GLOSSARY

1 : **Fines (fine coal)**
Coal in the size range 500 um to 150 um

2 : **Ultra Fines (ultra fine coal)**
Coal in the size range 0 um to 150 um

3 : **Uf/f Ratio**
mass of ultra fines / mass of fines (air-dried basis)

4 : **Double Layer**
A two-layered structure where upper part consists mainly of fines and lower part mainly of ultra fines.

5 : **Primary Dewatering**
Loss of water from the ultra fine slurry during the double layer formation stage by drainage through the fine coal cake.

6 : **Secondary Dewatering**
After primary dewatering, the double layer was thoroughly mixed to produce a new mixture with lower moisture-holding potential. The mixture was then sent to the screen for further dewatering.

7 : **Fines in Chapter Two**
This specifically refers to Goodehoop Fordertechnik screen product which consisted mainly of - 500 um + 150 um coal.

8 : **Fines in Chapter Four**
This specifically refers to pilot plant cyclone underflow which consisted mainly of - 500 um + 150 um coal.

9 : **Ultra Fines in Chapter Two**
This specifically refers to Goodehoop filter product which consisted mainly of - 150 um coal.

10 : **Ultra Fines in Chapter Four**
This specifically refers to a pilot plant thickener product which consisted mainly of - 150 um coal.

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Acknowledgements

The author wishes to express her sincere gratitude to Professor D.W. Horsfall for his guidance and encouragement.

The author also would like to thank the following institutions/personnel for their assistance in the work.

- National Energy Council (project sponsor)
- Velmet (equipment donor)
- Goodehoope Colliery (sample donor)
- Anikem (chemical donor)
- Ms. P. Jennings and Mr. J.G.R. Eklund (style and English)
- Mr. L. Tshabalala, Mr. M. Ten Harve and Mr. I. Van Der Heerver (assistance in hard physical work)
- Mr. W. Stange (Microsim software programme)
- The dedicated staff members of the Department of Metallurgy and Materials Engineering , University of the Witwatersrand

To My Mother and Yualaun

ABSTRACT :

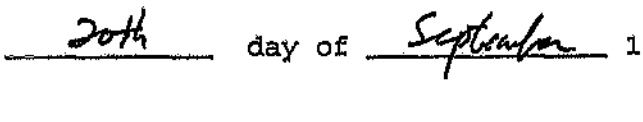
Due to modern mining and beneficiation methods, a lot of fine and ultra fine coal are being generated. Due to the large relative surface areas of these particles, dewatering economically becomes a real problem and subsequently a large portion of this material (especially the ultra fines) is sent to the slime dams. This is wasteful not only in terms of loss of useful energy resources, but also in terms of lost revenue. The slime dams also create potential environmental problems and require capital for construction and maintenance.

The aim of this project is to investigate the feasibility of dewatering fine and ultra fine coals by using/modifying conventional equipment (dewatering screen) in order to establish an efficient and economical method of dewatering fine and ultra fine coal.

Laboratory scale test work was first performed to investigate the concepts involved on a small scale. Based on these findings, a pilot plant was designed to test the concepts on a much larger scale. Recommendations on the feasibility of applying these concepts on an industrial scale were made based on the results obtained.

Declaration

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in Engineering in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.



20th day of September 1996

DEWATERING OF FINE AND ULTRA FINE COAL BY USING/MODIFYING CONVENTIONAL EQUIPMENT (DEWATERING SCREEN)

Mei Chen Eklund (Née : Tsai)

A dissertation submitted to the Faculty of Engineering, University of the Witwatersrand, Johannesburg, in fulfilment of the requirement for the degree of Master of Science in Engineering

Kriel, 1995

2.1.1 : Experiment A

1 : A pre-determined amount of fines (air-dried to get rid of surface moisture) was washed in a Buchner funnel to produce a uniform bed. The quantity of water used was not measured. The purpose was to prepare a smooth and uniform fine bed (the cake).

2 : Weak vacuum was applied to the Buchner funnel for 10 seconds through a rubber pipe to remove excess water thus forming a fine coal cake with a moisture content between 20 % and 30 %. Then five increments were drawn across the diameter of the Buchner funnel for moisture determination using a modified syringe.

The weak vacuum was generated from a small vacuum pump. The setting of the pump remained fixed throughout the period of the laboratory scale test work. The purpose of the vacuum was to reduce the moisture level of the samples to suitable levels for the purposes of tests.

3 : The bed depth was then measured. After this the bed was reconstructed manually by filling in the voids with surrounding material and the new bed depth was measured and noted.

4 : Using a pre-determined ratio of ultra fines to fines (on dry mass basis), the ultra fines slurry (20 % solid) was poured gently onto the fine bed. Great caution was taken to minimise the disturbing effect caused by the pouring action onto the fine bed.

5 : The same weak vacuum was reapplied to the ultra fines and fines double layer. This time vacuum was applied until all visible water had disappeared. (If natural drainage was allowed to take place, depending on the uf/f ratio, the process could take up to two hours or more.)

6 : Five increments were again drawn across the diameter of the Buchner funnel for moisture and bed depth determinations.

7 : After weighing the total net mass of the system (the mass of the Buchner funnel with the filter paper was measured before the test) the double bed was thoroughly mixed manually for 10 minutes.

levels

Experiment D & E :
testing for the minimum vibration time required for secondary dewatering to occur with certain fixed starting moisture levels

2.1 : Experimental Procedures

Coal used : coals from Goodehoop Colliery, Amcoal

Fines : Fordertechnik screen product
Ultra fines : thickener product

The particle size distributions of the Fines and Ultra fines are tabled below.

As is commonly the case, the actual size analyses of the material from the colliery do not exactly confirm with the definitions of fines and ultra fines. However, from the tables it is obvious that the 'fine' coal used consists mainly of + 150 um material and the 'ultra fine' coal mainly of - 150 um material.

TABLE 2-1-A

% Particle Size Distribution of the Goodehoop Fines Used

size classes (um)	% particle size distribution
+ 500	39.84
- 500 + 150	54.39
- 150	5.78
Total	100.0

TABLE 2-1-B

% Particle Size Distribution of the Goodehoop Ultra Fines Used

size classes (um)	% particle size distribution
+ 212	32.72
- 212 + 150	6.95
- 150	60.34
Total	100.0

CHAPTER TWO : LABORATORY-SCALE TEST WORK - EXPERIMENTAL METHODS, DISCUSSION AND CONCLUSIONS

Summary :

Laboratory-scale test work was performed to test the concepts of the new technique viz. :

A : The cake of the fine coal formed on the dewatering screen can be used as the filtration medium for the ultra fine slurry. The excess moisture will filter through the medium leaving some of the ultra fine particles retained within the cake. Theoretically this will yield a double-layered structure with most of the ultra fines remaining on top of the fine cake and the excess water from the ultra fine slurry draining through the coal particulate system. Most of the material should be retained at this stage due to the static nature of the Laboratory scale set-up. This double layer formation stage is also referred to as the primary dewatering stage.

B : Thorough mixing of the double layer will yield a coal particulate structure with the ultra fine particles occupying the voids within the fine coal cake. This structure has less available space for water retention and consequently is easier to dewater.

However, as the ultra fine content increases, a saturation point will be reached in which most of the available voids within the mass will be occupied by the ultra fine particles. Any further increase in the ultra fine content after the saturation point will only increase the moisture-holding potential of the mixture because of the increased available surface area.

The dewatering stage of the fine and ultra fine mixture is referred to as the secondary dewatering stage.

The following five sets of experiments were performed to test the above concepts.

Experiment A :
to test concept A, B.

Experiment B & C :
to test concept B with certain pre-determined moisture

(A) : Instead of being sent to the slime dams and subsequently discarded, the ultra fines can be beneficiated through froth flotation and then the new technique can be applied to reduce the final moisture level of the product. Consequently ultra fines with low ash values can be recovered and blended with other products for sale.

(B) : In terms of capital, maintenance and operating costs the dewatering screen is a much more attractive alternative option than filter type equipment.

(C) : Fines and ultra fines are dewatered simultaneously. This implies possible saving in terms of less equipment required and simplified plant operations.

1.8 : Experimental Procedures

Laboratory scale test work was performed to test the feasibility of the concepts on a small scale (Chapter Two). Based on the results of the laboratory scale test work, a pilot plant was designed, constructed and commissioned to test the new technique on a much larger scale. (Chapters Three and Four) Recommendations were based on the experimental result.

1.9 : Structure Of The Dissertation

The dissertation consists of five chapters. Except for chapters one and five, the chapters commence with a short summary and finish with a conclusion section.

The headings of the tables and graphs follow the numbering of the section in which they appear, e.g. all tables and graphs of Chapter Two, section one (2-1) will be called Table (Graph) 2-1-X.

Due to the large amount of data gathered and the subsequent analyses performed, the detailed results will be included in the forms of appendices with separately numbered pages.

within the mixture, there will be a saturation point in which all the existing voids within the coarse coal mass has been occupied. After that, any further increase in the ultra fine content will start increasing the moisture-holding potential of the mass again, due to the additional available surface areas for moisture adsorption provided by the 'free' ultra fine particles. Therefore the mass ratio of ultra fine contents is very important (referred as ratio of uf/f).

Thorough mixing of the 'double layer' is required to ensure that the voids within are occupied by the ultra fines. The 'mixture' will then be treated in a further dewatering process to reduce the final moisture level.

A short review concerning 1.6.1 and 1.6.2 is contained in Appendix G.

1.6.3 : Dewatering the fine and ultra fine coal simultaneously

By applying concepts 1-6-1 and 1-6-2, dewatering of the fine and ultra fine coals will occur simultaneously rather than separately as practised conventionally.

1.7 : Proposed New Technique

The cyclone underflow (fines) will go through the conventional dewatering route - namely the dewatering screen. The thickener product (the ultra fine slurry) will be gently introduced onto the cake of fine coals on the dewatering screen to form the double layer. This step is performed on the dewatering screen since natural drainage would take far too long.

