

DUAL FLOCCULANT SELECTION IN THE FIBER CEMENT PROCESS

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ABSTRACT

It is well known that flocculants are required in the manufacturing process of asbestos free, PVA fibre cement products. Whilst there are some guidelines for the suitable selection of flocculants, there are also varied opinions on the choice of the right flocculants to be used in the process. Simply put, there is no universal solution. Each process needs to be individually evaluated, based on the characteristics of the machines and the type of mix formulations.

This paper deals with the unique approach of considering the use of multiple flocculants.

Typically flocculants are expected to perform two distinct functions within the closed loop Hatschek process; these are solids retention in the vats and settling in the cone tanks.

By splitting the process and evaluating the individual requirements, we are better able to understand the influences on the process and make a more suitable selection of flocculants.

Furthermore, the significant influence that wet waste has on the selection of the polymer and the resultant retention characteristics in the vat is presented.

KEYWORDS:

Flocculants, dual, retention, settling, wet waste

INTRODUCTION

It is commonly accepted that the use of polymers (Flocculants) is an integral part of the manufacturing process of non-asbestos fibre cement products, using Hatschek technology.

Furthermore, based on this understanding and from knowledge gained by operating Hatschek type equipment, it is also noted that polymers are required to cater for two very distinct functions.

The two functions are identified as:

- Solid retention in the vat
- Settling in the cone tanks.

This paper presents the logic behind the selection of polymers for the separate role of solids retention and settling. From observations while operating the machines, it has become apparent that there are unexpected behavioural characteristics and external or unknown factors that influence the selection of the polymers for these two functions.

This paper also looks at these influences and discusses some of the possible reasons behind the unexpected behaviour. Based on these observations, the influences have been replicated in the lab and extensive testing has been undertaken in an attempt to fully understand them. Having fully evaluated the results from the lab work, solutions have been developed to negate the influence found in the production process.

In addition, the paper also looks at the cyclic influences noted in the Hatcheck process resulting from the use of polymers, with the intention to provide solutions related to this. Similarly every effort is made to ensure that the solutions do not in themselves cause a further negative influence on the process. For the purpose of this paper we do not consider the negative influence of having a super effective retention on the sieve and the resulting difference of the matrix from the sieve side to the felt side. It is however noted.

The methods used to select the polymers and the basis for understanding how polymers work in the Hatcheck process draws heavily on information presented by A M Cooke,

S A S Akers, J V Leite and R Winter, - IIBCC 2010. These are presented below:

Basics of flocculation

The function of the polymer and how it works is shown below in Fig. 1.

The word comes from the greek *polumeres*, which means 'having many parts'. Polymers are large molecules consisting of repeated chemical units ('monomers') joined together, usually in a line, like beads on a string.

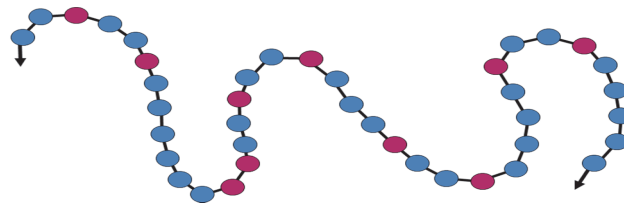


Fig. 1

Typically these chains of polymer are negative, positive or neutral in charge (Fig. 2)

Non ionic

Anionic

Cationic

Fig. 2

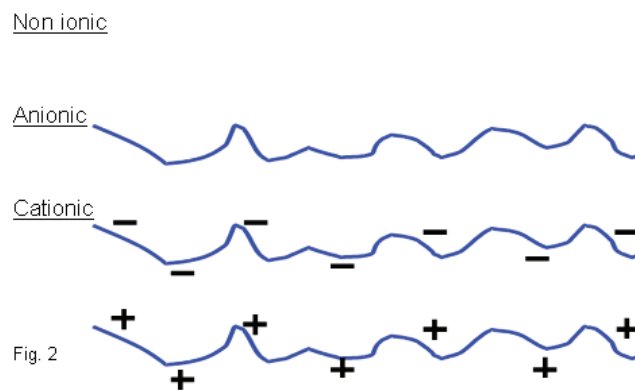


Table 1 given below, represents a typical selection of flocculants used for the purpose of the study presented in this paper.

