendered paper production line. To investigate, and minimize, the formation of those sticky deposits, we collected deposit samples from a supercalender stack and analyzed them for their chemical compositions, metal ion contents, and thermal properties. Acetone soluble substances, which were considered as pitch or wood extractives, were shown to account for the majority of these deposit samples. The thermogravimetric analyzer gave the result that, for the deposit sample, the mass loss due to heating in the temperature range of 50°C–200°C was less than 5%. Gas chromatography results showed similar chemistry for the deposit samples both before and after the thermogravimetric analyzer analysis. Throughout the mill process, a large portion of wood extractives passed through the thermomechanical pulp mill and into the paper mill with the pulp streams. Two control programs, detackification versus fixation, were compared to evaluate their ability to decrease the extractives-related deposit formation on the supercalendering stack.

Application: Pitch-related deposit formation can be reduced in a thermomechanical pulp-based specialty paper mill.

The formation of pitch-related deposits on process equipment, such as supercalender rolls, can negatively impact both product quality and paper machine operation. Supercalendered (SC) paper is typically used for magazines, catalogues, and directories requiring high smoothness, good opacity, reasonable brightness, and strength. A typical furnish for SC paper consists, on average, of 20% bleached softwood kraft pulp (BSKP), 60% thermomechanical pulp (TMP), and 20% fillers. Some functional chemicals may be added to the process to improve the runnability of the paper machine and the properties of the final products.

Irving Paper in Saint John, NB, Canada, exited the newsprint business to convert its operations to value-added SC grades with the installation of a new state-of-the-art on-line supercalender [1]. In comparison with the off-line supercalendering, the on-line calendering technology reduced costs and increased the production capacity without compromising final paper properties [2]. The company made significant investments in the paper machine and other unit operations.

Irving Paper has implemented a number of processes in the peroxide bleaching process, notably the reducing agent-assisted chelation process; the Q_y process [3,4]; the P_M process [5,6]; and the magnesium hydroxide-based peroxide bleaching technology [7–9], which affects the metal ion profiles. The interactions of metal ions and extractives can affect the thermal stability of the pitch system [10].

Our goal was to minimize the formation of sticky deposits on one of the guide rolls of the supercalendering stack, as



1. Pitch-related build-up on the guide roll of a supercalender.

shown in **Fig. 1**. Formation of sticky deposits not only increases downtime to clean the rolls but also can cause roll cover failure. Previous analysis of the deposits scraped from the guide rolls showed that the deposit consisted of extractive pitch, fillers, and pulp fibers. Extractive pitch was the major part of the deposits, and its tacky nature can peel off fillers and fibers from the paper surface.

Approach	Description	Chemicals
<i>Dispersing/removal</i>	Emulsifying pitch and increasing its fraction in water and removal by thickening	Phosphates, polyacrylate
<i>Detackification</i>	Adsorbing pitch and coating it with less-sticky hydrophilic layer	Talc, bentonite, modified clay
<i>Fixation/removal</i>	Chemical anchoring of the acid fraction of pitch to the fiber and removal with final products	Polydiallyldimethylammonium chloride (polyDADMAC), polyacrylamide (PAM), polyethylenimine (PEI), etc.

I. Chemical approaches for pitch control.

Our objectives were to (1) gain better understanding of the formation of deposits and (2) test the effectiveness of two different strategies for decreasing the deposit formation.

EXPERIMENTAL

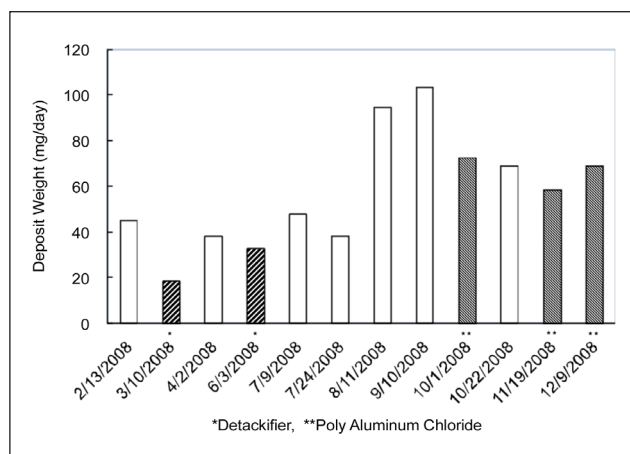
Table I [11] shows a number of strategies/approaches for pitch control, such as dispersion/removal, detackification, and fixation/removal.