After the filtration stage, the double layer will be mixed thoroughly to produce a new mixture with even lower moisture-holding potential. The new mixture will then be reintroduced to the dewatering screen for secondary dewatering. Since the moisture-holding potential of the new mixture is expected to be lower than that of either of its parent components, the product of the secondary dewatering should, theoretically, produce an even lower moisture level than of the 'normal product' obtained by the same dewatering procedure.

The aim of the project is to achieve the aforementioned effects by modifying the usage of the dewatering screen rather than modifying the structure of the dewatering screen which is dynamically balanced. If the concept proves to be feasible up to an industrial scale, then the new technique offers several attractive advantages :

1.6 : Basic Concepts Involved In The Proposed Technique

1.6.1 : The fine coal cake (product of the normal dewatering screen, 22 % to 30 % total moisture) can be used as a filtration medium for ultra fine slurry (thickener product, 35 % solid).

The ultra fine slurry will be introduced gently onto the existing cake of fine coal; the excess water will filter through the fine coal cake leaving the ultra fine particles on top of the fines. There will be some penetration of the ultra fines into the main cake structure. However, it is expected that a relatively well defined double-layered structure, with the upper part consisting mainly of ultra fines and the bottom mainly of fines, will be obtained.

This concept was applied in the U.K. in the 1950's on slightly coarser coals (Horsfall [3]).

1.6.2 : By mixing particles of different sizes at appropriate ratios, a new mixture with lower moisture-holding potential than that of either of the two original components will emerge

This concept was investigated extensively as early as 1899 by German scientist Slichter, who produced an extremely elegant mathematical analysis on the subject; this was later further extended by Graton and Frazer [4] in 1937 and Heywood [5] in 1946. In 1957, C.C. Harris and H.G. Smith [6] of University of Leeds published a paper relating the concept to the moisture-retention properties of the fine coals.

Convincing as the mathematical analyses of packing of spheres may be, when applied to practical situations, few yield realistic predictions. The reason is that in order to perform theoretical analyses, the authors had to assume 'packing conditions' such as the ways (combinations) of packing, dimensions of particles, shapes of particles etc. As a result, the models obtained are often 'special cases' rather than general and in reality each packing is different.

However, the essence of the concept is actually quite simple. By having the ultra fine particles filling in the voids among the fine particles, there will be less spaces available for moisture retention hence the easier the dewatering process.

However, with the increase in the ultra fine content

58 %; the sulphur content varies from 0.6 % to 2.2 %; the CV value ranges from 15.0 MJ/kg to 26.8 MJ/kg. Of this material, 2 Mtpa had a CV in excess of 22.0 MJ/kg, ash content 6 % to 23 % and a sulphur content of 0.55 % to 0.85 %. Eight collieries between them produced 75 % by mass of the total slurry discard (Horsfall [1])

Dumping is not only a waste in terms of a loss of useful energy resources, but also in terms of potential revenue. The slime dams also require huge amounts of capital for construction and general upkeep. It is also a potential environmental problem.

1.5 : Aim Of The Project

Most of the export steam coal is sold at 6300 Kcal/kg on a gross as received basis. It is obvious that the external moisture content is critical in meeting this quality requirement. The coal used for all the test work was from Goedehoop Colliery. Goedehoop steam coal typically has an inherent moisture of 2.5 % with a CV of 28.0 MJ/kg air-dried. To meet the requirement of 6300 Kcal/kg gross as received, the external moisture of the product must not exceed 8.0%. To combine fine and ultra fine coal (- 0.5 mm coal)to the export product to attain the optimal yield, the external moisture and CV of the combined fines and ultra fines must be taken into account. The fines from Fordertechnik screen typically has 21 % to 28 % moisture. Ultra fines from thickener typically is a slurry with 35 % solid. It is obvious that combining these high moisture level coals in the export product will seriously reduce the yield of +0.5 mm coal in order to meet the quality requirement.

This project looks at using existing dewatering screens to economically reduce the moisture content of fines and ultra fines to a level where they can be economically treated further by other dewatering processes i.e. thermal or handled easily for disposal, thereby creating new opportunities. For this purpose, the immediate target would be to reduce the combined moisture contents of fines and ultra fines to less than 30 % moisture. This lower new moisture level then opens up new options for easier and cheaper treatment.

Laboratory scale test work was performed to test the basic concepts involved. Based on these findings, a pilot plant was designed, constructed and commissioned to test the concepts on a much larger scale.

TABLE 1-3-A

Summary of Available Dewatering Equipment with Corresponding Operating Ranges and Costs

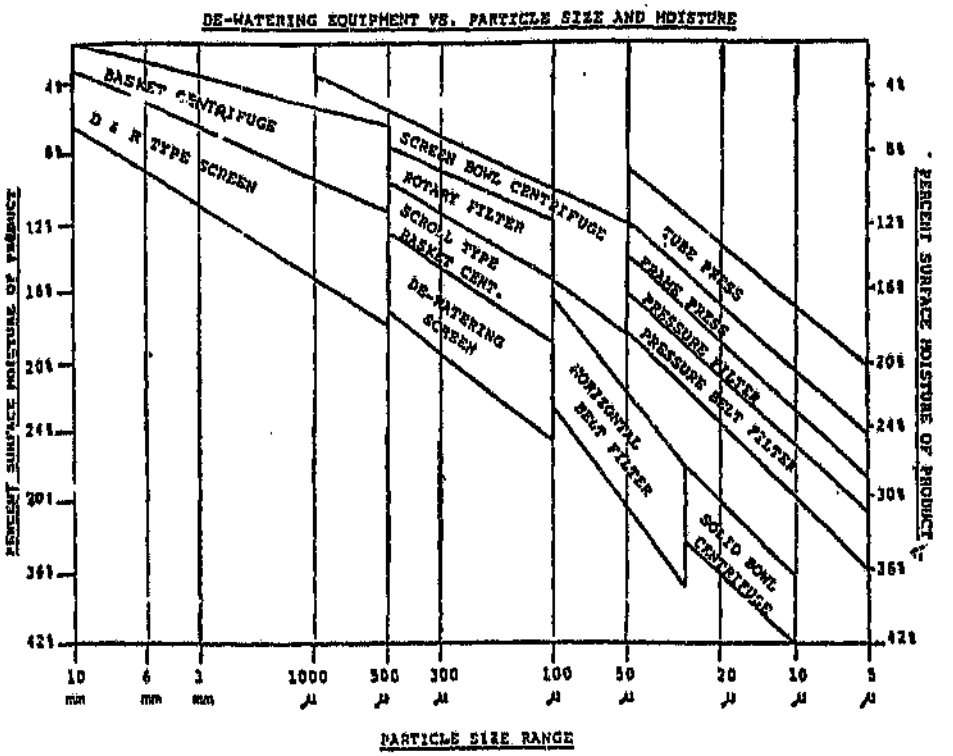
Equipment	Particle size range mm	Free % H2O of prod.	Size	t/hr	Forces	Capital cost / annual. ton (R)	OP. Cost R / ton
D & R screen	150-0.5	4-15	3.6*4.7 m	240	3 G's	0.12	0.02
Basket Cent.	20 - 0.5	8-10	1300 mm	120	50 G's	0.21	0.09
De-water. screen	0.5-0.1	16-24	1.8* 3.7	50	5 G's	0.31	0.05
Scroll Centr.	0.5-0.1	12-18	900 mm	30	150 G's	1.51	0.39
Rotary Filter	0.5-0.1	10-14	70 m^2	28	Vacuum	7.08	0.52
Disc Filter	0.5-0.1	10-14	70 m^2	27	Vacuum	6.56	0.56
Screen Bowl Cent.	0.5-0.1	8-14	1100*330 0	35	3400's	0.22	0.50
Horizon Belt Filter	0.5-0.05	8-35	120 m^2	50	Vacuum	5.95	0.44
Solid Bowl Cent.	0.05-0.0	30-42	1100*330 0	20	6000's	10.91	1.89
Pres. Belt Filter	0.05-0.0	28-36	2000mm	18	-	12.46	2.72
Pres. Filter	0.05-0.0	26-30	70 m^2	40	-	10.04	1.60
Frame Press	0.05-0.0	18-24	1050 m^2	25	25 bar	39.60	1.70
Autofil press V	0.05-0.0	22-24	-	5	20 bar	71.00	3.06
Tube Press	0.05-0.0	12-18	0.5*3m	15	140 bar	106.00	2.90
Hole-Flight Dryer	0.5-0.0	0-16	3 unit	35	-	18.18	3.20
Thermal Dryer	0.5-0.0	6-10	-	28	-	49.21	6.04

1.4 : Waste Of Useful Energy Resources Due To The Lack Of Economical Dewatering Methods

Slime dams consist mainly of ultra fine coal and a small percentage of fine coal. The dumping is mainly due to the lack of economical dewatering processes for materials with large specific surface area.

A survey of the South African coal industry in 1985 indicated that 3.7 Mtpa of bituminous coal was being discarded in the form of fines and ultra fines. The ash content of this material ranges from 6 % (very low !) to

FIGURE 1-3-B


DE-WATERING EQUIPMENT VS. PARTICLE SIZE AND MOISTURE
BASKET CENTRIFUGE
D & R TYPE SCREEN
SCREEN BOWL CENTRIFUGE
ROTARY FILTER
SCROLL TYPE BASKET CENT.
DE-WATERING SCREEN
TUBE PRESS
FRAME PRESS
PRESSURE FILTER
PRESSURE BELT FILTER
HORIZONTAL BELT FILTER
SOLID BOWL CENTRIFUGE
PERCENT SURFACE MOISTURE OF PRODUCT
4%
8%
12%
16%
20%
24%
30%
36%
42%
10 min
6 mm
3 mm
1000 μ
500 μ
300 μ
100 μ
50 μ
20 μ
10 μ
5 μ
PARTICLE SIZE RANGE

The feed to the plant reports to the primary wet sizing screen. The overflow of this primary sizing stage normally consists of particles greater than 12 mm which normally is handled by a dense medium bath-type circuit. The underflow (- 12 mm) of this stage reports to a desliming screen. The overflow from this screening operation (- 12 mm + 0.5 mm) is sent to the dense medium cyclone circuit. The underflow of the desliming screen (- 0.5 mm i.e. fines and ultra fines) is separated by a classifying cyclone.

