Stickies: Management And Control

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ABSTRACT

This paper presents a broad overview of the various methods used to reduce the stickies from the conventional recycling process operations to the development of enzymatic solutions especially designed to minimize the stickies. It covers different mechanical, physio-chemical technologies, chemical treatments (passivation, fixation, dispersion) and enzyme based solutions for the removal of stickies/reduction of their detrimental impacts in the deinking process. Recent development on recycle compatible adhesives is also discussed in thes paper.

Keywords: Stickies, macro-stickies, micro-stickies, enzymes, stickies control, surfactant

Introduction

While producing papers using recycled fibres, mills very often face a problem of organic deposits which originate from adhesives, ink binders and coating binders on various equipment of the paper machine (wire, press, drying cylinder, converting and calendaring section). These detrimental contaminants involved in deposit formation are often termed as stickies. Stickies able to pass a sieve of 100 or 150 μm (depending on standard) are called micro-stickies, whereas the particles retained on the screen are called macro-stickies. Dissolved and colloidal stickies are called secondary stickies. There are standard methods for measuring macro-stickies, but a standard method measuring the total amount of stickies is scanty. Many problems are associated with these deposits e.g. paper break, presence of spots, holes, dirt counts and reduction in drying efficiency due to felt clogging. This phenomenon leads to frequent stoppage of the machine for cleaning of the clogged equipment.

Control Of Stickies

The control of stickies may be roughly divided into two strategies; removal of stickies to the maximum extent and prevention of the remaining stickies to deposit. Removal of stickies is usually the primary goal, and deposit control is performed to minimize the detrimental effects of the stickies that can't be removed.

Removal of stickies may happen anywhere where there is a reject stream. Depending on the handling of the reject, stickies are either purged out of the system or recirculated back. The true exit points are usually the pulper rejects, dewatering screen, cleaner, flotation and internal water treatment rejects, and wastewater.

Pulping

Pulping is not a removal step by itself. Nevertheless, pulping largely influences the removal of stickies and other containments in the following steps. Thus, the pulping step has to meet with contradictory requirements: to reach a good defibering, to achieve a good ink detachment and at the same time to avoid the fragmentation of containments such as stickies. This is why the old low consistency pulpers with high speed rotors and deflakers have been replaced by medium consistency pulpers and their auxiliary equipment in deinking plants. Drum pulpers have also been introduced in order to keep contaminants in large pieces. Due to the absence of rotor, the drum pulper does not have any cutting action and some contaminants, like bookbinders, remain intact and are rejected by the associated rotary screen. To meet these requirements, a complete process has been proposed in order to improve the removal of stickies in a deinking plant; recovered paper is pulped at low temperature, without chemical and fine screening and cleaning stages are implemented immediately after the pulping stage. After thickening, hot dispersion with chemicals, is then used for ink detachment before its removal in a second loop.

Deinking chemistry is important for stickies removal in a deinking mill. The stickies are detached from their substrate in the pulper for the first time, and thus the conditions in the pulper are very important for the performance of the subsequent unit processes.

Screening

The efficiency of the removal of stickies has increased with progress in screening technologies, which have occurred over several years. Contoured fine slot screens (with slots down to 0.15 mm and sometimes 0.10 mm) remove most adhesive particles. Unfortunately, some of them, mainly due to their small size and shape, still can go through the slots and contaminate the accepted pulp. In this respect, it is assumed by Heise et al. 2000 that 5 to 30% of primary stickies may pass through the screening slots.

Thus, there is need of improvement in screening which includes design of new equipment or new screening process.

Cleaning

The stickies removal efficiency of cleaners depends on the density of the particles to be removed. Unfortunately a lot of stickies have a density close to 1 and are not removed effectively by cleaning.

Flotation

Flotation appears to be an interesting way to remove residual stickies from the pulp. However, recent works carried out in laboratory (Julien et al. 1998) and in mill (Heise et al. 2000) show that the efficiency of flotation to remove stickies depends on various parameters such as the shape, size and surface properties of stickies, and also on the hydrodynamic parameters.

