Removing the Unknown of Lap Pulp Colloidal Stickies to Improve Paper Machine Runnability

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ABSTRACT

For many paper machines producing printing and writing grades the introduction of recycle pulp or increasing the amount of recycle pulp can be a challenge. Most operations will purchase recycle lap pulp and add 10% or more to the furnish mix. The addition of recycle pulp can cause issues and introduces a level of uncertainty of the stickies content and impact on runnability. Most operations depend on macrostickies count to determine the stickies content level but the measurement is not always reliable for preventing a stickies outbreak on the paper machine. The unknown possibility of issues for any given bale of recycle lap pulp means many operations will limit or refuse to use recycle fiber.

This study looks at recent efforts to measure the colloidal stickies and tackiness of the recycle lap pulp to help paper machines know with more certainty the potential impact on runnability. By developing a test method that looks both at the invisible (colloidal stickies) and visible world (tackiness) of stickies the recycle lap pulp can be evaluated and the risk reduced or eliminated for paper makers.

INTRODUCTION

Operations producing printing and writing grades are seeking to increase their usage of recycle fiber. Some locations are seeking to introduce recycle content while others are going from 10% to 20% or going from 20 to 40%. This means running longer productions with recycle fiber and bringing more into the process. A critical barrier to the use of recycle fiber is the inclusion of stickies leading to deposition issues and runnability problems such as scratching at the coater due to large contaminant particles [1]. Most printing and writing operations bring the recycle fiber in as lap pulp rather than producing on-site. Papermakers want to know if a given lot of lap pulp will run well or produce issues. The perception that it is by chance, a roll of the dice, that a given run of lap pulp will go well. This mindset limits the desire to use recycle fiber. Currently macrostickies are the means of measure stickies quantity and yet problems will still occur. Part of the reason is that macrostickies are only the tip of the issue. It is the smaller stickies passing thru the screening process and passing through the screens used for measurement of macrostickies that can be source of the problem (Figure 1). A significant amount of the material is actually below the typical 150 micron fine screen slot. It is this portion of the stickies that needs to be measured with respect to concentration and stability. Recycle plants have worked to reduce the number of macrostickies going from a count of 15 to 30 in 1994 to 5 to 8 mm^2/kg by 1999 [2-3].