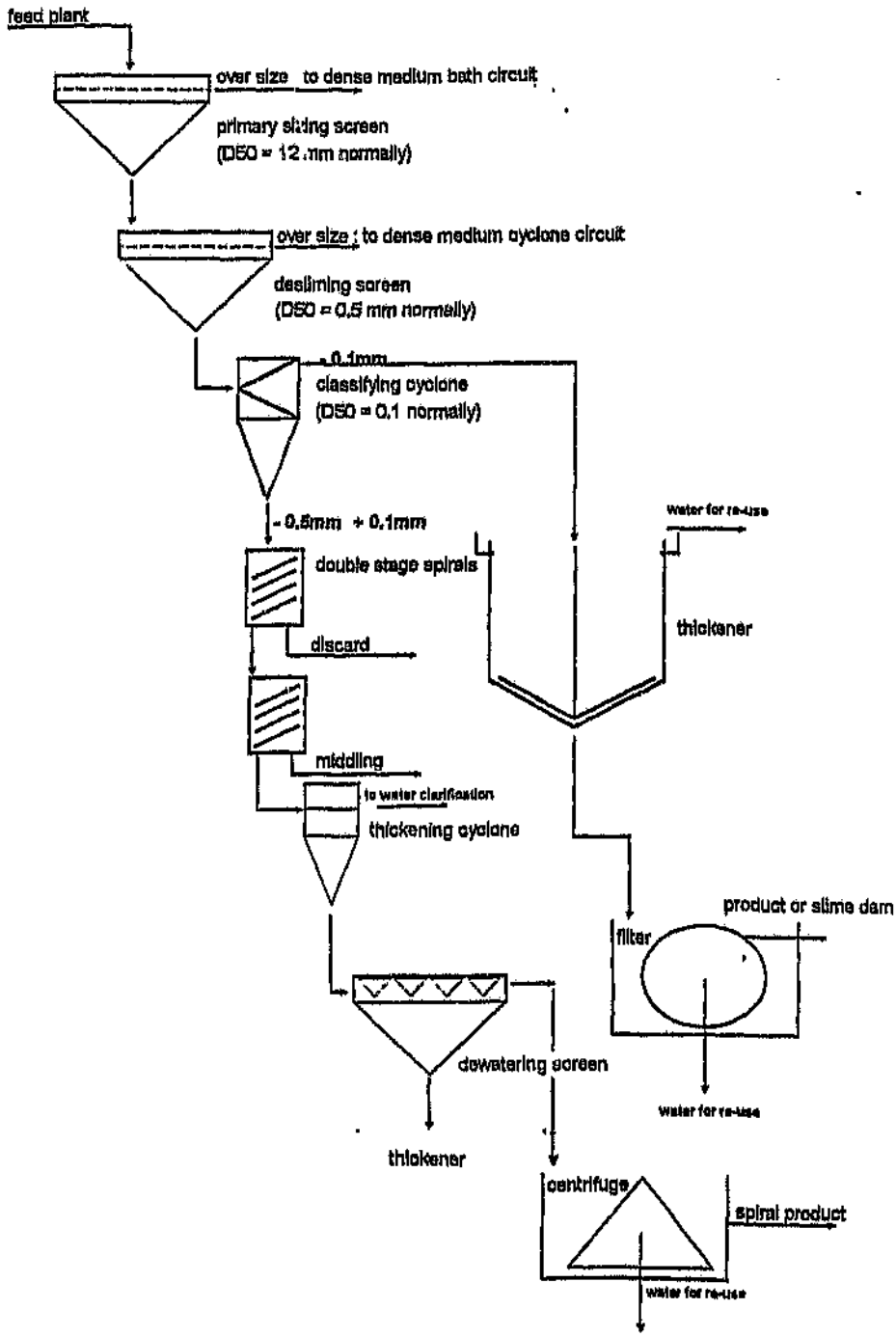
The underflow of the classifying cyclone consists mainly of fines. This product can be upgraded using spirals. The spiral product is normally dewatered on the dewatering screen to a surface moisture content of about 16 % to 24 %. This product is then further dewatered by using centrifuges to a final moisture level to below 10 %, depending on the operating conditions and equipment used (Du Preez [2]).

The overflow of the classifying cyclone consists mainly of ultra fines (- 0.15 mm). Due to the relatively large specific surface area of the material, it is much more difficult to reduce this material to acceptable moisture levels. Due to the prohibitive costs involved in reducing this size fraction's moisture content to acceptable levels the common practice is to concentrate this material in a thickener. The slurry from the thickener underflow is pumped to slime dams for water retrieval. In some cases the thickener products are treated in filters to yield products with moisture levels within the range of 8 % to 35 % depending on the operating conditions and equipment used (Du Preez [2]).

The smaller the particle size, the greater the specific surface areas open to the actions of the adhesive and cohesive forces holding the free moisture. It is obvious then that the smaller the particle size, the greater the energy required to remove the surface and free moisture, hence the greater the costs of dewatering equipment and operation. The following figure and table clearly illustrate the point (Du Preez [2]).

Figure 1-3-A

Conventional Path of Fine and Ultra Fine Coal in a S.A. Coal Preparation Plant



CHAPTER 1 : INTRODUCTION

1.1 : Definition Of Fine And Ultra Fine Coal

The convention used is based on the one made by Horsfall and Franzidis in 1988 [1]; fine coal being between 500 um and 150 um (or between 0.5 mm and 0.15 mm) whereas ultra-fine coal is less 150 um (or 0.15 mm).

1.2 : Origin Of Fine and Ultra Fine Coal

Coal fines and ultra fines arise whenever coal, which often is a very brittle material, degradates. Modern mining and beneficiation methods are prone to generate ever increasing amounts of fines and ultra fines.

The amount of fines and ultra fines present in run of mine coals are complicated functions of parameters such as the nature of coals (e.g. porosity, hardness, grindability, friability) and processing methods employed.

In S.A., it is estimated that between 8 % and 12 % of the feed to the plant are reported as fines. It was further suggested that of the order of 50 % more fines are produced in the plant than indicated by conventional run-of-mine sizing analysis. This is because conventional laboratory square-mesh sieves are used in the size analysis of the raw coals whereas wedge wire screens are employed in plant (Horsfall [1])

1.3 : Conventional Processing Route Of Fine and Ultra Fine Coal And The Associated Dewatering Costs

Conventionally in the coal preparation plant, fine and ultra fine coals report to the underflow from wet screening operations. The following simplified flow diagram illustrates the most common processing route used.

TABLE 2-3-C

Moisture Level of the Final Product for Experiment C

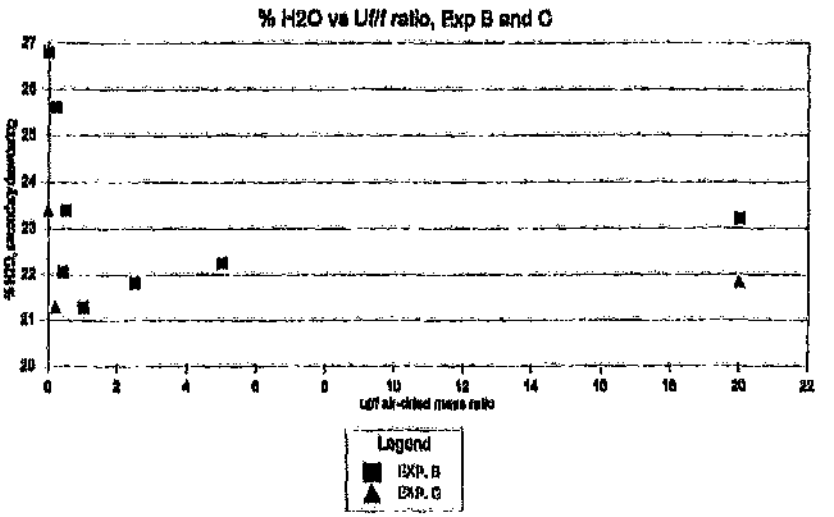
uf/f ratio in fraction	% final moisture level	% moisture reduced (absolute, not relative)
0.0	23.4	6.5
0.2	21.3 +- 4.9 %	8.6 +- 12.1 %
100 % ultra fines	21.8 +- 0.1 %	8.0 +- 0.2 %

@ figures reported as average with relative standard deviation in %

@ Starting moisture level before secondary dewatering is 29.82 %

Graph 2-3-B plots the final moisture level vs uf/f ratio from Table 2-3-B and 2-3-C.

Graph 2-3-B



The trend shown in the above graph is interesting. The product moisture level of secondary dewatering decreases as the uf/f ratio increases. This trend continues until the ratio of 1.0 (50 % fines and 50 % ultra fines)is reached. At the ratio of 1.0, the moisture level was

mixture then underwent the normal ' secondary ' dewatering routine. The results obtained are presented in the following table.

TABLE 2-3-B

Moisture Level of the Final Product for Experiment B

uf/f ratio in fraction	% final moisture level	% moisture reduced (absolute, not relative)
0.0	26.8 +- 0.1 %	3.0 +- 1.2 %
0.2	25.6 +- 3.7 %	4.2 +- 22.4 %
0.4	22.0 +- 2.6 %	7.8 +- 7.5 %
0.5	23.4	6.5
1.0	21.3 +- 4.9 %	8.6 +- 12.1 %
2.5	21.8 +- 0.1 %	8.0 +- 0.2 %
5.0	22.2 +- 1.0 %	7.74 +- 0.0 %
100 % ultra fines	23.2 +- 3.4 %	6.6 +- 11.8 %

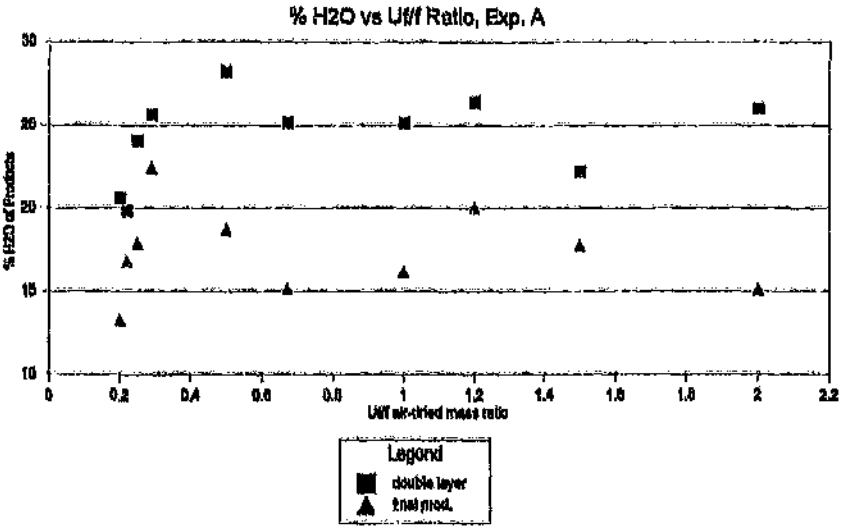
@ figures reported as average with relative standard deviations in %

@ Starting moisture level before secondary dewatering is 29.82 %

2.3.2 : Product moisture level after secondary dewatering

From Table 2-3-A, it is obvious that the mixing of the double layer product and subsequent secondary dewatering further reduced the total moisture level. The following graph plots average % moisture levels of double layer and secondary dewatering product vs uf/f ratio from Table 2-3-A.