Flocculant		Charge	Charge (Mol %)	Molecular Weight (Daltons)
1	Bulab 5275	Anionic	20 to 25	10 to 15 Million
2	Bulab 5616	Anionic	15 to 20	10 to 15 Million
3	Bulab 5618	Anionic	25 to 30	10 to 15 Million
4	Bulab 5230	Anionic	1 to 5	10 to 12 Million
5	XP 12-037	Anionic	10 to 15	10 to 12 Million
6	Bulab 5167	Anionic	30 to 36	10 to 12 Million
7	Bulab 5363	Non-ionic	0	8 to 10 Million
8	Bulab 5264	Non-ionic	0	8 to 10 Million

Table 1 - Typical range of Polymer samples tested in the Hatcheck process

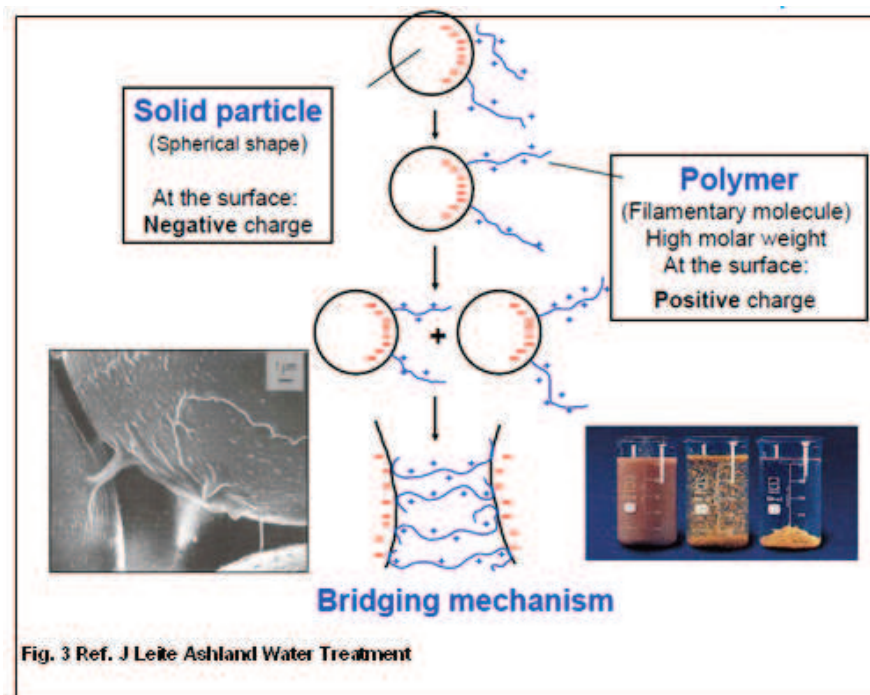
Note: Sample Polymers and technical information supplied by Buckman Laboratories SA

Selections of materials as used in a Hatchcheck process, which require flocculating, are listed in Table 2 below. These particles are typically positively charged as detailed in the Table below.