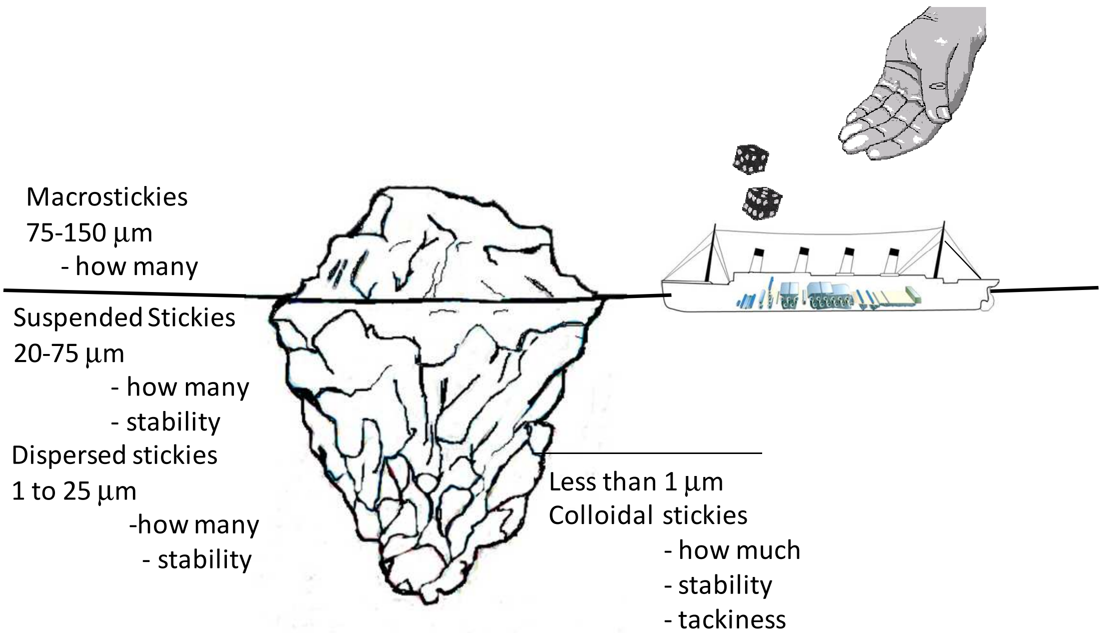

Figure 1. Stickies Iceberg Principle

The industry saw the start-up of several deinked market lap pulp operations in the late nineties. These operations sought to chip away the issues with stickies, the standard fine slot screen size of 150 microns went from zero in 1997 to one third of the segment using 100 microns fine slot screens by 2003 [4-5]. The importance of stickies size for recycle lap pulp into fine paper is seen when comparing fine screen slot size reported in an industry survey on stickies (Table I).

A stickies cut-off of 75 microns was found to be important with respect to stickies behavior during a study comparing methods for measuring microstickies. Methods that did not fractionate or fractionated above 75 microns detected stickies that behaved in a similar manner as macrostickies. The dissolved, colloidal, dispersed and suspended stickies below 75 microns behaved in a different manner [7-8]. The IPST TOC method which measures colloidal pitch and stickies below 25 microns has shown that stability is also an important measurement for predicting lap pulp behavior [9-11] beyond the typical macrostickies tests.

Table I. Fine Screen Slot Widths Found in Recycle Plants by Percentage [5-8]

Diameter in microns	Diameter in thousandth of an inch	Board Mills in 2003	Newsprint in 2003	Fine Paper & Tissue in 2003	Comment
0.2 to 5					Colloidal Stickies measures stability
1 to 25					Dispersed Stickies
20 to 75					Suspended Stickies
75	3				200 mesh - behaves like macrostickies
100	4			33.3	behaves like macrostickies
150	6		54.5	16.7	Standard in 1997 - typical micro/macro demarcation line
200	8	22.2	36.4	33.3	
250	10	66.7	9.1	16.7	
360	14	5.6			

While reduction in fine screen slots and looking at smaller stickies has helped what more can be done to evaluate the lap pulp so that paper makers can know if a given lap pulp will not cause issues beyond macrostickies measurement. One approach is to look at the colloidal stickies that can be detected using the IPST TOC test which measures the amount of colloidal stickies and with a shear stress test determines the stability of the stickies. Think of the invisible colloidal stickies as an indicator of how well a given load of lap pulp will interact with the paper machine process water. Under shear stress the colloidal organics will remain about the same, increase as stickies are broken into smaller pieces or drop as the colloidal organics agglomerate into larger pieces. It is this latter condition that will most likely lead to issues. The shear stress test can also help see how the lap pulp interacts with repulper dilution water, coated broke and other pulps.

Another test to consider measures the tackiness of the filtrate which gives a visible response to the nature of the invisible colloidal stickies coming in with the lap pulp. A relationship has been found between tackiness and colloidal organics with the majority of samples falling on an expected line, some samples having material with a low tackiness and other with a high level of tackiness (Fig. 2). Samples with a higher than expected tackiness have been linked with runnability issues on the paper machine.