The main advantage of flotation (compared to screening in particular) is its potential to remove small stickies (micro-stickies) from the pulp

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suspension. Indeed, it is reported in various papers that small size stickies, which are not affected by screening, present the best removal efficiencies during flotation. It is also reported (Heise et al. 2000) that the removal of stickies in post flotation, performed after a dispersion step, must be more efficient than in the pre-flotation step where stickies are larger. In this regard, Johansson et al. 2003 have shown that flotation may remove over 70% of the micro-stickies content of the pulp.

The high concentration of dissolved and colloidal materials in the pulp and in the process water (resulting from the increased water loop closure) is considered as a major cause of secondary stickies formation and deposits. Thus, dissolved air flotation of process waters, associated with the use of a cationic coagulant has been proposed as a solution to reduce the colloids concentration in the process water and consequently to reduce the secondary stickies problems.

Dispersion of primary stickies

Hot dispersion (by low speed kneaders or high speed dispersers) has been widely developed for the treatment of OCC containing waxes or hot-melts in order to avoid the formation of spots in the paper. In a deinking plant, hot dispersion is efficient for dispersion of hot melts if particles have not been removed by cleaning and screening, but finely - divided hot-melt particles can contribute later, in the wet part of the paper machine to the formation of deposits. Adhesive particles from tapes and labels are not completely dispersed, but are reduced in size and their shape is changed; flat particles become spherical, so some improvement in their removal by screening can be expected. In any case hot dispersion can't be considered as the way to solve the stickies problem. Some improvement of visual aspect of the paper can be expected, but if hot dispersion is implemented without a previous efficient removal of adhesive particles, secondary stickies will certainly appear later.

Therefore, hot dispersion of residual stickies has to be considered in relation to the dispersion of residual ink and specks, and implementation of a post-flotation stage.

Control with mineral additives

Talc

Talc, hydrous magnesium silicate, has the planar surface, and is electrically neutral and hydrophobic (organophilic). The bonding between talc and stickies is based on adsorption. Indeed, the hydrophobic surface has an affinity for stickies while the hydrophilic edges allow an easy dispersion of the talc in water. Thus, it is believed that talc coats the stickies surface and consequently reduces their tacky character. Talc is often introduced at the inlet of the kneader or disperser to favor its mixture with the pulp components.

More recently new talc application strategies have been proposed with the aim to control stickies deposition:

- It has been reported that the coating of stickies by talc induces an increase of their density (Biza et al. 2002). As a consequence, this allows the stickies to be more efficiently removed by high density cleaners.
- The surface treatment of the paper sheet in the forming section of the paper machine is done by spraying the talc slurry onto the paper (Biza et al. 2001). This kind of treatment enables to achieve the passivation of the stickies which appears on the paper surface and which are the most detrimental regarding deposit formation.
- Modified talc (the hydroxyl groups on the edges are modified by a cationic polymer) is proposed for stickies control application (Sharma et al. 2002). The cationic charge carried by this modified talc is believed to favor both its attachment onto negatively charged stickies and its retention in the paper sheet.

Bentonite

Bentonite in association with polyethylene oxide is used as a very efficient retention system which largely improves the stickies and pitch removal (Putz *et al.* 2003; Sjöström *et al.* 2004). This kind of system may be considered as secondary stickies control: indeed, the dispersed stickies are fixed by the chemicals onto the fibers and consequently removed from the process by the paper sheet.

Diatomite

Diatomite is a mineral composed of the skeletal remains of single celled aquatic plants (diatoms). This mineral is mainly based on amorphous silica (90%) and presents both organophilic and hydrophilic parts. These properties explain why the product is proposed as stickies passivating agent (Williams 1987, Vogel 2002).

Control with organic additive

Mainly two types of organic additives are used to control stickies; cationic polymers and surface active agents.

Stickies fixation by cationic polymers

The use of cationic polymers for the stickies control is very common in deinking and recycling mills. During the pulping process, some of the paper contaminants are dispersed in a colloidal form and consequently can't be removed by the various decontamination process of the recycling chain. The role of the cationic polymers that are added to the pulp is to prevent the formation of secondary stickies. In fact, the principle of this treatment is to induce a controlled precipitation of the colloidal contaminant and their fixation onto the fibers, so that they are removed with the paper sheet (Taylor 2001).