Graph 2-3-A



It is evident from the above graph that mixing prior to secondary dewatering indeed helps to further reduce the moisture level of the mixture as predicted. However it is also demonstrated that with varying starting moisture levels (double layer moisture levels), it is difficult to obtain a trend relating the product moisture level of secondary dewatering to uf/f ratio.

To investigate the relationship between the product moisture levels from secondary dewatering and the uf/f ratio, experiments B and C were performed (for procedure, see 2-1-2). Since the focus point is not the double layer, the double layer formation stage was omitted. A mixture of fines and ultra fines with specific uf/f ratios were mixed with water and the sealed system was allowed to reach an equilibrium moisture level of 29.82 %. This was within the normal range of the double layer moisture levels obtained under laboratory conditions. The

conglomerates into 'balls' during the secondary dewatering stage.

2.3 : The Product Moisture Levels Of Double Layer And Secondary Dewatering Stages

TABLE 2-3-A

Important Results Concerning the Product Moisture for Experiment A

uf/f ratio (in fraction)	% final moisture level of double layer	% moisture level after secondary dewatering
0.2	20.6 +- 6.87 %	13.2 +- 15.7 %
0.22	19.9 +- 1.9 %	16.8 +- 13.5 %
0.25	24.0 +- 17.8 %	17.8 +- 16.0 %
0.29	25.6 +- 6.2 %	22.4 +- 8.0 %
0.5	20.2 +- 2.5 %	18.7 +- 4.7 %
0.67	25.1 +- 3.9 %	15.1 +- 28.2 %
1.0	25.1 +- 9.0 %	16.1 +- 25.9 %
1.2	26.4 +- 8.7 %	20.0 +- 24.7 %
1.5	22.2	17.7
2.0	26.0 +- 11.3 %	15.0 +- 33.3 %

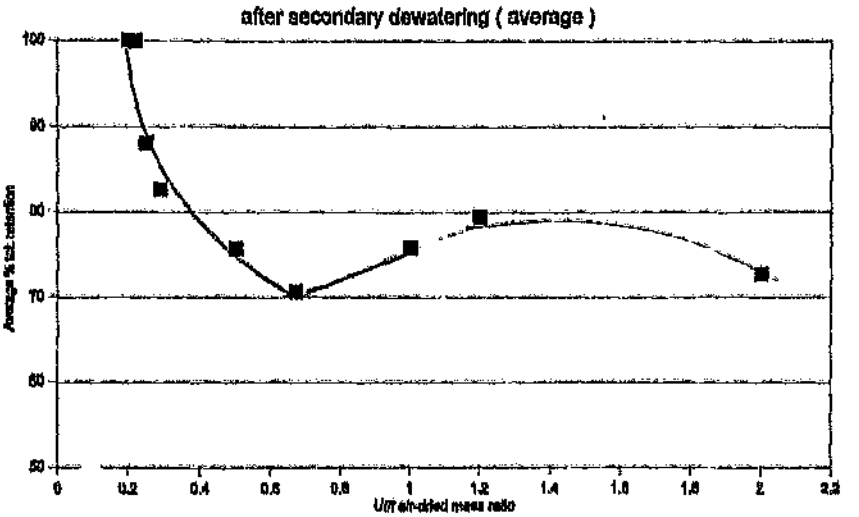
N.B. average values with relative standard deviation in % reported

2.3.1 : % Moisture level of double layer

In Experiment A, the ultra fines slurry (20 % solid) was introduced gently onto the fine coal cake (moisture contents between 20 % to 30 %) to form the double layer. Excess moisture was removed by the application of vacuum for 10 seconds. (natural drainage took far too long, section 2-1-1 : experimental procedure for Experiment A).

It is apparent from Table 2-3-A that within the range of uf/f ratios tested excess water can always be drained away from the double layer leaving the double layer with a final moisture content less than 30 %. The important issue here is the drainage time required to achieve acceptable final moisture contents under normal operating conditions. Natural drainage takes too long but vibratory motion of the dewatering screen is expected to increase the rate of drainage considerably.

Graph 2-2-B : % Total Retention vs Uf/f



Graph 2-2-B and Table 2-2-A show a trend that with increasing uf/f ratios the less is the total retention value. This trend continues until the ratio of around 0.67 is reached (equivalent to 40.1 % ultra fines and 59.9 % fines) with a corresponding retention value of 70.7 %. After that the retention values appear to increase slowly again. The highest ratio tested was 2.0 and this was equivalent to 67.0 % ultra fines and 33.0 % fines.

The increase in the specific area with increasing ultra fines content is probably responsible for this phenomena, the logic being that as the specific area increases within the particulate system the adhesion forces increase resulting in a lower loss of the minus 150 um particles.

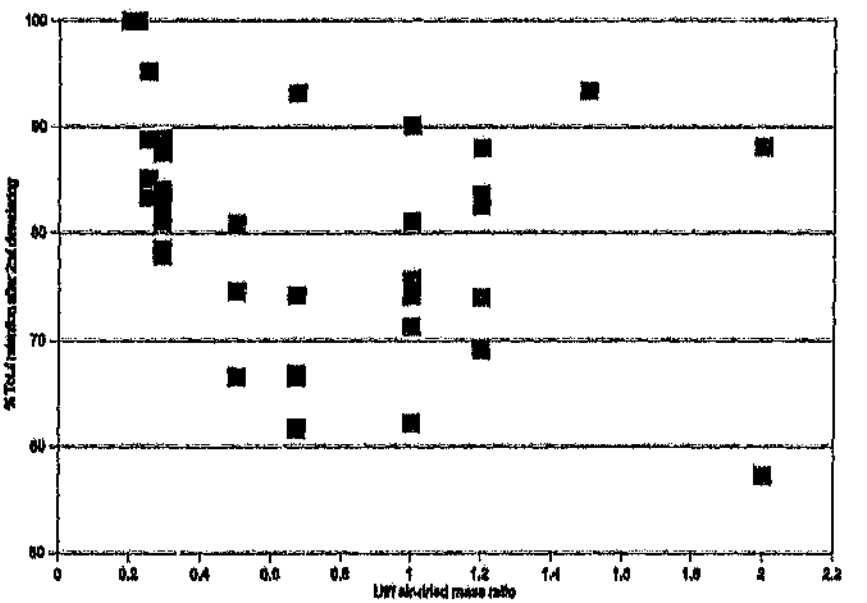
As mentioned earlier, the dynamics between the Laboratory scale vibratory screens and normal industrial dewatering screens are very different. The poorer results obtained from the laboratory scale tests were probably caused by the breakage of cakes taking place 'inside' the screen. This is not expected to occur on industrial dewatering screens under normal operating conditions. In fact pilot plant results show no loss at all of the - 150 um material during the secondary dewatering stage. During this stage, the free moving mixture actually

screen. Consequently the retention figures obtained would be expected to differ from each other considerably. The results obtained from pilot plant tests confirmed this. Nevertheless, the results obtain from the laboratory scale tests were reported in Table 2-2-A and the following two graphs.

The following two graphs (Graph 2-2-A and Graph 2-2-B) plot % retention of the total feed material after secondary dewatering stage vs uf/f ratio. (see also Table 2-2-A). Graph 2-2-A plots the result of every test and Graph 2-2-B only plots the average figure for every ratio tested.

Graph 2-2-A

% Total Retention vs Uf/f Ratio after Secondary Dewatering, (all tests)



2.2.1 : The retention of the minus 150 micron fraction during the double layer formation stage

Observations made during the experiments confirmed that it is feasible to use a fine coal cake (moisture contents between 20 % to 30 %, see Table 2-1-A for particle size distribution) as a filtration medium for the ultra fines slurry (20 % solid, see Table 2-1-B for particle size distribution).

The retention of the ultra fine material during the double layer formation stage was excellent with the underflow slurry containing very little solid material (mainly - 45 um). The mass loss was usually in the order of less than 5 % w.r.t. the original ultra fine mass content. This is not listed in Table 2-2-A.

As natural drainage is too time-consuming, use is made of vacuum to increase the speed of the filtration. The final moisture of the obtained double layer was in the order of 25 %. One would expect the retention of the - 150 um fraction to be even higher should natural drainage be allowed to take place.

The depths of the initial fine coal bed and the double layer are presented in Table 2-2-A. It is noticed from the table that the increase in the bed depth as the result of the introduction of ultra fines is not as high as one expects. This is primarily due to the material compaction caused by the applied vacuum. If natural drainage were allowed to take place, the depth of the double layer would be much higher than the initial fine coal cake. However, the table shows the trend that the double layer bed depth did increase with the introduction of ultra fines. The increase in bed depth was increased as the uf/f ratio increased.

From the observations, it is obvious that fine coal cake serves as a good filtration medium for ultra fine retention.

2.2.2 : The retention of the minus 150 micron fraction after secondary dewatering

The aperture of the screen used during secondary dewatering was 150 um. Since both the fine content and the ultra fine content contain - 150 um particles (Table 2-1-A and 2-1-B), it is difficult to determine from exactly which constituent the - 150 um is lost during secondary dewatering. Therefore the retention of the total feed material is used instead.