Mill trials were carried out for two programs from two key chemical suppliers. One program was a dual-component program consisting of a dispersant and a detackifier. The detackifier was a hydrophobically modified cellulose that coated on the pitch surface and then bonded to the pulp fibers through hydrogen bonding. All of the feedstock to the paper machine, including the bleached TMP, unbleached TMP, and rejects, were treated with the product. The anionic dispersant mixed with a nonionic surfactant was added to the TMP refiners to emulsify pitch in liquid form, which was then largely removed in the following thickening steps.

The other program was a single-chemical treatment of bleached TMP with polyaluminum chloride (PAC), which helped to fix the pitch particles onto pulp fibers. By immobilizing pitch within the paper internal structure, its potential transfer to the equipment surface could be decreased. This mechanism applied only to the acidic pitch fraction, which was the main pitch found in the deposit collected from the calender roll [12].

During each machine shutdown, the deposit samples were scraped from the guide roll. All samples were extracted in acetone at room temperature, followed by centrifugation at 3,000 rpm for 30 min to separate the insoluble substances consisting of pulp fibers, fillers, and additives. The deposit samples were also analyzed for their metal ion contents using TAPPI T 266 om-02 "Determination of sodium, calcium, copper, iron, and manganese in pulp and paper by atomic absorption spectroscopy."

Wood pitch can exhibit tackiness only when the material is above its glass transition temperature [11]. Some pitch components are volatile, such as terpenes [13]. To verify how these volatile components affected the deposit formation, the mass losses from heating were carried out in a thermogravimetric analyzer (TGA) under the following conditions: 50°C



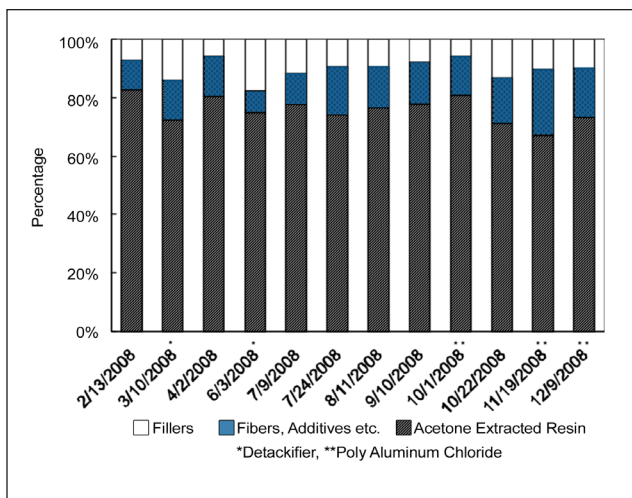
2. Daily deposit formation on the same area of equipment surface.

for 2 min, ramping 5°C/min to 200°C, and then 200°C for 2 min. Gas chromatography (GC) analysis was used to determine the volatile components in the deposit samples by comparing the profiles before and after the TGA analysis. The samples were extracted in 20 mL acetone, and the insoluble substances were isolated by centrifugation. The supernatant sample (5 mL) was silylated with 100 µL bis(trimethylsilyl) trifluoroacetamide (BSTFA), for 1 h at 70°C. The GC analysis was performed under the following conditions: soft photon ionization (SPI) injector, 340°C; flame ionization detector (FID), 370°C; column temperature from 100°C to 220°C at a rate of 5°C/min and from 220°C to 350°C at a rate of 15°C/min; and isotherm at 350°C for 10 min.

RESULTS AND DISCUSSION

Deposit formation

Deposit samples were scraped from the same location along the circumference of the guide roll and were weighed. **Figure 2** shows that the average deposit formed varied from about 20 mg/day to about 105 mg/day at the same area. When the detackifier program was applied, the deposit formation decreased from about 44 mg/day in February 2008 to about 20 mg/day in March 2008. In June 2008, when the same program was applied, the deposit formation increased to about 32 mg/day. The increased deposit formation in the second half