The higher retention of stickies also prevents the accumulation of stickies in the white water, and makes the stickies exit the system with the paper. Thinking globally, this will introduce the stickies again to a papermaking system if the produced paper is again recycled. Fixing of detrimental substances with high-charge, low molecular weight organic polymers on the fiber may be thought as the first step of retention. Too large particles don't stay on the fiber and end up depositing, but by micro fixation of the stickies as small as possible with optimized polymers, machine downtime due to wire cleaning can be reduced (Hättich *et al.* 2002). In order to reduce the stickies problem, the stickies have to be made small with a non-ionic dispersant and fixed to fiber as small particles with a high charge density fixative (Ward *et al.*1994). Hamann *et al.* 2004 found that the fixing of coated broke reduced the quantity of materials deposited. Gruber *et al.* 2000 found aluminum sulphate and cationic fixatives to reduce wet deposition of stickies. Poly-DADMAC together with acrylic acid or acrylamide is patented for deposit control (Song *et al.* 2006). Huo 2002 noticed poly-DADMAC to adsorb on the surface of model micro-stickies and prevent the agglomeration of the stickies. In the presence of fibers, poly-DADMAC was shown to form fiber-stickies-flocs.

Cationic polyacrylamide (C-PAM) is very commonly used as a flocculant in retention programs. C-PAM has been shown to be able to fix model secondary stickies on the fibers and reduce deposition (Li & Zhan 2005). They also found that cationic starch destabilizes model secondary stickies, but also adsorbs on the sticky surface and reduces tackiness, while calcium may boost the deposit formation.

The ability of different chemicals to coagulate and flocculate dissolved and colloidal substances was tested by Tinna Sarja, 2007 on laboratory scale with the turbidity difference method, which measures colloidal substances sensitive for pH shocks (mainly wood extractives).

The figure 1 clearly shows that polyaluminium chloride has the highest ability to coagulate the colloidal substances and wood extractives. All chemicals enhanced the flocculation as compared to the blank without any chemical.

The effects of fibers, different cationic polymers and salts on the stability of the micro-stickies were investigated by Xin Huo 2002. The agglomeration of micro-stickies with poly-DADMAC was reported mainly via a neutralization mechanism. In contrast, the agglomeration of micro-stickies with cationic starch did not correspond with neutralization mechanism. It was reported that both poly-DADMAC and cationic starch could stabilize the micro-stickies if they were charged to the system in excess.

The stability of model micro-stickies in the size range of 1 to 50μm has been reported to depend on salt concentration and dosage of cationic polymer. It has been reported by Xin Huo 2002 that micro-stickies started to precipitate at the charge ratio of 1/3 for poly-DADMAC (Table 1). The turbidity was found to decrease significantly from 100 to 30 NTU as the charge ratio increased from 2/3 to 3/3. The maximum precipitation of micro-stickies with poly-DADMAC occurred at the neutral point where the charge ratio is 3/3, as determined by turbidity measurement performed after mixing. It was suggested that the flocculation of the micro-stickies with poly-DADMAC was greatly assisted by charge neutralization. However, if the charge ratio was raised to above 5/3, in other words if the suspension was overcharged with cationic polymer, the turbidity of the suspension increased, indicating that the sticky particles were somewhat restabilized by the excess polymer. However, the precipitated agglomerates produced at all levels of poly-DADMAC were large in particle number and could not be dispersed again by shaking the suspension vigorously.

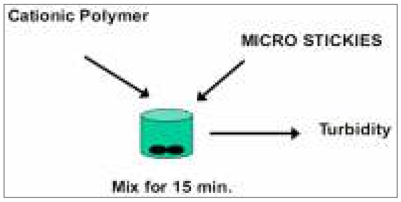
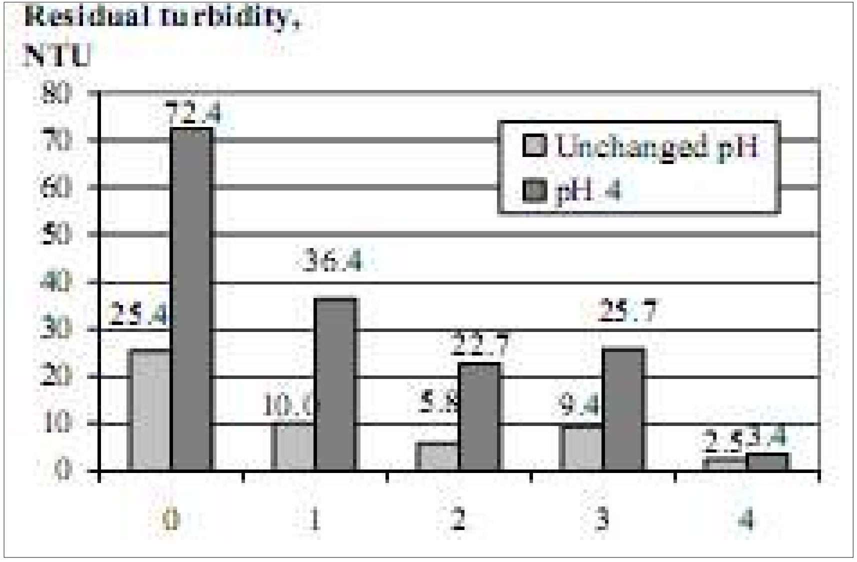


