Simulation of Recycling Pilot Plant Process: Effect of Process Modification on Stickies Control

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ABSTRACT

Stickies control is one of the most complex problems being faced by the recycled fiber (RCF) based mills. Given the unpredictable nature of the stickies and stickies related problems, it is necessary to study the influence of possible control solutions before they are adopted by any mill. Computer simulation technique offers one such approach that can be used to study the effects of various treatment options that are available for stickies control. Different probable solutions can be simulated and compared in order to find the best possible solution. In the present study, a recycling pilot plant trial was simulated to study the effects of process modification on stickies removal efficiency. The pilot plant trial included physico- chemical processes like floatation & dissolved air floatation (DAF) that are known to facilitate removal of stickies from a paper recycling system.

INTRODUCTION

Stickies are the most deterrent contaminants encountered in the recycled fibre based mills. Even though a large number of options are available for control of stickies, the diversity of stickies generating sources, their variable nature and physicochemical behaviour, and the inability of existing methods to effectively measure and control different types of stickies, make stickies control - a complex problem . As a consequence, stickies remain one of the major causes for poor process efficiency & product quality in recycled fibre based mills, both in India and the world over, needing effective control solutions.

Besides sorting of wastepaper for source control of stickies, the traditional methods for stickies control consist of both mechanical and chemical treatment. While each of these methods is effective for a specific type of stickies , none of these methods provides a complete control against all the different types of stickies encountered during paper recycling for instance - macro and micro /colloidal stickies. To minimize the limitations of both the methods, the current approach to stickies control combines the benefits of both the mechanical and chemical treatment. Chemicals are now being used to improve the stickies removal efficiency of mechanical processes.

The use of physico- chemical processes like Floatation and Dissolved Air Floatation (DAF), using different chemical aids, has been more recently explored for stickies removal. However, when incorporated in the process line, these processes can have different bearing not only on the stickies content of RCF pulp but also on other aspects of the process .It is therefore important to study and define the effects of such process modifications before their adoption by any RCF based mill .

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COMPUTER SIMULATION STUDIES

Computer simulation technique has been applied in several areas of pulp and paper process, equipment or product design. The technique has been used to gain a better understanding of the process for process optimization, finding alternative equipments, define effects of variables on product quality and quantity or even to find best ways to utilize raw material and energy.

This paper highlights the findings of a computer simulation study that was used to predict the influence of changing processes, process sequence and variables on the different types of stickies and subsequently on the total stickies removal efficiency of the process. Besides the stickies removal efficiency, the effect on process losses was also simulated. For carrying out the study, a simple pilot plant process, complemented with laboratory scale studies on DAF, was modelled and simulated. To minimize the complexity of the computer model and the simulation process, only the most relevant parameters/ variables were incorporated in the model. The study was carried out as a part of the project activity for the CPPRI - CTP, France collaborative project "Understanding & Control of Pitch and Deposits in Papermaking."

METHODS & MATERIALS

Description of the pilot plant

In the study, pilot plant sequence consisting of Pulping Cleaning - Screening Floatation - Washing was used. The sequence is depicted in the flow diagram below:

Pulping was carried out in the hydra pulper at a consistency of 5 % and temperature of 40° C for duration of 30 minutes. This was followed by high

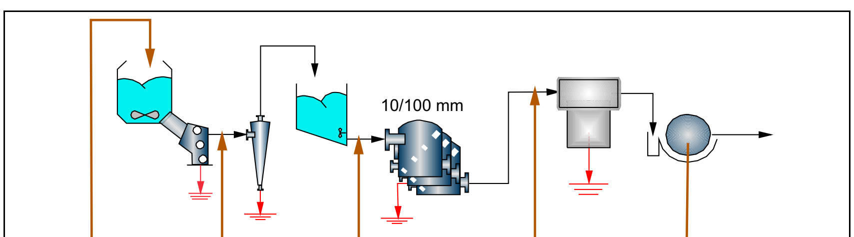


Fig 1: Flow diagram of Pilot Plant

density cleaning and screening in the pressure screens at a consistency of 2.5% and reject rate of 2%. To maintain the consistency at the screens, dilution of the pulp was made using the filtrate recovered from the washer.

The pulp accept from the pressure screens was floated in two vertical pilot floatation cells. Accepts from the first floatation cell was floated in the second cell before being sent to the washer .The conditions maintained during floatation were Air ratio 200%, addition of Sodium oleate 0.2 g/l and addition of calcium 0.15 g/l

Washing was carried out in a sloped wire washer of 100µm. During washing, an inlet consistency 1 % and outlet consistency 10 % was maintained. Washing filtrates were then collected and subjected to clarification by the means of the laboratory Dissolved Air Floatation (DAF) unit. Addition of PDMAC (poly diallyl dimethyl ammonium chloride) 50 ppm + CPAM (Cationic poly acrylamide) 2 ppm was made to induce the removal of colloidal substances along with fine suspended material.