3. Composition of the deposit samples.

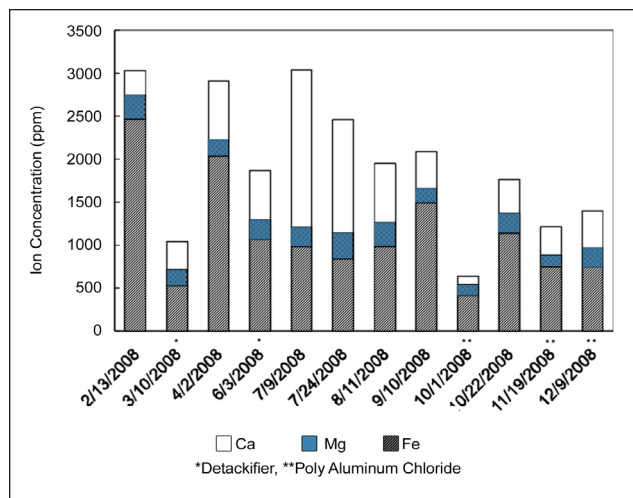


4. Appearances of build-up samples (A: control sample without pitch control strategy, B: with detackifier program, C: with the PAC program).

of the year was attributed to the use of a chip supply containing more bark; the wood extractives content in bark was known to be more than double that in the wood for spruce [13]. From October through December 2008, the PAC program was tried at the mill. The results appeared to be less effective than the detackifier program, which prevented pitch particles from agglomeration and coated them with a cellulosic protection layer that rendered them less sticky. It should be noted that the PAC program was run during a high-pitch season while the detackifier program was run during a low-pitch season. Therefore, the difference between the two programs in Fig. 2 may be due in part to this seasonal effect.

Figure 3 shows the compositions of the deposit samples. Obviously, the acetone solubles were dominant, accounting for 70%–80% of the total mass of the deposit samples, while the presence of pulp fibers and fillers was much less. The detackifier or the PAC program did not change the composition of the formed deposit. On the other hand, the visual appearance of the deposit samples was different: with the detackifier program, the samples looked much lighter in color and were less sticky than those of the control or those with the addition of PAC, as shown in **Fig. 4**.

The deposit samples ranged in color from light brown to intense black. The metal results showed that there were always some metal cations present in the samples, among which



5. Metal contents in the deposit samples.

Ca^{2+} , Mg^{2+} , and Fe^{3+} were very noticeable, as shown in **Fig. 5**. These metal ions could be from wood, process water, and/or process equipment, and magnesium may be attributed to the $\text{Mg}(\text{OH})_2$ -based peroxide bleaching process. The deposit samples obtained with the pitch control program on had much lower metal content. In particular, the presence of ferrous ions made the deposit samples dark in color [14].

The paper machine produced various grades (from low to medium gloss and other surface requirements, such as SCB grade, to superior gloss and other surface requirements, such as SCA+ grade) of supercalendered paper for rotogravure and offset printing. When producing different grades, the supercalendering stacks were run at different stack temperatures and loads. Essentially, SCA+ required the highest temperature and load to achieve the smooth surface needed, while the SCB grade only needed a modest temperature and load. **Table II** shows the effect of paper grade, supercalendering conditions, and fresh water usage on the amount of deposit formation.

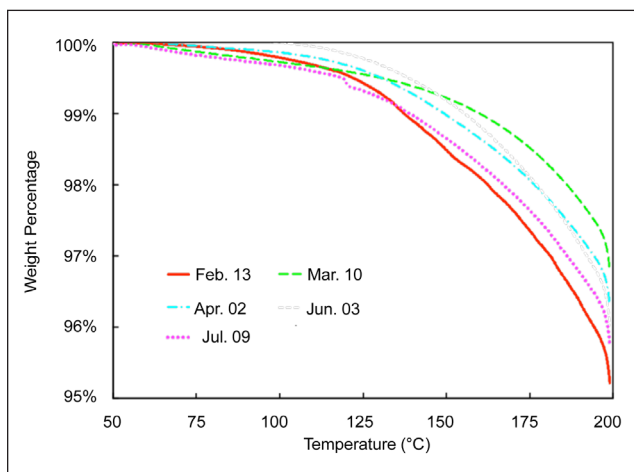
As shown in Table II, the deposit formation rates could be divided into two groups: (1) from February to July 2008 when regular wood chips were used and (2) from August to December 2008 when the high-bark chips were used. The results supported the conclusion that without the pitch control program, long running hours of SCA and SCA+ led to the formation of more deposits, indicating that higher temperature and stack load may enhance deposit formation. The pitch control program was able to decrease the deposit formation at similar SCA and SCA+ running hours.