Figure 2 a: Experimental procedure for adsorption of micro-stickies with cationic polymer

The dosage of cationic starch was according to the calculated charge demand of the cationic starch and micro-stickies (Table 2**).** The turbidity of the suspension measured overnight for the cationic starch decreased from 125 to 5 NTU as the charge ratio increased from 4/3 to 5/3. Based on the turbidity overnight, the maximum precipitation occurred at a charge ratio of 5/3 for the cationic starch rather than at the neutral point as for the poly-DADMAC. The reason may be that starch has a much higher molecular weight and lower charge density than starch which may prohibit the access of sticky particles. Similar to the poly-DADMAC, the sticky particles treated with cationic starch could be



Sample number	Chemical	Dose (ppm)
0	None	-
1	Bentonite/A-PAM	30/2
2	Cat.fix/C-PAM	20/2
3	Poly-DADMAC	30
4	PAC	400

Figure 1: Effect of different coagulation and flocculation chemicals on the turbidity difference of paper machine loop DAF inlet. A-PAM = anionic polyacrylamide, C-PAM = cationic polyacrylamide, PAC = polyaluminum chloride (Tinna Sarja, 2007)

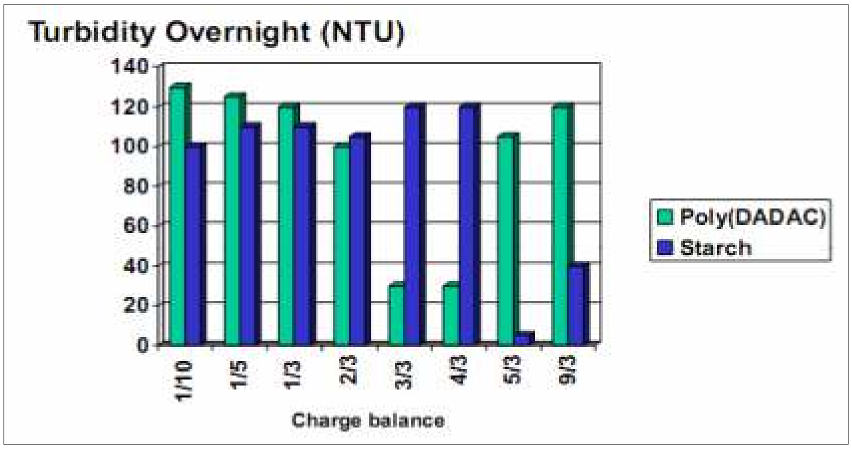


Figure 2b: Effect of polymer on stability of micro-stickies

Table 1: Stability of micro-stickies in the presence of poly-DADMAC (Xin Huo 2002)

Dosage of poly-DADMAC (charge ratio)	After mixing turbidity (NTU)	Overnight Turbidity (NTU)	Agglomerate	Average particles ? inside floc (after mixing)
0	no precipitation(130)	*(130)	Stirrer, irreversible	1
1/10	*(130)	*(130)	top, irreversible	very large
1/5	*(130)	*(125)	top, irreversible	very large
1/3	***(125)	No change(120)	wall, irreversible	very large
2/3	***(120)	No change(100)	top, irreversible	very large
3/3	***(30)	No change(30)	top, irreversible	very large
4/3	***(30)	No change(30)	top, irreversible	very large
5/3	***(120)	No change(105)	top, irreversible	very large
9/3	***(130)	No change(120)	top, irreversible	very large

The symbols * and *** indicate the appearance of a small amount and significantly larger amounts of precipitate respectively.