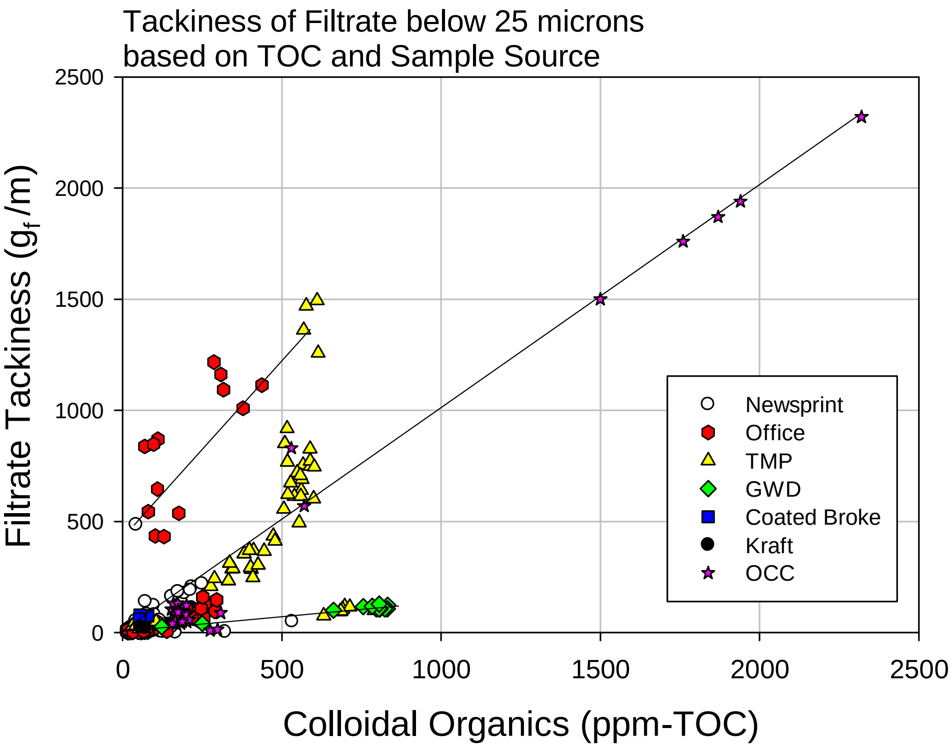

Figure 2. Relationship of Filtrate Tackiness to Colloidal Organics

A final test would be to measure the behavior of the stickies between 25 to 75 microns although the behavior is thought to be similar to what is seen with colloidal organics. This paper will look at how the IPST TOC method to measure colloidal organic stability and the tackiness test can be used to reduce the uncertainty of recycle lap pulp stickies behavior going to printing and writing paper grades.

PROCEDURES

The method for measuring colloidal organics is based on fractionation and then measurement of the Total Organic Carbon (TOC). The first fractionation of the sample removes fiber and fines and the second fraction uses a tangential flow membrane to separate out the dissolved organics. The properties of the second fraction will vary depending on the water management practices of the mill, the type of pulp and the layout of the water process. The differences between these two fractions represent the high molecular weight colloidal material that could potentially contribute to runnability issues. Since this is only a partial measurement of micro-stickies/pitch it is described as the "Effective Measurement of Micro-organic Accumulation" Potential or the EMMA Potential. This measurement can be thought of as concentration of colloidal pitch (natural), colloidal stickies (recycle fiber) or colloidal organics (combination from virgin and recycle fiber). The off-line test consists of filtering through a 25 micron filter paper and then through a 5,000 MW tangential flow membrane. Step by step procedures and equipment for testing is available [12]. Testing has shown that between 70% to almost 100% of the organic materials in the process streams are below 200 nm in size [13].

While it has been very valuable to track changes in the invisible world of colloidal stickies it also helpful to see how this material impacts the visible world. Measurement of the tackiness of this filtrate is helpful because this shows the visible behavior of the colloidal material. Tackiness is measured by preparing a textile fabric strip (SCA, Tork 606 Cleaning Cloth) that has been cut 4.8 by 14.9 cm and then the end reinforced with a piece of tape 1.9 cm long with half placed on one side and then fold it to the other side. A hole is punched through the tape and cloth, the center of the circle should be in the middle of the strip, no more than 0.32 cm from the edge. The strip is soaked in the filtrate from the 25 micron sample fraction for 40 seconds. The excess fluid is removed and then placed on a polished stainless steel sheet and then flatten to remove air bubbles. The stainless steel sheet is placed on hot surface of a peel tester for 12 minutes at 85 ^{o}C. For this study a Thwing-Albert FP-2250 was used. This is repeated 4 to 6 times for each sample with the results averaged and outliers discarded.

The shear stress test has been conducted by taking pulp at between 3 to 5% consistency and mixing in a kitchen aid mixer for 15 minutes. The method was developed during evaluation of interaction between deinked pulp (DIP) and thermo-mechanical pulp (TMP) [14]. The pulp is placed in hot water baths to maintain a constant temperature and the sample consistency is measured. Each test uses 50 dry grams of pulp based on consistency. The mixing action creates a high shear environment and destabilizes the colloidal organics in the pulp. A 500 ml sample of pulp is collected and saved for fractionation and measurement of the total organic carbon. For the lap pulp a hand mixer for 30 seconds was used to restore the pulp to a 3 to 5% consistency using tap water at a hardness of 60 ppm as $CaCO_3$. In addition to the 15 minute shear stress an additional 30 minute shear stress tests was run to see if the amount of colloidal organics remained the same, continued to increase or started to agglomerate.