Material	Composition	Particle Size	ζ Potential ^a	Comment
Portland Cement	C ₃ A, C ₄ AF C ₃ S, C ₂ S	10 – 50 μm	~+5 to 30 mV ~0 to 10 mV	Only the Al containing minerals are significantly charged Strongly -ve at high pH but switches to +ve in presence of Ca ²⁺
Ground Silica	→SiOH groups on surface	10 – 50 μm	~+5 to 30 mV	
Silica Fume	→SiOH groups on surface	<0.1 – 1 μm	~+5 to 20 mV	Strongly -ve at high pH but switches to +ve in presence of Ca ²⁺
Alumina Trihydrate	Surface OH ⁻	10 – 50 μm	~+5 to 20 mV	+ve over wide pH range
Calcium Carbonate	CaCO ₃	10 – 50 μm	~+10 to -40 mV	Depends on [Ca ²⁺]
Cellulose fibre	Surface OH ⁻	~2.5mm x 20 μm	~+5 to 20 mV	Strongly -ve at low pH but switches to +ve in presence of Ca ²⁺
PVA Fibre	Surface OH ⁻	~4mm x 20 μm	~+5 to 20 mV	Strongly -ve at low pH but switches to +ve in presence of Ca ²⁺
Polypropylene Fibre	Hydrophilic Coating for fibre cement use	~4mm x 20 μm	Probably 0	Unlikely to adsorb ions

Table 2. A M COOKE, S A S AKERS, J V LEITE and R WINTER- IIBCC 2010

Looking at flocculation in simplistic terms, whilst taking note of the more complex elements that are required to form coagulants, the following general statements can be made. The polymers used in fibre cement are of an ionic (Negative) nature while the materials are typically of a positive nature. The particles being of opposite charges are drawn toward each other. When the polymer strings and the particles are brought into contact, a bridge is formed between the polymer and the particles. See Figure 3, a schematic representation given by Leite.



On completion of the bridging, loosely formed coagulants are formed, these assist:

Firstly, in the vat where the larger group of particles are more easily trapped into the fibre matrix, forming a layer on the sieve drum and secondly, in the cone tank where the coagulated particles become heavier and start to settle to the bottom of the cone tank, returning the solids back to the mix box.

The prime objective of any Hatcheck process is to maximise the retention in the vats. The more effective the flocculation processes, the thicker the lamina formation. This improves efficiency of raw material utilisation and decreases the time to produce a unit / sheet.

The secondary objective is to return solids that pass through the sieve drum during the forming of the lamina. The quicker the solids are returned, the less chance of the solids “aging” and the risk of the system becoming overwhelmed, is reduced. Aging in this context refers to the cement and additives, which have already started to react when coming into contact with production water.

Case Study

Considering the difference in material composition between the vat and the cone tank:

- a) In the vat, the material is made up of specific percentages of cellulose fibre, synthetic fibre, cement and other materials.
- b) In the cone tank (Sieve water), the percentage of fibres is significantly reduced and the remaining particles of the cement and other materials are made up mainly of smaller particles and fines.

With this in mind, it makes sense that the two respective processes will require different polymers.

To test this theory a two tier approach was adopted.

Firstly:

The theory was tested under lab conditions using the Leite method. A standard mix formulation, currently being used to produce PVA corrugated sheets on one of the production lines of the Everite plant in South Africa, was tested using a series of Buckman polymers.

With the assistance of Buckman Laboratories South Africa the mix formulation was tested for retention and drainage characteristics. Thereafter, simulated sieve water from the above process was tested for settling, using a second series of polymers and a standard settling test. Based on the lab work two polymers were selected.

Secondly:

Based on the selection of the polymers in the lab, the tests were replicated on a full production scale, using the PVA corrugated line at Everite. Polymers were introduced separately into the mix box and the cone tank, to provide retention and settling respectively.

During the running of the machine the effectiveness of flocculation in the vat was tested using a modified Leite test while the settling in the cone tanks was tested using standard monitoring of the sieve water and solids return line from the cone tank.

From the above two tier approach above, the results were tabulated, verified and compared.