Table 2: Stability of micro-stickies in the presence of cationic starch (Xin Huo 2002)

Dosage of cationic starch (charge ratio)	After mixing Turbidity (NTU)	Overnight Turbidity (NTU)	Agglomerate	Average particles ? inside floc.(after mixing)
0	No precipitation(120)	*(120)	bottom, irreversible	1
1/10	*(120)	no change(100)	bottom, irreversible	1
1/7.5	***(90)	no change(85)	top, irreversible	very large
1/5	***(120)	no change(110)	top, irreversible	very large
1/3	***(130)	no change(110)	top, irreversible	very large
2/3	***(140)	no change(105)	top, reversible	188
3/3	***(130)	no change(120)	top, reversible	174
4/3	***(135)	no change(120)	bottom, reversible	67
5/3	***(125)	very clear (5)	bottom, reversible	25
9/3	***(130)	clear (40)	bottom, reversible	2

The symbols * and *** indicate the appearance of a small amount and significantly larger amounts of precipitate, respectively.

restabilized by overcharging these particles at a charge ratio of 9/3. It was noted that the flocs precipitated by the cationic starch were different from those from poly-DADMAC. The average particles per floc for cationic starch became countable at a charge ratio over 2/3 and the average particles per floc decreased as the charge ratio increased. These flocs were also reversible, meaning that on vigorous shaking, the suspension became very turbid again. It was suggested that the forces that made the micro-stickies flocculate in the presence of cationic starch were weaker than those caused by the poly-DADMAC. In fact, the difference in turbidity after mixing and after settling overnight for the cationic starch was attributed to reversible shear-induced breakage during mixing. The results showed that the cationic starch (more hydrophilic) was less effective in flocculating the micro-stickies (Xin Huo 2002).

In some cases these polymers are modified with the introduction of specific functional groups (usually hydrophobic groups) in order to favor their interaction with the colloidal stickies. The use of a fixed dosage of the fixing agent may, in some cases, represent a drawback (Gould, 1993). The major risk is certainly linked to a decrease of the colloidal contaminant concentration. Indeed, as the coagulant dosage is fixed, a decrease of the colloid concentration will induce a higher destabilization level. This no-well-controlled destabilization may in some cases give rise to a sudden formation of secondary stickies.

To avoid this drawback, solutions are proposed, which usually consist of regulating the dosage of fixing agent (Renaud, 2001). For this purpose, the anionic colloid concentration is continuously measured (online charge measurement) and the dosage of the coagulant is adjusted on the basis of the charge content of the pulp. Consequently, a target of charge level is achieved which enables very stable running condition. Such a controlled system not only reduces stickies problem, but also leads to many other advantages like improvement of efficiency of cationic starch, retention and drainage aids.

Stickies control by surfactant

In one of the approaches concerning the use of surfactant; products having a passivating action (reducing the tacky character of stickies) are proposed (Hall and Nguyen 1998), which are based on particular non-ionic surfactants (ethoxylated alkyl phenol, ethylene oxide - propylene oxide block copolymers). However, these products only modify the surface properties of stickies, but don't favor the removal of the stickies particles.

The other approaches targeted for stickies removal (Bossaer 1999, Doshi and Dyer, 1999, Severtson et al. 1999, Coffey 1999) are as follows:

- Combined treatment based on dispersant, generally added at the beginning of process (pulping) in order to favor the dispersion and the passivation of the stickies, and on cationic fixing agent added near the paper machine intended to fix the stickies previously dispersed onto fibers and thus to eliminate them via produced paper.
- For the treatment of the waxed paperboards a combined treatment has been suggested; in the first phase (pulping) the wax is dispersed at low temperature using a specific formulation including a wax melting point depressor and an anionic dispersant. The dispersed paraffin is then separated from the fibers by a washing or thickening stage. Finally, the resulting water, containing dispersed wax, is treated by micro-flotation (DAF) with a specific chemistry which enables the removal of wax particles.