The amount of fresh water usage may also affect the deposit formation because fresh water is much colder than the process water and may cause temperature shock that can increase the pitch deposition on process equipment, such as foils, suction boxes, press felts, and press rolls [13]. As shown in Table II, the fresh water consumption was higher in the second half of the year than in the first half of the year. This finding correlated well with the higher amount of deposits formed in the second half of the year, although it must be

Sampling Date	Deposit (mg/day)	Total Operating Hours by Grade			Temperature of Supercalender (°C)			Load of Supercalender (kN/m)		TMP Fresh Water Usage (gal/min)
		SCB	SCA	SCA+	1st stack	Steam box	2nd stack	1st stack	2nd stack	
2/13/2008	45.2	17.5	168.5	410	188.5	125.7	180.4	351.5	394.4	1,837
3/10/2008*	18.8	58	235.5	278	183.9	132.3	174.9	352.1	390.4	1,845
4/2/2008	38.2	5	167.5	328	189.9	139.0	181.2	369.5	403.7	1,937
6/3/2008*	32.8	69	154	356	190.3	127.1	181.2	357.8	387.3	1,961
7/9/2008	47.9	11.5	102.5	187.5	186.7	123.7	177.7	339.0	373.4	2,157
7/24/2008	38.2	57	145	119	180.4	121.5	173.1	343.0	376.8	2,338
8/11/2008	94.5	95.5	77	220.5	182.3	116.9	175.0	342.8	368.8	2,323
9/10/2008	103.5	131	141.5	375.5	187.6	119.4	177.7	337.4	371.1	2,177
10/1/2008**	72.7	202	78	155.5	180.7	102.3	171.8	291.2	332.0	2,474
10/22/2008	69.0	45	95.5	275	190.4	121.0	180.4	334.7	383.8	2,013
11/19/2008**	58.7	79.5	98	392.5	190.4	125.0	177.2	344.9	378.0	2,104
12/9/2008**	69.2	79.5	97.5	251	190.8	122.4	177.4	323.6	385.9	1,993

*Detackifier program; **PAC program.

II. Effect of paper grade, supercalendering conditions, and fresh water usage on deposit formation.



6. Mass loss of deposit samples due to heating.

noted that during this period the high-bark chips were used and thus introduced more extractives.

Mass loss due to heating treatment

To verify whether the volatile components, such as residual terpenes, would be partially responsible for the deposit formation, the mass losses due to heating for some of the deposit samples were determined on the basis of the TGA analysis. As shown in **Fig. 6**, the weight losses were less than 5% for all the samples analyzed in the temperature range of 50°C–200°C. Therefore, we reached the conclusion that the deposit formation was due to the migration of melted extractives from paper to the roll surface rather than the volatilization and condensation of the extractive components. Figure 6 also shows slight differences in behavior during the TGA analysis. The sample collected in February, which was the

most tacky and darkest in color, had the highest mass loss among all of the samples studied. With the detackifier program, the mass losses due to heating were decreased.

Gas chromatography analysis results

Gas chromatography was used to determine the extractive compositions in the deposit samples. For extractives from spruce TMP, the characteristic chromatography for fatty acids was found in the temperature range of 120°C–150°C while for resin acids it was close to 200°C [15–17]. **Table III** shows the results of the original deposit samples and samples after TGA analysis. Resin acids were found in all five samples and fatty acids were present in two of the five samples.

By comparing the results in Fig. 2, the higher total extractive in Table II led to a higher deposit amount, such as the sample collected in February. It is interesting to note that without the detackifier program, two of the three deposit samples showed trace amounts of fatty acids. These results may suggest that the presence of fatty acids would be important in controlling the pitch-related deposit formation.

Extractive distribution along z-direction

In this mill, pitch deposition was on the roll that was in direct contact with the paper web going into the calendering nip. One hypothesis was that there might have been more pitch on the top side (in direct contact with the roll) of paper than the bottom side. An SCA+ paper sample was split into six layers along the z-direction by a Beloit sheet splitter. The extractive contents in each layer were determined and are shown in **Table IV**.

The extractives content in different layers was in the range of 0.4%–0.51%, and it was not evident that the extractives of the top layers were higher than those of the bottom layers. In

	Sample February 13		Sample March 10*		Sample April 2		Sample June 3*		Sample July 9	
	Before	After	Before	After	Before	After	Before	After	Before	After
Fatty acids	0.11	0.05	-	-	0.08	-	-	-	-	-
Resin acids	0.78	0.67	0.65	0.58	0.62	0.51	0.64	0.48	0.72	0.62

*With the detackifier program.