The results were measured against the behavior of lap pulp that had been identified to cause runnability issues on the paper machine.

RESULTS –Evaluation of Lap Pulp Known to Have Caused Runnability Issues

Results are reported for stability testing of lap pulp. Bringing the lap pulp back to a 4% consistency using tap water has been shown to have a measureable amount of colloidal stickies. The source of this material is thought to be the colloidal stickies closely associated with the fiber that is carried with the lap pulp from the recycle plant. Figure 3 shows that for lap pulp that has been known to cause issues on the paper machine the amount of colloidal stickies drops as shear stress is exerted by mixing. The amount of colloidal stickies varies over a wide range going from 10 to 130 ppm-TOC. The common characteristic is the agglomeration (reduction) of colloidal stickies under shear stress. The material is agglomerating or precipitating out of the water onto fiber, fines, filler, fixtures and other stickies which will lead to runnability issues. The high concentration may have a potential of causing runnability issues during longer runs using recycle fiber or in situations where recycle content is increased. ***The critical behavior is the colloidal instability which is seen as a reduction of colloidal stickies under shear stress.*** Lap Pulp sample B was known to differ due to it having a high stickies count and was run on a paper machine that could handle higher macrostickies content. It is seen to first have a large increase in colloidal stickies followed by a decrease when going from 15 (stressful) to 30 (high stress) minutes of mixing. For lap pulp the inclusion of a 15 and 30 minute stress test is a useful test of colloidal stability which also should relate to the stability of stickies in the 25 to 100 micron size range.

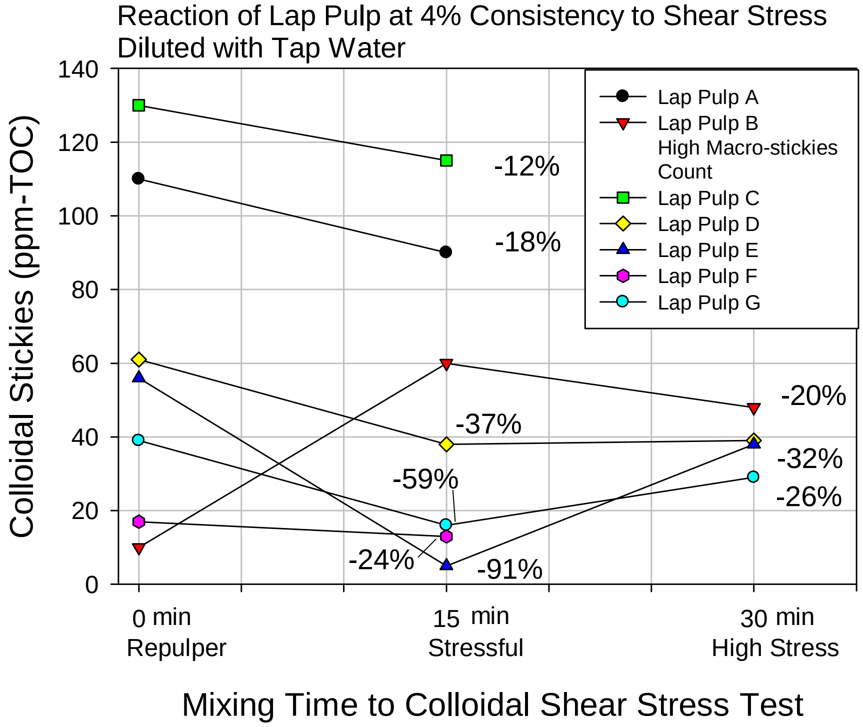

Figure 3. Colloidal Stickies Response to Shear Stress of Lap Pulp Known to Cause Issues at Paper Machine

RESULTS – Tackiness

Also under development alongside with the evaluation of lap pulp colloidal stickies stability was the measurement for tackiness. As shown in Figure 2 pulp samples should fall along the expected tackiness to colloidal organic curve. This relationship of expected tackiness also holds true for lap pulp diluted to 4% consistency with tap water (Figure 4). When the tackiness is above the expected tackiness curve paper machines have reported deposit or runnability issues. Tackiness measurements below 10 g_f/m should be considered to have no tackiness or at the limits of the tackiness measurement with the peel tester. Based on lap pulp tackiness testing and reported behavior on a paper machine known to be sensitive to stickies, tackiness values below 25 $g_{f/}$m can be considered to have an insignificant amount of tackiness to cause issues. If a sample has a tackiness value greater than 25 grams force but on the expected tackiness curve or below then that lap pulp has been found to generally not have runnability issues due to stickies.