However, the dynamics of the laboratory screen vary greatly from that of the industrial scale dewatering

TABLE 2-2-A

Retention of the Feed in Experiment A

uf/f ratio in fraction	Bed depth of the fine cake bed in mm	Bed depth of the double layer in mm	% Total retention of the feed after secondary dewatering
0.2	34.0 +- 4.2 %	34.5 +- 2.0 %	100.0 +- 0 %
0.22	34.9 +- 1.3 %	34.9 +- 0.4 %	100.0 +- 0 %
0.25	33.8 +- 7.4 %	32.2 +- 2.8 %	88.1 +- 6.0
0.29	33.9 +- 5.3 %	38.1 +- 4.7 %	82.7 +- 4.3 %
0.50	34.5 +- 4.9 %	38.1 +- 4.6 %	75.7 +- 8.9 %
0.67	33.7 +- 6.4 %	41.9 +- 6.7 %	70.7 +- 16.9 %
1.00	21.3 +- 32.3	32.1 +- 41.7 %	75.7 +- 12.4
1.20	18.4 +- 8.2	26.0 +- 13.6	79.4 +- 9.7 %
1.5	20.0	30.0	93.6
2.0	8.5 +- 8.3	21.5 +- 23.0 %	72.7 +- 30.0 %

N.B. average values with relative standard deviation in % are reported

Note :

1 For uf/f ratio of 1.5, the standard deviation is not available.

2 For uf/f ratio of 1.0, the standard deviation is high, tests for this particular ratio were not repeated due to time constraint. However, special reserved approach was applied when studying the results.

pure ultra fines

2.1.3 : Experiments D & E

1 : A pre-determined amount of air-dried fines and ultra fines were thoroughly mixed. The ratio of ultra fines to fines was fixed at 0.4 for these two sets of experiments.

2 : In Experiment D a pre-determined amount of water was added to the mixture and the sealed system was allowed to reach equilibrium. The same procedure was applied to experiment E.

3 : The mixture was then introduced onto a 150 um Labotec screen and vibrated for a given period of time in a gentle circular motion.

4 : The product and underflow were collected for moisture and loss determinations (underflow).

5 : Procedures 1-4 were repeated for different periods of time.

2.2 : Ultra Fine Retention Properties Of The Feed Material Of (I) Double Layer Formation Stage (Primary Dewatering Stage) And (II) Secondary Dewatering Stage

For easier reading, a very short description of 2.2.1 and 2.2.2 and important data are listed below before the commencement of the actual sections.

Section 2.2.1 deals with the double layer formation stage

Tests were performed to establish the feasibility of using a fine coal cake as a filtration medium for the ultra fine slurries. With the gentle introduction of ultra fine slurries, most of the ultra fines were expected to remain on top of the fine cake. Small amounts of ultra fines would be filtered through into the fine coal cake. The excess water from the ultra fine slurry should be drained from the coal particulate structure. At this stage, the retention of material is expected to be high due to the static nature of the experimental conditions.

Section 2.2.2 deals with the ultra fine retention after the secondary dewatering stage

The following table lists the important results obtained from experiment A concerning the above two points.

9: Procedures 1 - 8 were repeated for the following ultra fine to fines ratio (dry mass basis)

0.2
0.22
0.25
0.29
0.5
0.67
1.00
1.20
1.49
2.00

2.1.2 : Experiments B & C

1 : Pre-determined amounts of air-dried fines and ultra fines were mixed thoroughly to produce a homogeneous mixture.

2 : A pre-determined amount of water was added to the mixture. The coal and the water were thoroughly mixed and the sealed system was allowed to reach equilibrium.

3 : This mixture was then introduced onto a 150 um Labotec screen and vibrated for 20 minutes in a gentle circular motion.

4 : The product and the underflow of the screen were collected to determine the moisture level and material retention.

5 : Procedures 1-4 were repeated for the following ultra fine to fine ratios.

Experiment B :

0.00 (pure fines)
0.20
0.40
0.50
1.00
2.50
5.00
pure ultra fines

Experiment C :

0.0 (pure fines)
2.00

8 : The mixture was then introduced onto a 150 um Labotec screen and vibrated for 20 minutes in a gentle circular motion (see following diagram.

The entire screened product was taken out for moisture determination.

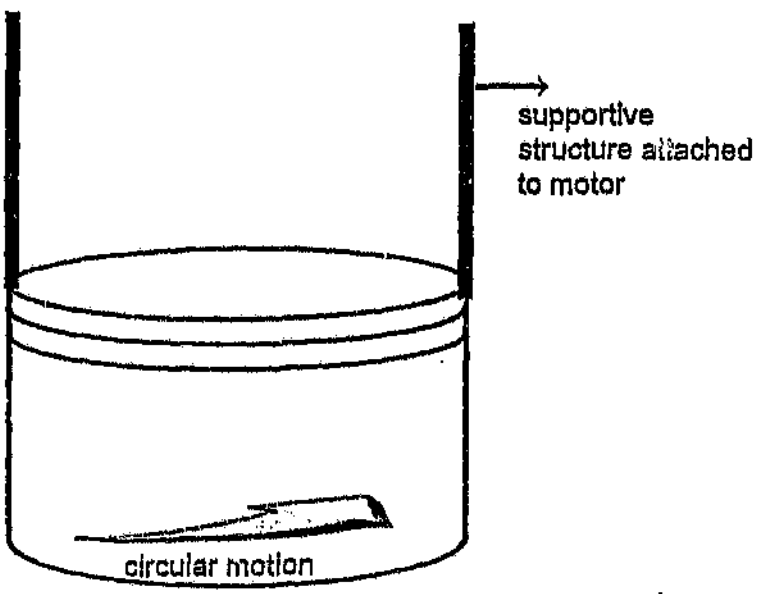


Figure 2-1-B : Vibrating Screen

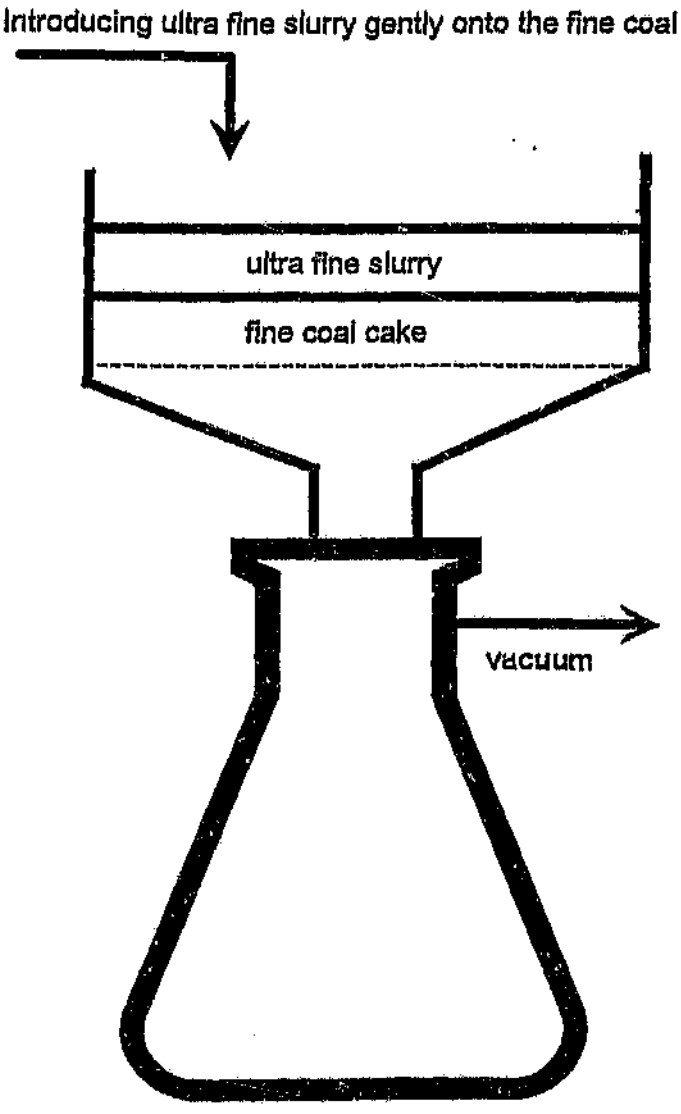


Figure 2-1-A : Buchner Funnel Set-Up of Experiment A

Flowsheet description

This is a closed-circuit operation with re-circulating streams.

Material from the sump (unit 4) is mixed thoroughly by the stirrer and the turbulence caused by the five returning gravity-fed streams to the sump. The returning streams are : screen discharge (No. 3), screen underflow (No. 4), outlet streams of flow rate setter No. 12 and 13 and thickener overflow (No. 9) which washes the screen discharge down the pipeline. The sump has only one outlet stream (No. 5) which is pump-fed to the classifying cyclone (unit 2).

The two outlet streams of the cyclone are cyclone underflow (No. 6) and cyclone overflow (No.7). Cyclone underflow is gravity fed to the flow rate setter (unit 6) and split into two streams - No. 1 and No. 12. No.1 was the one with the set flow rate and was therefore gravity-fed to the dewatering screen. No.12 was gravity-fed to the screen discharge collecting pan and was washed down to the sump with thickener overflow (No.9).

Cyclone overflow (No. 7) was fed to the thickener by gravity. During the run flocculant (No. 11) was dosed to the thickener at a constant rate (see Appendix C for details of flocculant dosage calibration). There was always more than 1 ton of material present in the thickener during the run to maintain a steady state condition in case of temporary shortage of flocculant. Thickener product (No. 8) was pumped up to the flow rate setter which split the streams into two streams No.2 and No. 13. No.2 was the one with the desired flow rate and was the feed (by gravity) to the thickener product feeding pan, unit 7, which hung above the screen. The ultra fine slurry was gravity-fed to the fine cake counter-currently at +- 20 cm near the screen discharge end. No. 13 went through the same routes as No.12.

The screen discharge (No.3) was collected in the screen discharge collecting pan. This stream was joined by No. 12 and No.13; all were washed down by thickener overflow. The screen underflow (No. 4) also returned to the sump by gravity.