It was interesting to note that whilst there was an expected drop off in the effectiveness of the polymer in the vat, the results were also erratic. Typically it is expected that the flocculated particles are broken down due to mechanical agitation. This phenomenon has been discussed in detail. Ref. Negro C, Blanco A, Fuente E, Sanchez L M and Tijero J, A.Alonso, -IIBCC 2006, Ref. A M Cooke, S A S Akers, J V Leite and R Winter-IIBCC 2010

There are however conditions that indicate not all the influences, on the effectiveness of the polymers, are related to mechanical breakdown or conditions in the machine.

One such observation is the influence of wet waste.

It is well known from production experience (in particular machine operators) that there is an observed difference in the process when wet waste is returned to the mix box. This aspect can be simulated in the laboratory without the influence of mechanical agitation and is not related to any machine specific characteristics.

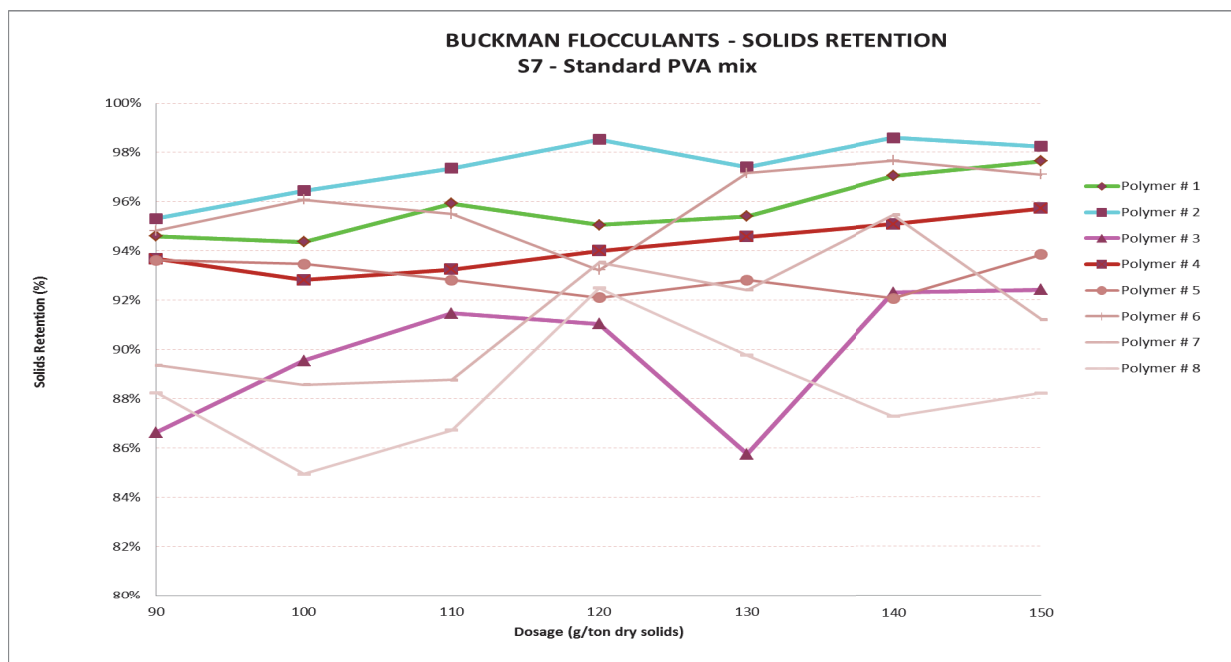


Fig. 4 Selection of Buckman Polymers tested for solids retention in vat.

Polymer # 2 shows the best overall solids retention of 98% at a dosage of 120 ppm.

Product	Dosage (mg/l)	TSS (mg/l)	Bed height (mm)	Settling rate (ml/s)
Control	0	187	150	17.2
Floc M1	4	30	120	35
Floc B1	4	50	115	43.5
Floc B2	4	30	115	45.5
Floc B3	4	20	110	60.6
Floc B4	4	25	110	48.8

Table 4 - Selection of Buckman Polymers for maximised settling in the cone tank.