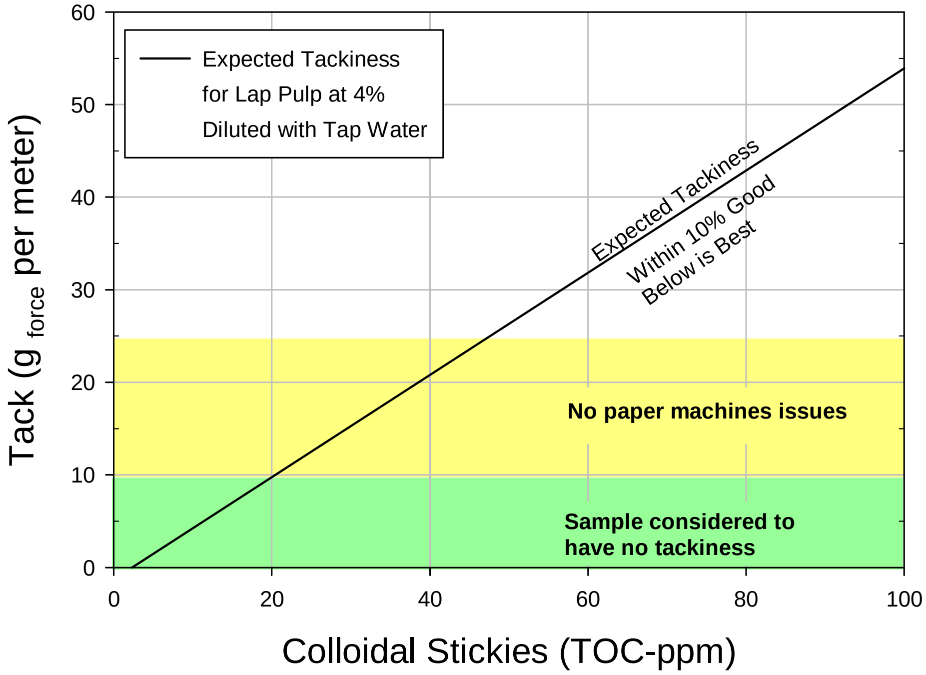

Figure 4. Relationship of Colloidal Stickies Content to Tackiness of Filtrate

In Table II is listed the results from three different sets of lap pulp evaluation. The first and third sets have lap pulp samples treated and untreated with a patented technology incorporating cyclodextrin [15]. This product has been found to reduce or eliminate tackiness and provide colloidal stability. Because the nature of the incoming furnishes and incoming stickies is unknown, the behavior of the stickies in the final lap pulp can vary. A good treatment program will provide colloidal stickies stability and lower tackiness of the lap pulp day in and day out so that the paper machine has little uncertainty in how a given load of lap pulp will behave.

From Table II-A the tackiness is seen to drop as treatment is started. Sample F-3 goes though some colloidal instability as seen but tackiness has been eliminated (below 10 grams-force means no tackiness) and the pulp was not an issue on the paper machine.

Table II. Examples of Lap Pulp Testing for Colloidal Stability and Tackiness

Table II -A Lap Pulp Set #1 -

Colloidal Stability Test

Lap Pulp	Repulped - 0 Min	Stress - 15 Min	High Stress - 30 Min	Paper Machine
F-1 at 0 kg/t	32	36-inc	34-same	No Issues
F-2 at 1 kg/t	28	33-inc	32-same	No Issues
F-3 at 2 kg/t	36	33-same/dec	25-dec	No Issues

Tackiness of Lap Pulp Filtrate

Lap Pulp	Tackiness - g-force/m	Is Tackiness below 25 gram-force/m	Is value at or below expected tackiness	Paper Machine
F-1 at 0 kg/t	21	at 25	No - Above	No Issues
F-2 at 1 kg/t	13	Yes at 10	On Line	No Issues
F-3 at 2 kg/t	8	Yes-below 10	Below	No Issues

All of the lap pulp in Table II-B was treated and all of the lap pulp samples saw an increase in colloidal stickies with shearing (stable). One lap pulp, H-3 had a tackiness value above 25 with a measured tackiness of 33 g-force, high enough to possibly cause issues. However, when plotted on Figure 4, the pulp sample was well below the expected tackiness of 45 g-force and should not cause an issue. The paper machine had no deposit related issues on this set of lap pulp.