Surfactant may also be used to treat paper machine clothing such as felts or wires. The principle is to directly treat (usually with surface active agent) the paper machine equipment, which is sensitive to deposits. Two types of applications can be distinguished:

- Protection of wires and felts (Lynch 1993)

  The treatment is intended to modify the surface properties of the wire or the felt in order to make them more hydrophilic, which would tend to prevent the stickies deposition. A solution containing specific surface-active agent is thus sprayed onto the wires or felts by means of the rinsing water. This enables the formation of a protective coating thus reducing the stickies adhesion.
- Cleaning of wires and felts

  These treatments take place during paper machine shutdowns. For this purpose, cleaning solutions are used, which are mixtures generally containing soda (2 to 5%), anionic or non-ionic (0.1 to 0.5%) surfactant and cleaning agent.

Stickies control by enzymes

A new enzyme-based control system breaks macro-stickies into smaller particles that can be removed from the mill process, thus reducing their impact on runnability and paper quality. It uses esterase-type enzymes to break down the stickies into smaller, less tacky particles.

A study of the chemical composition of stickies reveals that those contain a number of ester-type bonds that link the basic building blocks of the sticky together. This directed the search to esterase-type enzymes, an enzyme product for stickies control that catalyzes the breaking of ester bonds. Breaking the ester bonds reduces the size of the sticky into smaller components. A key advantage of this approach is that once broken down, the chance of the particles reagglomerating further in the process is greatly reduced.

Park et al., 2004 has reported that the amount of sticky contaminants in screen rejects increased with the enzyme treatment and the content of toluene extract in the final product was decreased. Table 3 shows the content of the sticky compounds. In each fraction of the enzymatic pulping, the MOW and ONP contained sticky synthetic polymers. When enzymes were used as a pulping additive, the content of the sticky compounds was higher in the reject materials of the screen. It was considered that the enzyme attacked the surface of the paper where the sticky compounds were applied and released the same from the fibre. Therefore, the sticky content of the 200 mesh passed fraction was reduced in both the ONP and MOW. The sticky compounds in the 200 mesh passed fraction could be potential colloidal stickies and flowed into the white waters of the papermaking system and caused the sticky troubles.

Table 3: The content of sticky compounds of fractionated ONP and MOW pulping slurries (Park et al. 2004)

	ONP			MOW		
	SR (%)	A (%)	P (%)	SR (%)	A (%)	P (%)
Water	17.2	0.2	82.6	43.1	43.1	13.8
1.5% NaOH	15.6	"	84.2	44.8	49.5	5.7
Enzyme	20.1	"	79.7	53.7	42.5	3.8

SR; Sweco screen reject, A; 200 mesh accept, P; 200 mesh pass

In order to understand how the enzymes can reduce the sticky content in the reject material in the Sweco screen, a carbon black mixed with hot melts was coated into the MOW and was pulped with each condition. Then the black sticky deposit in the handsheet of the MOW was analyzed by image analysis. As shown in figure 4, the particle size of the hot melt adhesive in the pulp defibrillated with the enzymes was a little larger than that of the alkaline pulping condition. It means that the large size sticky film was more easily rejected in the screen (Park et al. 2004).


Water 1.5% NaOH Enzyme

Figure 4: Morphology of hot melt adhesive mixed with carbon black particles on MOW pulp slurry before screening (Park et al. 2004)

Table 4 show that the sticky content of the rejects on the Lamort screen of enzyme treatment is much higher than that of control. Also, the content of sticky contaminants in the final product predominantly decreased with the enzymatic pulping.

Table 4: Content of stickies in dried pulp processed from tissue and glazed paper (Park et al. 2004)

Sampling	Tissue paper		Machine glazed paper	
	Enzyme (%)	Control (%)	Enzyme (%)	Control (%)
Pulper	0.46	0.46	0.16	0.16
Lamort screen reject (Re)	3.96	2.49	0.24	0.18
High shaking screen accept (Ac)	1.73	1.58	0.12	0.14
Lamort screen accept (Ac)	0.35	0.39	0.07	0.33
Product	0.31	0.76	0.46	0.54

Buckman Laboratories has developed an enzyme (esterase) which is able to break down the macro-stickies and micro-stickies (Jones et al. 2003). This development is based on the observation that stickies often contain in their structure a number of ester bonds which may be attacked by esterases.