III. Extractive components in deposit samples before and after TGA analysis (mg/mg deposit).

Layer	wt%	Acetone Extractive, %
Top	20.7%	0.40
	13.7%	0.51
	18.4%	0.44
	17.5%	0.48
	11.7%	0.45
Bottom	18.0%	0.40

IV. Extractive contents in the z-direction of an SCA+ paper sheet.

contrast, the fines distribution along the z-direction was slightly higher on the top than on the bottom.

Mapping of extractives contents in different pulp and water samples

We also determined the extractives contents of various pulp and water samples. **Table V** shows that both the pre- and postbleaching presses removed 10%–20% of extractives in the feed. Bleaching decreased the extractive content by about 35% due to the saponification and subsequent removal of the

acidic components, such as fatty and resin acids, in the presence of the alkali source used for peroxide bleaching.

The mill has a fiber recovery system to recover pulp fibers in the pressate, which is based on the air flotation mechanism. Table V shows that the flotation-recovered fibers had much higher (three to four times) extractive contents than the main-line fibers, although it was known that the recovered pulp can improve the sheet consolidation, dry strength, and surface smoothness [18]. In an earlier study, the amounts of extractives in the recovered fibers from an air flotation system were found to be two times higher than that of the bleached TMP [19]. When comparing the detackifier program and the PAC program, it appeared that the former had consistently lower extractive contents in the pulps and water samples. It should be noted, however, that the PAC trial was performed in the second half of the year when the high-bark chips were used.

Table V also shows that white water samples in the paper mill contained less extractives than the water samples in the TMP mill, which may be due to the application of coagulant and flocculent at the wet end [20]. Therefore, using paper mill white water for diluting thickened pulp in the TMP mill could potentially decrease the amount of extractives in the pulps to be sent to the paper mill.

Sample	Unit	Detackifier Trial	PAC Trial
Storage tower	%	1.97	2.11
Prebleach press feed	%	2.01	2.08
Prebleach press discharge	%	1.58	1.82
Postbleach press feed	%	1.02	1.69
Postbleach press discharge	%	0.93	1.23
Flotation recovered fiber	%	2.84	4.64
TMP to blend chest	%	1.18	1.75
Cloudy white water	ppm	139.08	239.40
Clear white water	ppm	131.51	159.84
Prebleach press pressate	ppm	257.81	362.05
Postbleach press pressate	ppm	386.13	413.18
Flotation clarified water	ppm	296.90	78.05
PM1 white water	ppm	46.99	56.71
PM2 white water	ppm	37.99	42.18

V. Extractive contents in different pulp and water samples.

CONCLUSIONS

Wood extractives accounted for the majority of the deposit samples. The operating parameters of supercalendering stacks can have an impact on the formation of deposits. A higher stack temperature can render extractives components sticky, therefore promoting the deposit formation on the roll surface. Temperature shock caused by using more fresh water in the process can increase the amount of pitch-related deposits.

Pitch-related deposition in the paper mill can trace back to the feedstock. The results from different pulp and water samples showed that significant amounts of extractives were fed to the paper machine. Two control strategies, detackification versus fixation by PAC, were carried out. The results from the mill trial supported the notion that dispersant/detackifying chemistry, which made extractives less sticky, worked better than the PAC program that fixed the extractives to fibers. **TJ**

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ABOUT THE AUTHORS

Pitch-related deposit formation is an important issue in an Eastern Canadian specialty paper mill. To improve the mill operation and product quality, it was crucial to investigate and mitigate pitch-related deposit formation. Our study combined fundamental understanding—by characterizing the pitch-related deposits and pitch interactions with metal ions—and practical solutions to the problem.

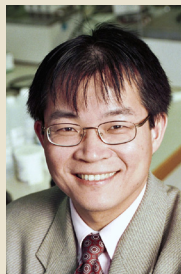
We developed a detailed mapping to pinpoint the pitch content at various streams at the mill. A significant finding was that pitch-related deposit formation could be controlled; the most relevant technologies could be applied once the complicated system was understood.

Using this project as an example of decreasing

pitch-related deposit formation, similar strategies can be applied at other mills.



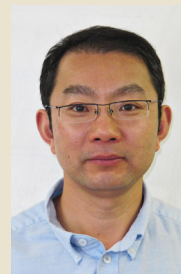
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Ni



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