Table II -B Lap Pulp Set #2

Colloidal Stability Test

Lap Pulp	Repulped - 0 Min	Stress - 15 Min	High Stress - 30 Min	Paper Machine
H-0	76	98-inc	106-inc	No Issues
H-1	77	105 inc	111-inc	No Issues
H-2	78	107-inc	114-inc	No Issues
H-3	88	106-inc	111-inc	No Issues

Tackiness of Lap Pulp Filtrate

Lap Pulp	Tackiness - g-force/m	Is Tackiness below 25 gram-force/m	Is value at or below expected tackiness	Paper Machine
H-0	17	Yes	Below	No Issues
H-1	24	Yes	Below	No Issues
H-2	27	At 25	Below	No Issues
H-3	33	No Above 25	Yes, below expected value of 45	No Issues

Table II-C is the final example, with the first two samples not treated and the final two treated. The shear stress test showed all of the lap pulp samples had stable colloidal stickies. Lap pulp samples K-9 and K-20 were just below the 25 g-force warning line. The last lap pulp K-22 was treated and showed no tackiness with a value of 10 g-force. The untreated lap pulp sample K-10 was above 25 g-force line but on the expected tackiness line for the given amount of colloidal stickies. The paper machine had no deposit related issues. Also note that for this set of lap pulp that while treatment did not drastically change the amount of colloidal stickies it did take the lap pulp from having some tackiness to have none by lap pulp sample K-22.

Table II -C Lap Pulp Set #3

Colloidal Stability Test

Lap Pulp	Repulped - 0 Min	Stress - 15 Min	High Stress - 30 Min	Paper Machine
K-9 at 0 kg/t	53	75-inc	77-inc	No Issues
K-10 at 0 kg/t	46	67-inc	75-inc	No Issues
K-20 at 2 kg/t	54	71-inc	76-inc	No Issues
K-22 at 2 kg/t	65	97-inc	108-inc	No Issues

Tackiness of Lap Pulp Filtrate

Lap Pulp	Tackiness - g-force/m	Is Tackiness below 25 gram-force/m	Is value at or below expected tackiness	Paper Machine
K-9 at 0 kg/t	22	Yes at 25	Below	No Issues
K-10 at 0 kg/t	38	No Above 25	On the line	No Issues
K-20 at 2 kg/t	22	Yes - at 25	Below	No Issues
K-22 at 2 kg/t	10	Yes - at 10	Below	No Issues

The above examples show how looking at both colloidal organic stability and the tackiness of the filtrate associated around the fiber can result in the paper machine being able to use the recycle lap pulp with greater certainty of good runnability. Lap pulp that does not see agglomeration of stickies (from 1 micron to 100 microns in diameter) and which does not contain colloidal organic material tacky enough to encourage that agglomeration has a higher certainty of running without issues on the paper machine. This does not mean that recycle plants and paper makers can forget macrostickies and other contaminants, just that with these additional tests that the paper maker can have greater certainty about the invisible stickies coming into the process.

RESULTS – Agglomeration at the Paper Machine

While it is easy to think that all the issues with recycle fiber is with the incoming pulp, in truth the issue could be with the dilution water or the stock that is mixed with the recycle fiber from the paper making process. When trying to introduce recycle fiber or increase recycle fiber and issues occur part of the source of the issue can be with the interaction of colloidal organics in the process water and virgin stock or coated broke with the colloidal stickies from the lap pulp.

The following is an example for an operation trying to introduce recycle fiber and seeing issues almost as soon as the lap pulp reached the paper machine. Both sets of lap pulp had been found to have a low macrostickies count. For colloidal stability to be a driver, a significantly large drop would need to be observed during shear stress testing. The lap pulp underwent shear stress testing to see if it was the recycle pulp or interaction at the paper machine causing issues. The first set of tests in Figure 5 is for shear stress testing of the lap pulp diluted with tap water and the second set of tests is for shear stress testing of lap pulp diluted with paper machine white water. The tackiness test method was still under development and tackiness was not measured for this study.