The above flow-sheet describes the set-up used during the primary dewatering. Since there was only one dewatering screen available, mixing and secondary dewatering procedures were performed separately and batch-wise after the completion of the primary dewatering stage (see also 3-2-2 : Test procedures).

Table : 3-1-C

Sampling Points and Flow Rate Measurement Points of Pilot Plant

Sampling Stream	Sampling and Flow Rate Measurement Point	Sampling Device
No. 3 screen discharge	screen discharge end	specially-made container with width slightly wider than that of the screen discharge end
No. 4 screen underflow	valve underneath the collecting pan	bucket
No. 1 cyclone underflow	from flxi. pipe after the flow rate setter	bucket
No. 2 thickener product	flxi. pipe after the flow rate setter	bucket
No. 7 cyclone overflow	by-pass pipe with valve	bucket
No. 5 feed to cyclone	sump	bucket

Table 3-1-B : Pilot Plant Flow Stream Numbers

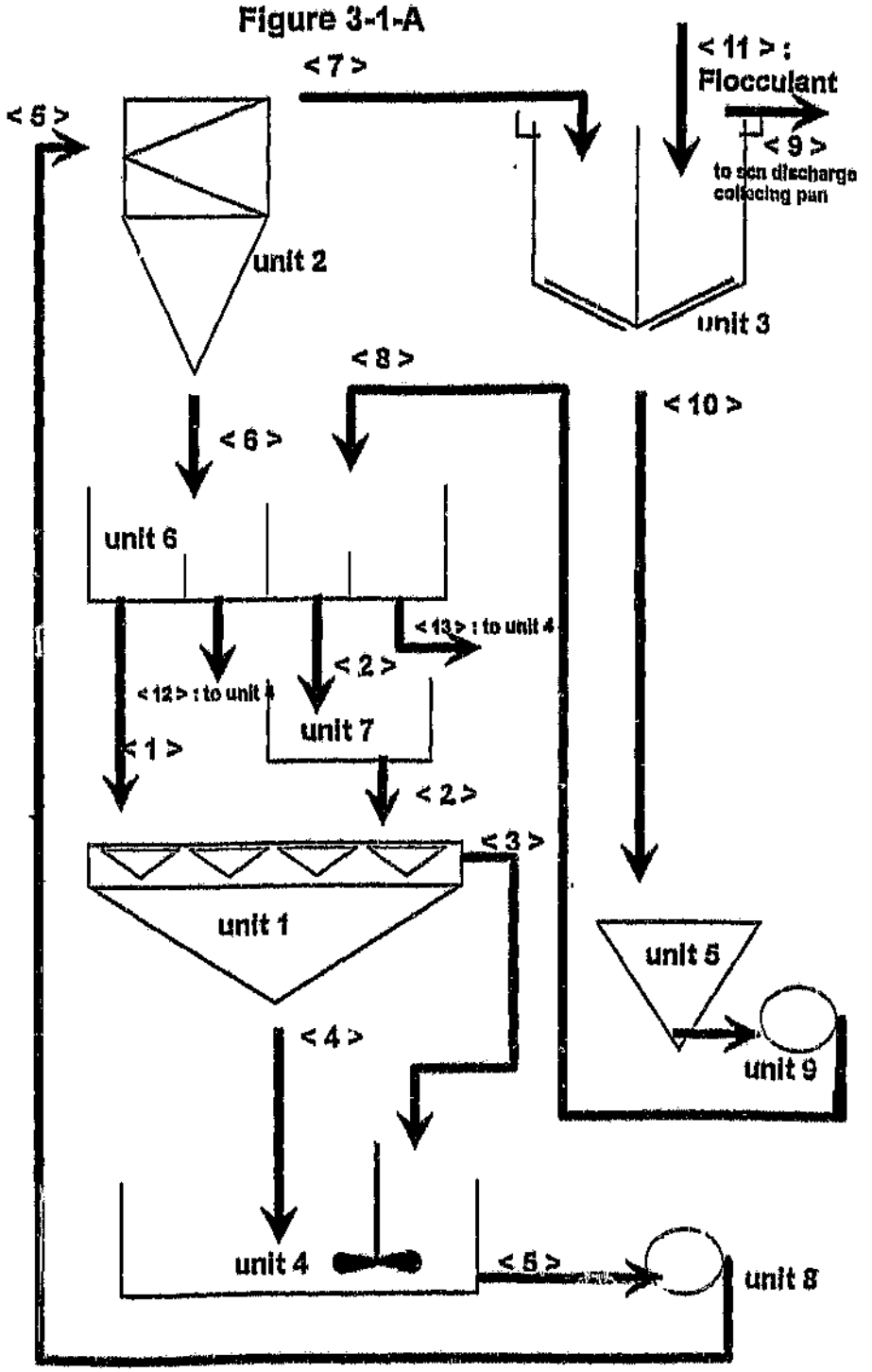
Stream No.	Stream Name	Description
1	cyclone underflow (fines)	45 % to 55 % solid slurry : +- 3.5 t/hr
2	thickener product (ultra fines)	30 % to 35 % solid
3	screen discharge	+- 25 % H2O : +- 1.5 t/hr cake
4	screen underflow	+- 80 % H2O
5	feed to cyclone	+- 10 % to 15 % solid
6	cyclone underflow	-
7	cyclone overflow	+- 95 % H2O
8	thickener product	-
9	thickener overflow	-
10	thickener product	-
11	flocculant addition	by special pump
12	cyclone underflow	-
13	thickener product	-

Table 3-1-A : Pilot Plant Unit Numbers

Unit No.	Unit Name	Description
1	Fordertechnik dewatering screen	7 304.8mm * 304.8mm panels first three : 500um other four : 300um
2	classifying cyclone	D50 between 150 um & 212um at 45 % to 55 % solid in u/f
3	thickener	under flow between 30 % to 35 % solid
4	sump	-
5	sala feed tank	-
6	mechanical feed rate setter	set feed rate of fines and ultra fines
7	ultra fine slurry feeder	provide gentle feed of ultra fines across the screen width
8	pump	-
9	sala pump	-

3.1 : Pilot Plant Set-up And Flow Sheet Description

Figure 3-1-A



CHAPTER 3 : PILOT PLANT TEST WORK

Summary :

Following the encouraging results obtained during the laboratory scale test work, a pilot plant was designed, constructed and commissioned to test the concepts on a larger scale.

The pilot plant was set up to determine the following functions :

- test the feasibility of using the fine cake (cyclone underflow) as a filtration medium for ultra fine slurry (thickener product)
- perform tests during a continuous primary dewatering process
- perform mixing and secondary dewatering stages batchwise

This chapter details the setting up of the pilot plant and the experimental procedures followed.

The three main sections of this chapter are listed as follows:

3.1 : Pilot Plant Set-up and Flow Sheet Description

3.2 : Experimental Methods and Test Procedures

3.3 : Sampling Scheme and Flow Rate Measurement Scheme

For the methods of sample preparation, analyses of moisture, particle size distribution, ash content, data smoothing and data analyses, please refer to the following : Appendix A, B and C. For detailed data for each test please refer to Appendix D.

The normal residence time of material on the dewatering screen is usually less than 2 minutes. Experiment D and B were performed to investigate the minimal time required to achieve acceptable results during secondary dewatering (section 2-4). The results obtained show that with an initial moisture of 29.82 %, half-a-minute was all that was required to reduce the moisture content levels to similar levels achieved with a laboratory vibratory screen (around 22.0 %). After that, no further reduction of product moisture level was observed.

pilot plant conditions the vibratory action of the dewatering screen should further aid the drainage rate. However, the additional rate of the ultra fine will be limited by the residence time (hence filtration time) available of material on the dewatering screen.

2.5.2 : The benefits from mixing and secondary dewatering

Observations and results obtained indicate that mixing and secondary dewatering does reduce the moisture content even further (section 2-3-2, Experiment A, B and C). The reduction moisture levels achieved was between 3.5 % to 15 % (absolute) depending on the testing conditions.

Experiment B and C were performed to investigate the relationship between secondary dewatering product moisture content and uf/f ratio. The results obtained indicate an interesting trend. The moisture level for all tests prior to secondary dewatering was fixed at 29.8 % which falls within the typical moisture range of the double layer obtained under normal experimental conditions. Initially the moisture level of the secondary dewatering product decreases with increasing uf/f ratio until a ratio of 1.0 (50 % ultra fines and 50 % fines) is reached. After that, the moisture content increases slightly with increasing uf/f ratio.

Under the conditions of Exp. B and C, indications are that when a ratio of 1.0 is achieved, the saturation point has been reached. Before the saturation point was reached, the ultra fine particles continued to fill the voids within the mixture thus reducing the moisture retention ability of the mixture. Consequently the product moisture content decreased as the uf/f ratio increased. After the saturation point was reached, there were no more available voids for the ultra fine particles to fill in. Thus the 'free' ultra fine particles added provided extra surface areas for moisture adsorption which resulted in increasing the moisture retention ability of the mixture again. As a result, the product moisture started to increase as uf/f ratio increased.

The saturation ratio of 1.0 was deduced from the results obtained under the specific conditions of Exp. B and C. This was a special case and results obtained should be used for reference only. With the laboratory conditions differing greatly from those envisaged on an actual pilot plant, even though the concept remains the same, it prohibits direct scale-up of results obtained during laboratory work. Thus results will be used for reference purposes only.

Studying the above tables and graphs, the following is derived

(1) : The final product moisture level of Exp. D is higher than that of Exp. E due to its higher starting moisture.

(2) : In Exp. D, there seems to be no additional moisture reduction after 10 minutes of vibration.

(3) : For Exp. E, there seems to be no additional moisture reduction after 0.5 minutes of vibration.

The 20 minutes screening time used during laboratory test work was excessive as 0.5 minutes was sufficient time to achieve final moisture of less than 30 %. Additional screening was of little benefit in further reducing final moisture. This was attributed to the weak vibrational forces of the laboratory screen.

2.5 : Conclusions

The results obtained were encouraging and subsequently work commenced on the pilot plant scale.