Measurement of various pulp components

The various pulp components like fibres, fillers , fines, micro and colloidal stickies, macro-stickies and total stickies for pulp & reject samples collected from each of the unit operation of the pilot plant, were determined using CTP methodologies .

Software for computer modelling studies

The Process Simulator software PS-2000 developed by CTP, France was used in the study.

EXPERIMENTAL

Characterization of Pulp And Rejects Samples

For the determination of separation co-efficient for the various pulp components like fibres, fillers, fines, micro and colloidal stickies, macro-stickies and total stickies , pulp & reject samples were collected from across each of the unit operation of the pilot plant and analyzed . The results of the analysis is given in Table 1

Table 1 : Characterization of Pulp and Reject Samples Collected across Unit Operations

	Pulper Outlet	Outlet Coarse Screen	Inlet Floatation	Accept Floatation	Washer Filtrate	Washer Accept Pulp	Reject Coarse Screen	Floatation Froth
Consistency g/l	47.32	25.95	13.32	12.66	2.52	77.97	14.42	17.20
Fibres g/l	32.61	15.28	8.15	8.92	0.42	62.84	1.81	3.75
Fillers g/l	8.56	4.5	2.38	1.31	0.70	5.49	-	8.31
Fines g/l	6.15	6.17	2.79	2.43	1.4	9.64	-	5.14
Total stickies , g/100 g entire pulp	0.964	0.927	1.147	0.725	1.220	0.302		2.806
Macro Stickies, g/100 g entire pulp	0.436	0.324	0.236	0.196	0.098	0.273		0.119
Micro/Colloidal Stickies, g/100 g entire pulp	0.529	0.603	0.912	0.529	1.122	0.029		2.686

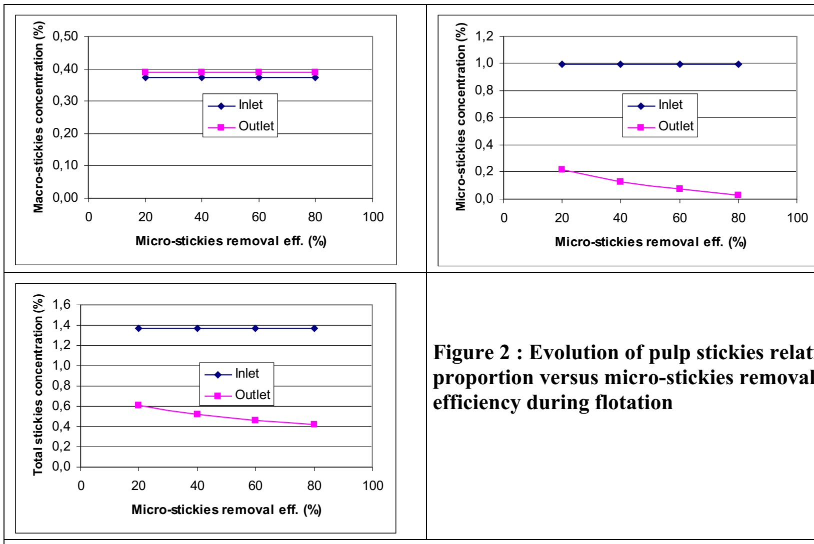


Figure 2 : Evolution of pulp stickies relative proportion versus micro-stickies removal efficiency during flotation

Designing of the Computer Model

A computer model was prepared based on the pilot plant process complimented by laboratory scale DAF studies, using process simulator software. The parameters that were incorporated in the model included fibers, fillers, fines, micro- , macro- and total stickies . The values for removal efficiencies for each of the pulp components, across different unit operations, were incorporated in the model. Removal Efficiencies were computed based on the experimental data from the pilot trial. The computer model was then employed for the simulation study.

RESULT & DISCUSSION

Studies on Influence of Various Process Modifications

The influence of four different process modifications on the stickies removal efficiency and process losses was studied by computer simulation. These modifications included - effect of variation of micro-stickies removal efficiency during flotation, influence of implementation of a second stage of floatation, influence of changing the position of floatation & washing and influence of DAF treatment on the washing filtrate.

Variation of Flotation Removal Efficiency of Micro-Stickies

This modification was studied to simulate the changes in the chemistry or changes in the physico-chemical conditions like surface tension which may prevail during flotation and affect the micro-stickies removal efficiency at the floatation cell. For the configuration, floatation followed by washing and micro- stickies removal efficiency ranging from 20% to 80 % at the floatation cell, the effect on macro, micro/colloidal and total stickies content was simulated. Figure 2 depicts these simulated results.