Polymer B3 shows the fastest settling rate of 60.6 ml/s with lowest solids bed height of 110 mm (most compact) and the least amount of suspended solids in the clarified water.

Based on the above (Fig. 4 and Table 4) Polymer 2 was selected for use in the mix box to maximise the solids retention in the vats. Polymer B3 was selected to maximise the settling in the cone tanks. For the purpose of the exercise, polymer was dosed directly into the mix box at the prescribed dosage and polymer B3 was dosed directly into the mud water tanks, also at the prescribed dosage.

OBSERVATIONS

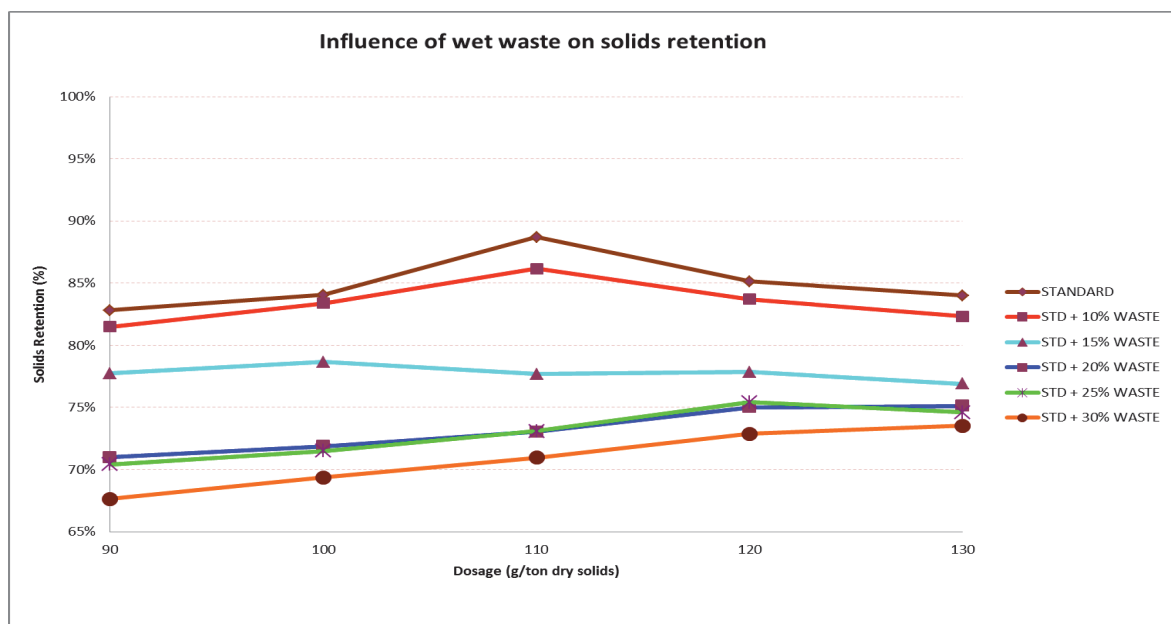


Fig. 5 Influence on solids retention by incremental increase of wet waste

The wet waste test was conducted using a similar selection of a PVA production formulation for corrugated product. The best performing polymer, based on a test method and selection as detailed above, was used. Retention tests were carried out with incremental percentages of wet waste added.

The wet waste was produced in the lab from the retained material using the standard Leite test. This was done without any mechanical agitation or shear of any kind. The wet waste was added into virgin mix, as per the above increments and tested individually.

From these tests it was found that as more wet waste was added, the retention decreased along with the effectiveness of the polymer. This observation was also noted during the commissioning of the S7 line at Everite South Africa and was also discussed by A M COOKE, S A S AKERS, J V LEITE and R WINTER-IIBCC 2010.

It was noted that as the trimmings were reduced on the green sheet and the effective wet waste was reduced, so the efficiency of the machine improved, given a specific selection of polymer.