Design of recycling compatible adhesives

For some years, adhesive suppliers

have performed extensive work to develop adhesives less detrimental to the recycling of papers and boards. Nonetheless, it is important to keep in mind that the first function of an adhesive is to stick before being easily removed in the recycling line. Adhesives less detrimental to paper recycling or "recycling compatible adhesives" are designed with two major approaches:

Approach: dispersible adhesives

The idea is to produce dispersible or soluble adhesives, which avoid the formation of primary macro-stickies in the pulp. Indeed, such dispersible adhesives are dispersed or solubilized in the water phase during pulping and therefore seem to disappear.

Various authors describe and promote the development of dispersible tapes based on the use of water dispersible polymers. Dispersible hot melt adhesives were also proposed for applications such as multi-wall bag sealing, book binding, roll wrapping etc.

Recently a new water soluble pressure sensitive adhesive has been synthesized carrying a cationic charge (Yan et al. 2003). The charge makes these materials easily removable by adsorption onto the negatively charged fibers and fines. This approach could potentially solve the problem of macro-stickies (dispersible adhesives) and secondary stickies, as most of the stickies would be removed with the paper product.

Approach: removable adhesives

This approach is based on the development of non-dispersible products that can be removed from the process as early as possible by screening or cleaning process. Although the design of totally removable adhesive is a difficult task, this approach is much preferred since it avoids the formation of both primary and secondary stickies.

In this respect, high-density hot melts (density approx. 1.2) (based on saturated copolyesters) have been proposed (Pieroni et al. 1986). This adhesive has all the properties of a normal EVA hot melt. 90% of this adhesive has been reported to be removed by a cleaner in single pass. The prohibitive factor is, however, cost. These saturated copolyesters have double the price of normal EVA hot melts.

Hot melts, which may be removed by screening, were also developed. To avoid excessive fragmentation during pulping and consequently to achieve good removal efficiency during screening, the melting temperature may be as high as possible. This makes the adhesive more resistant to shear.

Conclusion

The control of stickies in deinking or recycling mills is still a very complex issue. In fact, this is mainly the consequence of the wide variety of the materials called stickies. As a consequence, it seems that to reduce the impact of the stickies problem in the deinking or recycling industry no simple recipe can be given. In fact, each mill is a particular case and must research the best technical solution (or combination of solutions), which must be specifically adapted to its particular stickies problems. The recently acquired knowledge gives some new perspectives. Thus, flotation, dissolved air flotation and chemical treatments need to be improved with the goal to optimize micro-stickies removal from the process. This achievement could lead to a step forward in tackling the issues of stickies.

References

- Biza P., Gaksh E., Hangl M. "Treatment of stickies particles by surface application of talc", 2nd CTP-PTS Packaging Paper and Board Recycling International Symposium, 2001, Grenoble, France, 2.
- Biza P., Kaiser P., Gaksh E. "Use of talcum to enhance the removal of stickies", 10th PTS CTP Deinking symposium, Munich, 2002, Germany.
- Bossaer P., "The control of stickies by the means of dispersants and fixation aids", 1st Packaging Paper Recycling Symposium, 1999, Grenoble, France.
- Coffey M. J., "Dispersion of wax coatings at neutral pH and typical process temperature", TAPPI "Preparing for the next millennium",1999, Atlanta, USA, pp 221-225.
- Doshi M. R., Dyer J.R. (1999). "Wax in OCC-properties and control strategies", Paper Age, **115**(7), pp 20-23.
- Gould L., "Chemical control of stickies", Pira Conference on Developments in Waste paper Technology, 1993, Paper 11.
- Gruber E., Gattermayer J., Pätzold R. (2000). "Adsorption of micro-disperse polymers with adhesive potential (micro-stickies)". Ipw / Das Papier (5): T74-T80.
- Hall J.D., Nguyen D.T. "Stickies control using non ionic polymers in systems with lower operating temperatures", TAPPI Recycling Symposium, New Orleans, USA,1998, pp 73-77.
- Hamann A., Gruber E., Schädler V., Champ S., Kuhn J., Esser A. (2004). "Effect of fixation agents on the sticky removal" .Wochenblf Papierfabr, **132,** (3-4), pp102-106.
- Hättich T., Angle C.D., Knight P. (2002). "A novel and effective method to manage contaminants in packaging papermaking". Pap Technol., **43**(6): 39-44.
- Heise O. U., Kemper M., Wiese H., Krauthauf E. (2000). "A removal of residual stickies at Haindl Paper using new flotation technology", Tappi J., **83** (3), pp 73-79.
- Huo X. (2002). "Adhesive contaminants (stickies): characterization and their interaction with papermaking components during paper recycling". Doctoral thesis, North Carolina State University, Department of Wood and Paper Science, 163 p.
- Huo X., Venditti R.A., Chang H. (2001). "Use of deposition and extraction techniques to track adhesive contaminants (stickies) in a papermill". Prog Pap Recycling, **10**(2), pp15-23.
- Jones D. R., Fitzhenry J. W. (2003). "Esterase- type enzymes offer recycled mills an alternative approach to stickies control", Pulp Pap., **77** (2), pp 28-31.
- Julien-Saint-Amand F., Perrin B., De Luca P. (1998). "Stickies removal strategy", Progress in Paper Recycling, **7** (4).
- LeRoux R., Pruszynski P.E., Armstrong J.R., Lin J.F., Polverari M.S., Angelac A.P. (1997). "Control of stickies contaminant in newsprint applications review, mechanisms and novel approach". Pulp Paper Can., **98**(9), pp 54-61.
- Li Z. , Zhan H. (2005). "The effect of cationic polymers and calcium ions on model secondary