With tap water both lap pulps are seen to be stable with an increase after 15 minutes and little change seen when subjected to the high stress of 30 minutes of mixing. Both of these lap pulps should not cause issues on the paper machine. Mixed with the white water the amount of colloidal organics should have been higher than 170. Instead a reduction of 45 to 50% was seen for lap pulp X and 30 to 40% for lap pulp Y. This kind of agglomeration would be considered catastrophic on the invisible colloidal scale and was seen as deposit issues on the visible scale with issues occurring almost as soon as the stock hit the paper machine.

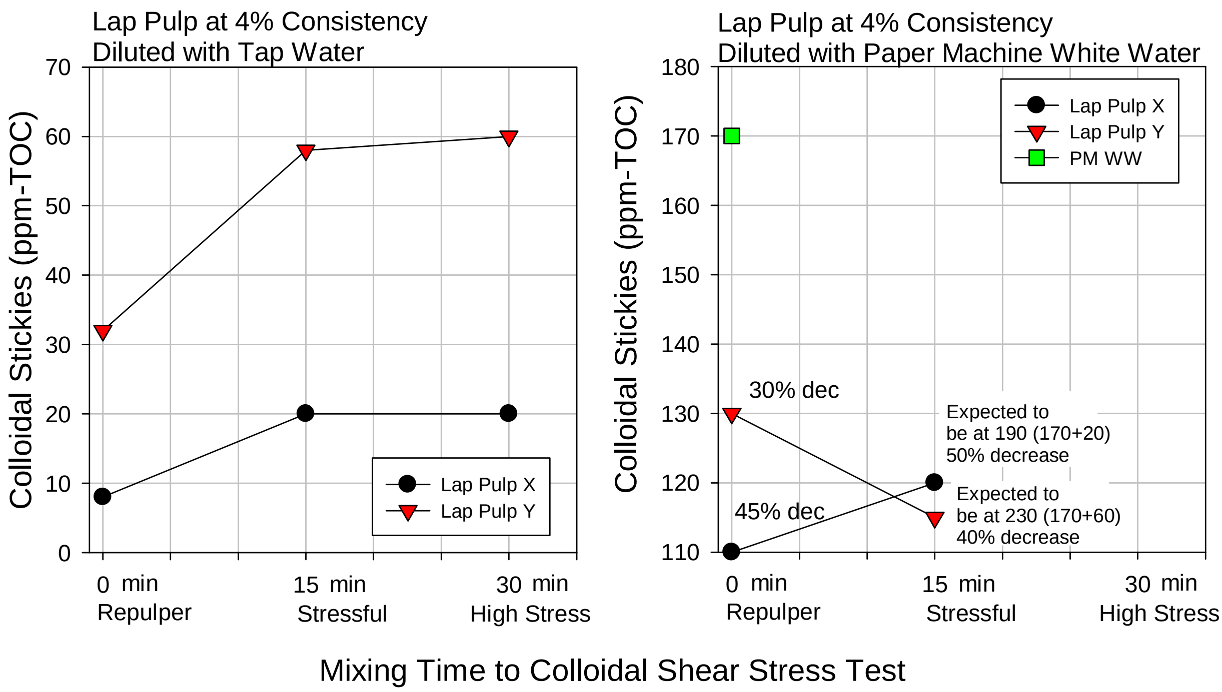

Figure 5. Differences in Colloidal Stickies Behavior with Tap Water and with PM WW

CONCLUSIONS

There is an industry need to use more recycle fiber in light weight coated sheets and the movement is for those adding none to introduce it and for others to increase that usage. A barrier to increased use of recycle is the feeling of uncertainty with each load of lap pulp, will this batch run well or will there be issues. Rather than take a costly roll of the dice, the choice is often to steer away from the danger of the unknown. Lap pulp suppliers have been working to improve their process, installing smaller slotted screens and measuring stickies below the traditional cut-off of 150 microns. This paper presented results showing how that looking at colloidal organic stability and tackiness associated with the lap pulp can help remove the unknown of the lap pulp. Tested lap pulp shown to be stable and to have a low tackiness or an expected level of tackiness was able to run without issues. Also shown was that with treatment, lap pulp that might have a higher chance of producing issues was able to remain stable or have their tackiness eliminated or significantly reduced. Finally an example was given where the issue was not the lap pulp but the paper machine white water that was the critical cause behind paper machine runnability issues.

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