From analysis of the above observations, the only common factor between the two is the polymer. This would indicate that the polymer in the wet waste is influencing the effectiveness of the very same polymer in the mix formulation.

In the explanation of how polymers work, we note that the polymer is a long chain of acrylamides that have a specific charge. These chains attach to the particles and after initial flocculation tend to change the charge density of the particles. This results in charge neutralisation or charge reversal. Once the Charge density has changed the original selection of polymer will not have the same ability to form loose coagulants.

Hatschek type production machines have typically two methods employed for the return of wet waste into the system:

The trimmings are loaded into a dissolver vessel, diluted with system water and transferred as follows.

- 1) Batch load to the fresh mix stirrer or
- 2) Batch load to a secondary wet waste stirrer and then dosed to the mix box.

In the first instance, dependant on when and how often the wet waste is discharged into the fresh mix stirrer, the ratio of wet waste to fresh mix can vary dramatically. As can be seen in Fig. 5, the influence varies at different percentages. This in turn leads to cyclic variability in the retention characteristics of the polymer in the vat and can influence the variability of the sieve solids and the cyclic change in thickness of the lamina and final sheet thickness.

Similarly, in the second instance the ratio can vary dependant on when and how much wet waste is returned to the mix box

Leading on from the above observations, it can be argued that if the effect of the wet waste on the retention can be controlled, reversed or neutralised, then the influence observed on the Hatschek process can also be neutralised.

Based on the analysis given above, there are two options available:

Option 1:

As indicated earlier, most Hatschek machines batch transfer the wet waste into the process. If the return of wet waste can be controlled to a fixed ratio, the effect can be controlled.

In all probability this would require some modification to the storage and feed systems for wet waste, back into the fresh mix. From practical experience it can be said that the solution is to have a designated stirrer for wet waste and a control system, linked to the supply valve of the fresh mix, which feeds the wet waste back into the mix box, at a fixed ratio.

Using the PVA line at Everite as an example, it is noted that the typical trimming returned from wet waste is 16%. From Fig. 5, it can be noted that the drop off is in the region of 10% of retention. Implementing the above physical changes to the plant will still result in a 10% drop in retention, but without any cyclic / erratic influence on the process.

Further to the above changes, the process needs to be re evaluated for a modified retention polymer, using the fixed percentage of wet waste for the specific Hatschek line. Select the polymer that gives the highest retention values. From experience it is noted that the effectiveness of the new polymer is subject to available polymers and is typically slightly lower than the original effectiveness, measured without wet waste. It is however an improvement and the cyclic/ erratic effect are significantly reduced.

Option 2:

Taking into account that it is not always practical or possible to modify the equipment; other alternatives need to be investigated. This thought train leads to the option of chemically treating the wet waste to counter the effect of the already flocculated material.

From earlier discussion it is clear that the overall charge of the wet waste has been changed.

By measuring the charge density of the fresh mix and the wet waste, an indication is given of how much the wet waste needs to be treated to bring it back into the range of the fresh mix.

Based on this measurement a selection of coagulants was tested.

The best performer (Coag01) was selected and a retest of the effectiveness of the polymer was carried out, using different levels of wet waste. The required dose rate of Coag 1 was found to be 30 ppm and was added to the wet waste before retesting for retention.