stickies stability and deposit ability". Prog Pap Recycling, **14**(4), 6-12.

- Lynch G.A. (1993). "Deposit control programs optimize papermaking operations", Paper Age, **109(**2), pp 18-19.
- Park Soung-Bae, Lee Jung-Myoung, Eom Tae-Jin, (2004). "The control of sticky contaminants with enzymes in recycling of waste paper", J. Ind. Eng. Chem., **10**, (1), 72-77.
- Pieroni M., Chiolle A., Tredici P., Koch V., Calmanti G., Gatti A. (1986). "Easily removable hot melt adhesives for use in repulpable paper products and related process", Commission of the European Communities, European Seminar, Brussels, Contract BOS 122.1.
- Putz H-J, Hamann A., Gruber E. (2003)."Examinations of sticky origin and sticky removal". Wochenblf Papierfabr, **131**(14-15), pp 883-891.
- Renaud S., "New measuring technique enhancing fixative control", TAPPI Papermakers Conference, 2001, Cincinnati, OH, USA.
- Severtson S. J., Coffey M. J., Nowak M. J. (1999), "Wax dispersion during recycling of old corrugated containers", Tappi *J.*, **82**(12), pp 67-74.
- Sharma S., Kortmeyer J. C., Spivey A., Lasmarias V. B. (2002), "A cost effective talc solution to stickies control in OCC pulps", 2002 Fall Technical Conference and Trade Fair, San Diego, CA,USA.
- Sjöström L., Östlund I., Mähler A. (2004), "RODET, reduction of detrimental substances in papermaking a joint European project". Industri-Kontakt (3), pp 14-16.
- Song Z., Ford P.A., Roy V.F., Grimsley S.A., Satcher K.W., Blazey M.A., Pelbois R. (2006). "Amphoteric cationic polymers for controlling deposition of pitch and stickies in papermaking". U.S. Pat. Appl. Publ. US 2006/0000570 A1.
- Taylor T. E. (2001). "Novel chemistry for white pitch and stickies control", 2001 TAPPI Papermakers Conference, Cincinnati, OH, USA.
- Tiina Sarja (2007), PhD thesis "Measurement, nature and removal of stickies in deinked pulp", University of Oulu, *www.herkules.oulu.fi/isbn9789514284649/index.html?lang=en*
- Vogel J.H., "Diatomite for stickies pacification", Proc. TAPPI Fall Technical Conference and Trade Fair, 2002, San Diego, USA, pp 151-155.
- Ward J., Hensel D., Patterson J. "A new approach to the control of stickies". Proc. Recycling Symposium, Boston, USA, 1994, pp 67-77.
- Williams G.R. "Physical chemistry of the absorption of talc, clay and other additives on the surface of sticky contaminants", TAPPI Pulping Conference, 1987, Washington, pp 563-570.
- Yan Z., Deng Y. (2003). "Water-soluble/dispersible cationic pressure sensitive adhesives. Part 1: adhesives from solution polymerization", *J* Appl. Polym. Sci., **90** (6), pp l624-1630.