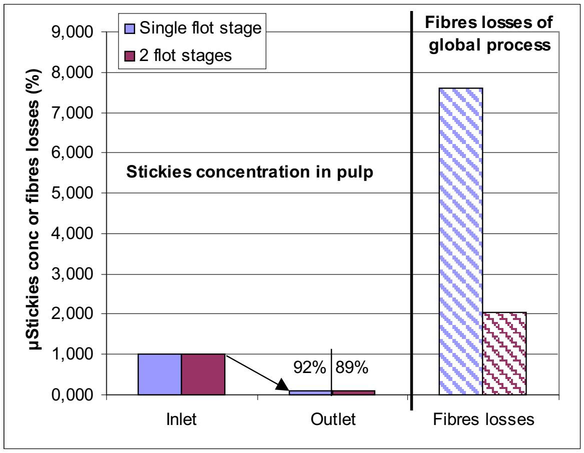
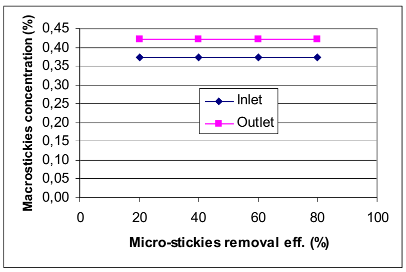
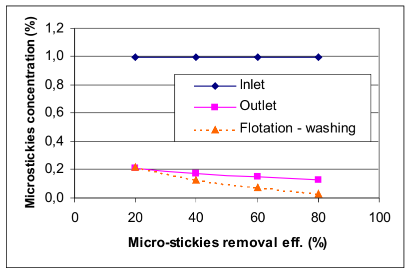


Figure 3 : Influence of a second stage of flotation





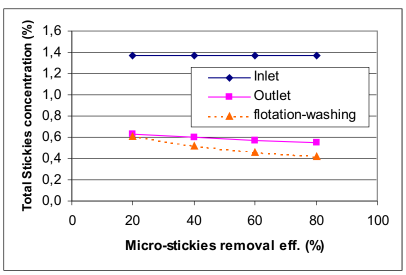


Figure 4 : Evolution of pulp stickies relative proportion versus micro-stickies removal efficiency during flotation

Table 2:Losses of the Different Simulated Processes for a 60% Micro-Stickies Removal Efficiency in Flotation

Process configuration	Fibres Losses (%)	Total Losses (%)	Total Stickies removal (%)
Flotation Washing Single Stage.	**7,6**	26,2	66
Flotation Washing Two Stage	2	17	61
Washing Flotation	2	14	58
Washing DAF	4,5	19	58

The results indicated that irrespective of the micro- stickies removal efficiency at the floatation cell, no significant effect on macro-stickies concentration is obtained. This is because while floatation induced the removal of macro- stickies, it simultaneously induced the removal of fines and fillers. As a result, at the end of the process, the relative concentration of macro- stickies remained unchanged. However, this configuration can effectively reduce the micro-stickies content of the pulp by 80 %, even at low micro-stickies removal efficiency of 20 %. This results from the fact that washing step returns most of the micro-stickies towards the floatation step, further inducing their removal. For micro-stickies removal efficiencies ranging from 20-80 %, the total stickies content of the pulp ranged from 55% to 70%. The simulated results however indicated that the configuration floatation followed by washing induced 7% loss of fibers & 25% loss of total suspended solids .

Influence of Implementation of Second Stage of Floatation

To reduce the losses of TSS & fibers, the influence of introduction of a second floatation stage to treat the foam from the first floatation stage was studied. Simulated results indicated a reduction of fiber losses from 7 % in single stage floatation to 2% in two stages. Micro stickies removal efficiency of 89 % was comparable to 92 % in single stage floatation- Figure 3.The use of two stage floatation sequence therefore shows a good compromise between the stickies removal efficiency and the process losses and appears to be an attractive option.

Influence of Changing the Position of Floatation & Washing

Reversing the process configuration from Floatation - Washing to Washing Floatation can also reduce the process losses .The effect of such change was simulated. Figure 4 shows the effect on macro, micro and total stickies content of the pulp when the removal efficiency of micro-stickies in the flotation cell varied from 20 to 80%.For Comparison, the results of both the scenarios i.e. flotation / washing and washing / flotation are given .

The results indicate an increase of macro-stickies concentration in the pulp. This is because most of macro-stickies are retained with the pulp during washing while suspended solids (mainly fines and fillers) are removed. The high micro-stickies removal efficiency for this configuration is similar to flotation / washing. Since micro-stickies are the predominant stickies species, a good micro-stickies reduction induced a strong decrease of the total stickies content of the pulp. Losses in this situation are only 14% showing this option is slightly better, in terms of yield, than the implementation of two floatation stages.

Influence of DAF treatment on the Washing Filtrate

DAF may be used instead of floatation to treat the washing filtrate. The simulated results indicated that the removal of micro- stickies with washing/ DAF, 89 %, is as good as in the case of Washing/ floatation. However, since this process is less selective it induced higher losses at 19 %.

The simulated results of all the above process modification are summarized at Table 02.

CONCLUSION

The above studies demonstrate how computer simulation studies can be effectively utilized to predict the influence of process modifications on the stickies removal efficiency .The studies also indicate that process modifications can have significant influence not only on the stickies removal efficiency of the various physico - chemical processes but also to a large extent on the process losses. The results show that the best compromise between total stickies removal and material losses is achieved with washing / flotation configuration and flotation in two stages / washing. However, washing / flotation should be preferred since it induces the lowest losses for a relatively higher stickies content reduction.

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