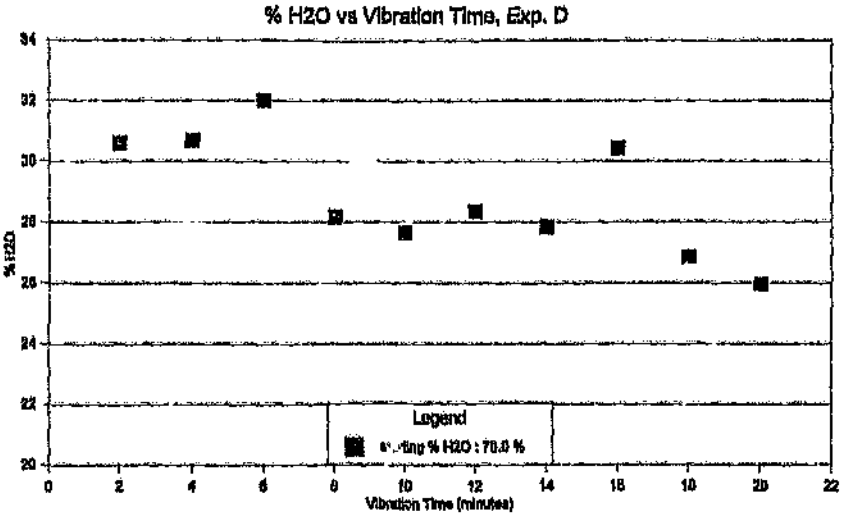
2.5.1 : The feasibility of using a fine coal cake as filtration medium for ultra fine slurry

Under the laboratory scale testing conditions, results obtained indicate that the fine cake (moisture level 20 % to 30 %) is a good filtration medium for the ultra fine slurry (20 % solid).

Under the static conditions experienced under the Lab. scale test work, the retention of the - 150 um fraction throughout the uf/f range tested was high. The material filtered through was mainly - 45 um and the amount constituted less than 5 % of the original ultra fines added (section 2-2-1). Most of the excess water from the ultra fine slurry was drained out to leave a fine and ultra fine coal double layer with moisture contents between 20% to 30% (section 2-3-1).

The important parameter here is the minimum required drainage time. Tests showed that to achieve a double layer with moisture levels between 20 % to 30 %, using natural drainage, takes at least two hours or more depending on the uf/f ratios applied. Subsequently vacuum was used in the laboratory to speed up the filtration rate at the expense of losing relatively small quantities of - 45 um material with the excess water removed. Under

Graph 2-4-A



Graph 2-4-B

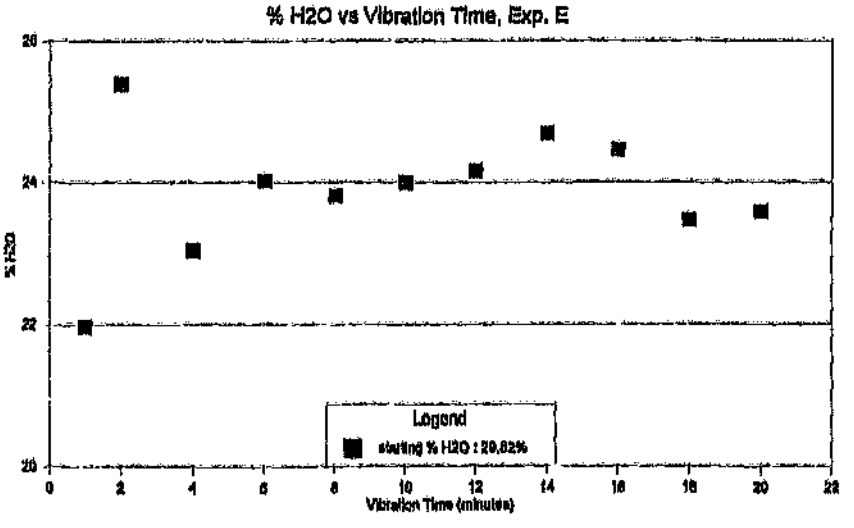


TABLE 2-4-B

Results of Experiment E

vibration time (minutes)	product moisture level
20	23.58
18	23.46
16	24.46
14	24.69
12	24.16
10	24.00
8	23.81
6	24.02
4	23.04
2	25.39
1	21.97
0.5	22.19

@ Starting moisture level 29.82 % (similar to the moisture level of the double layer)

reduced from 29.8 % to 21.2 % which corresponds to a total reduction of 8.6 % (absolute). After that the product moisture levels appears to increase slightly with uf/f ratio. At the last point where no fines were added, the final moisture content was 21.8 %.

This seems to indicate that under the specific conditions of experiment B and C, the saturation point is achieved when a ratio of 1 (ultra fine : fine = 50 % : 50 %) is reached. Thus what is theoretically predicted to occur seems to be borne out by the findings from the above tests.

2.4 : The Minimum Vibration Time Required for Secondary Dewatering

In Exp. A, B and C the vibration time (gentle circular motion) of the fine & ultra fine mixture was twenty minutes. However, the normal residence time of material on a dewatering screen is less than 2 minutes. Exp. D and E were therefore performed to investigate the minimum vibration time required to yield a product with a satisfactory final moisture level. The starting moisture level of Exp. D was 70.0 % (a slurry) and for Exp. E was 29.82 %. The uf/f ratio was fixed at 0.4 (28.6 % ultra fine and 71.4 % fines) for both experiments. For the experimental procedures please refer to section 2-1-3.

The result of experiment D and E are listed in the following two tables (Table 2-4-A and Table 2-4-B) and graphs (Graph 2-4-A and Graph 2-4-B).

TABLE 2-4-A
Results of Experiment D

vibration time (minutes)	product moisture level
20	25.95
18	26.05
16	30.42
14	27.85
12	29.35
10	27.66
8	28.27
6	32.00
4	30.69
2	30.89

Starting moisture level 70.0 %

4.1 Secondary dewatering stage

No material was lost at all during this stage. The average moisture level of product from primary dewatering was around 25 %, i.e. basically cake. During secondary dewatering, conglomeration of coal particles occurred leading to the formation of small round conglomerates at the beginning of the screen. No material loss was observed.

4.2 : Product Moisture Levels Of (I) Primary Dewatering Stage (Double Layer Stage) (II) Secondary Dewatering Stage

The following table lists all the important results.

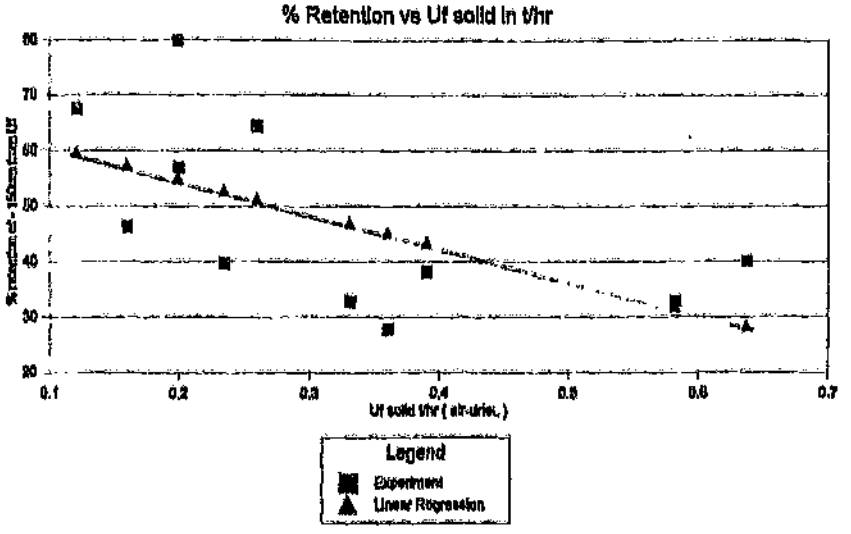
% - 150 um material and judging by the relatively small uf/f ratio possible due to the limits imposed by the available filtration time, it is easy to understand why the % of - 150 um material does not increase significantly despite the relatively high corresponding retention value.

With the existing set-up for ultra fine addition in the pilot plant, the ultra fine slurry was able to travel from the point of addition for the lengths of three panels i.e. 0.9 m before reaching the region with no available filtration medium. This set-up provided sufficient filtration zone, consequently sufficient filtration time, for up to 0.7 t/hr of thickener product (at 30 % solid gives 0.2 t/hr solid). And 63.0 % of the - 150 um material from the thickener product was recovered under these operating conditions. The corresponding uf/f ratio in % here was in the region between 10 % to 15 %.

The capacity of the normal industrial dewatering screen is 50 t/hr with dimensions of 1.8 m * 3.7 m. The dimension of the pilot plant dewatering screen was 0.3 m * 2.1 m hence the area available is only 9.4 % of the industrial scale screen. For a normal plant feed of 1200 t/hr coal, assuming 5% fines, there would only be 144 t/hr fines loaded to the dewatering screen. Allowing for misplaced material, one can assume that 180 t/hr coal is loaded to the dewatering screen. Six industrial size dewatering screens would offer 300 t/hr processing capacity therefore the extra capacity 120 t/hr can be used for the ultra fines addition. 120 t/hr is 10 % of the plant feed of 1200 t/hr and in reality the ultra fine content in the feed to the plant should be much lower than 10.0 %. Normally the design aims at 3.0 % ultra fine content in the feed to the plant. With the much larger area of the industrial dewatering screen, the retention of the ultra fines should be much higher than the 63.0 % obtained in the pilot plant.

Based on the figure from Du Preez [3], the dewatering screen running cost is 0.26 R/t (capital + operating) with a capacity of 50 t/hr. The horizontal belt filter, on the other hand, is R 6.39/t for a capacity of 50 t/hr. The cost is 24 times greater than the cost of the dewatering screen. By using less than 6 dewatering screens, it would be possible to reduce the moisture content of the ultra fines to a reasonable level at a lower cost than using the belt filter. Operation-wise, a belt filter is also more difficult to operate efficiently.

Graph 4-1-A



From the graph it is clear that the higher the ultra fine addition rate, the less the retention of the -150 um material from the ultra fine slurry.