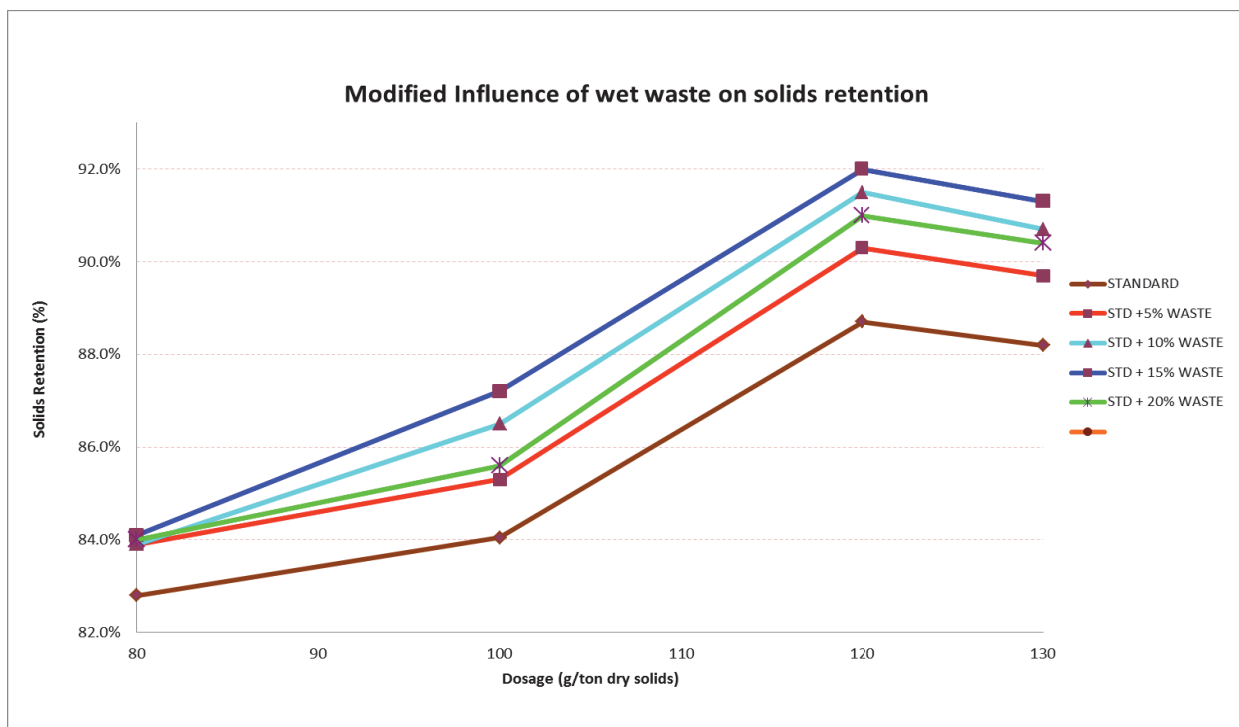


Fig.6. Influence of solids retention using best performing polymer (polymer #2) on fresh mix with increments of pre coagulated (Coag01) wet waste.

From the above it is noted that by chemically altering the charge density of the wet waste, that the effectiveness of the polymer is increased and that the influence of the previously flocculated wet waste is eliminated. It also appears that regardless of the percentage of wet waste in the fresh mix, the effectiveness is improved to the original retention ratio or better.

However, on closer examination it must be noted that it is important not to create a situation whereby the retention is increased to such a level that the cyclic effect is re created in reverse of the original cycle. Looking at Fig 6 it can be seen that at a dose rate of 110 ppm with the pre coagulated wet waste; the improvement is above 4% of the original retention of virgin fresh mix.

By restricting the dosage of polymer # 2 to 80ppm along with 30 ppm of Coag01 in the wet waste, it is possible to ensure a steady retention ratio in the vats irrespective of the amount of wet waste returned. From Fig 6 it is shown that at 30ppm of Coag01 and 80ppm for the Poly2 and PolyB3 combined, the retention ratio remains between a cyclic scatter of less than 2%. This is a significant improvement to the cyclic scatter of more than 20 % given in Fig. 5.

CONCLUSION

It is shown in this paper that by separating the roles of the polymers in the Hatschek process with regard to retention and settling properties, it is possible to provide more efficient processing conditions. Furthermore by chemically treating the water using coagulants, it is possible to influence process conditions in particular with regard to wet waste return. It is also possible to isolate the influences of the polymers on the Hatschek process and engineer solutions to eradicate these influences.

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