Observations made during the following tests showed that there was sufficient filtration time for the ultra fine slurry: RUN 4, E2T2, E2T3, E3T3 and E4T3. During these tests no unfiltered slurry was observed. The retention values of the - 150 um material from the ultra fine slurry for these tests were high. The average value was 62.9 % with a relative standard deviation of 19.8 % and the average ultra fine solid addition rate being 0.2 t/hr +- 0.05 t/hr. This corresponds to 0.7 t/hr ultra fine slurry with 30 % solid content. The highest retention value achieved was 78.9 % (E4T3) with a corresponding ultra fine solid addition rate of 0.2 t/hr. Among these five tests the lowest retention value achieved was 46.2 % (E3T3) with a corresponding ultra fine solid addition rate of also 0.2 t/hr (Table 4-1-A). Other tests with ultra fine addition rates higher than 0.2 t/hr yield poor retention values due to insufficient filtration zone.

Although the retention of - 150 um material from the thickener product can be as high as nearly 80 %, it does not necessarily mean that the % - 150 um material in the screen discharge will increase significantly. The pilot plant thickener product already normally consists of 60

Table 4-1-A

Retention Results

test ID	uf slurry t/hr	uf solid t/hr	scn. disch t/hr	uf/f ratio in %	ret. of - 150 um mat. from uf in %	% - 150 um mat. in scn disch.
E1T1	0.0	0.0	1.7	0.0	N.A.	8.5
E1T2	1.5	0.6	2.0	42.0	40.0	11.4
E1T3	0.5	0.2	1.6	16.2	39.6	9.1
E2T1	0.0	0.0	1.6	0.0	N.A.	9.0
E2T2	0.7	0.3	2.0	15.3	64.3	12.3
E2T3	0.6	0.2	1.7	14.6	56.9	8.7
E3T1	0.0	0.0	1.6	0.0	N.A.	6.6
E3T2	1.0	0.4	1.6	24.2	27.7	11.7
E3T3	0.5	0.2	1.6	10.8	46.2	8.4
E4T1	0.0	0.0	1.5	0.0	N.A.	5.1
E4T2	0.9	0.3	1.4	23.3	32.8	9.1
E4T3	0.7	0.2	1.5	13.9	79.8	7.9
RUN 7	0.0	0.0	1.9	0.0	N.A.	4.7
RUN 4	0.3	0.1	1.3	10.7	67.5	9.2
RUN 5	1.5	0.6	2.5	29.6	32.7	8.4
RUN 6	0.9	0.4	2.6	19.1	38.1	6.2

N.B. tests E1T1, E2T1, E3T1, E4T1 and Run 7 are conventional dewatering process

The retention of - 150 um material from the ultra fine slurry vs the ultra fine solid addition rate is plotted in the following graph. The simple linear regression line with 95 % confidence interval is also shown in the same graph.

fine addition rate is too high, the unfiltered material will travel towards the feed end of the screen, due to the screen slope. Eventually it will reach the turbulent region of the screen where the filtration medium has not yet been established. The moisture level of the screen discharge product obtained with a double layer (primary dewatering product) was investigated.

The double layer was collected and mixed thoroughly under sealed conditions before being sent back to the dewatering screen for secondary dewatering. This step was performed batch-wise since there was only one dewatering screen available. The moisture levels between products of primary and secondary dewatering stages were compared. The material retention during secondary dewatering was also investigated.

4.1 : Retention Of - 150 um Material From Ultra Fines During (I) The Double Layer Formation Stage And (II) The Secondary Dewatering Stage

4.1.1 : Double layer formation stage (primary dewatering stage)

Results from the pilot plant tests show that the main limiting factor was the available filtration time for the ultra fine slurry. The fine cake itself proved a reasonably good filtration medium.

When the addition rate of ultra fine slurry was too high, some unfiltered slurry would reach the turbulent region of the screen where the fine cake was not yet formed. Since the fine cake only started to form after the mid-point of the fourth panel, the unfiltered ultra fines reaching beyond this region were inevitably lost through the screen apertures.

Another possible factor contributing to the loss of - 150 um material are the losses through the filtration medium. In the tests where conventional dewatering was applied (no ultra fine addition), no loss of coal with the excess water draining through the screen apertures was observed after reaching the mid-point of the fourth panel. In the tests where the new technique was employed, it was evident that the slurry was being filtered and excess water with some ultra fines was going through the last 3 panels (the ultra fine slurry was introduced near the end of the screen counter-currently to the fine coal cake).

The results obtained are presented in the following table.

CHAPTER FOUR : THE PILOT PLANT TEST-WORK - DISCUSSION AND CONCLUSIONS

Summary :

Sixteen pilot plant tests were performed. The 'fines' referred to in the pilot plant test was the pilot plant classifying cyclone product stream, which on average consists of 50 % + 150 um - 500 um material and less than 10 % - 150 um material. The 'ultra fines' referred to was the pilot plant thickener product which normally consists of 60 % - 150 um material. The coals used are the thickener underflow and the Fordertechnik screen products from Goodehoop Colliery.

Five of the tests conducted employed conventional dewatering of fines (cyclone underflow) using the pilot plant scale Fordertechnik screen. These five tests RUN 7, E1T1, E2T1, E3T1 and E4T1 were performed to establish the following:

(i) The moisture level attainable by the specific dewatering screen used in the pilot plant

(ii) The extent of loss of the - 150 um material in the cyclone underflow (fines) while being screened. Since both the fines and ultra fines fractions contain - 150 um material, if the amount of - 150 um material lost from the fine portion can be determined, the retention of - 150 um material from the ultra fines (thickener product) can be deduced.

All the ExT2 and ExT3 were performed immediately after the corresponding ExT1, e.g. E1T2 and E1T3 were performed directly after E1T1. Therefore the performance of each unit in the circuit should have remained consistent during the three consecutive tests. Hence the retention characteristics of - 150 um in the cyclone underflow from ExT1 can be used in the formula to estimate the retention of - 150 um material from the thickener product in ExT2 and ExT3. (Chapter 3 : Experimental methods of pilot plant tests and Appendix A : Method of estimating retention of - 150 um material of thickener product of tests performed by the new technique).

Eleven tests using the new technique were performed. The ultra fines slurry (+- 30 % solid) was introduced counter-currently via a special feeder onto the fine coal cake (+- 25 % moisture) 20 cm from the screen discharge end to form the double layer. The limiting factor here is the available filtration zone on the screen. If the ultra

rate measurement started. The flow rate measurements were performed on the following streams :

- No.3 : Screen discharge
- No.4 : Screen underflow
- NO.1 : Cyclone underflow (feed to screen)
- No.2 : Thickener Product (for tests with conventional method, this is omitted)
- NO.7 : Cyclone overflow (for RUN 4, RUN 5, RUN 6 and RUN 7 only)

The flow rate measurement of each stream was performed separately. At least 20 l of slurry or 20 kg of solid (in the case of screen discharge) was collected per measurement. A stop watch was used. After weighing the material collected, the material was re-introduced to the circuit and the system was allowed to come to equilibrium before taking the next measurement. Three measurements were taken and the average and std. deviation calculated. If the relative std. deviation was more than 5 %, more measurements were performed until a precise result was obtained.

For the method of sample preparation and moisture determination, particle size distribution and ash , please refer to Appendix C : Operation and control of the pilot plant.

For the method of data smoothing, please refer to Appendix B : Method of data smoothing of pilot plant test data.

For the method of data analysis, please refer to Appendix A : Method of estimating the retention of - 150 um material of thickener product of tests performed by the new technique.

The ultra fines were introduced at a position of approximately 20 cm from the screen discharge end. With the set-up of the feeding pan , the thickener product was able to fall gently (by gravity) to the existing fine cake. The thickener product then flowed in the direction of the screen feed end while being filtered through the cake structure along the way.

Fresh coal was used for each experiment. Within each experiemnt, to avoid overdosing the coal with flocculant, flocculant was only dosed during the sampling stage.

3.3 : Sampling Scheme And Flow Rate Measurement Scheme

The sampling scheme was designed in compliance with SABS standards. Thirty-two increments were collected with the mass of solid of each increment not less than the figure calculated by the following equation (applicable to top particle size less than 150 mm) :

P (Kg) = 0.06D , where P is the mass of each increment, and D is the top particle sizes in mm, however, P is always greater than 0.5 Kg

The sampling and flow measurements were performed during steady state conditions. It was physically impossible to sample all streams simultaneously and therefore increments from each stream were collected in the following order :

1 : NO.3 - screen discharge
2 : NO.4 - screen underflow
3 : No.1 and No.2 - cyclone underflow and thickener product simultaneously
4 : No.7 - cyclone overflow (only for RUN 4, RUN 5, RUN 6 and RUN 7)
5 : No. 5 - feed to cyclone (only for RUN 4, RUN 5, RUN 6 and RUN 7)

The pilot plant operates as a closed circuit system therefore to avoid changes to the steady state conditions due to incremental sampling, after collecting one increment from each stream, a pre-determined amount of prepared coal with a similar particle size distribution was added to the sump as compensation.(The compensation coal was prepared in batches before experiments started. Particle size distribution analyses were performed to assure quality). After this, the system was allowed to run for another 2 minutes before repeating the above procedure.

After the completion of the sampling scheme, the flow

stopped and the suction valve closed. Finally the mixer of the sump was stopped. The analyses of the samples should be completed within five working days, after that one was ready to start another set of experiments. By this time all the coals would have settled at the bottom of the sump. Excess amount of water could then be removed from the sump by siphoning. A bit of the ultra fines and/or fines could be added if required.

Immediately after shut-down of the plant, manual mixing began of the representative samples collected during primary dewatering stage (3-3 : sampling scheme and flow rate measurement scheme). The mixing procedure was performed under sealed conditions so that moisture loss was minimised. After that, the screen was re-started and the entire sample was re-introduced to the screen for secondary dewatering. In this case the entire sample was collected for analysis.

3.2.3 : Method of introducing the thickener product

One of the new concepts tested was the usage of a fine coal cake as the filtration medium for the ultra fine slurries. The excess water was supposed to drain through the cake leaving the ultra fine particles on top and within the fine coal mass.

The pilot plant dewatering screen has a different set-up to that of the industrial scale. It has a steeper inclination angle which promotes cake formation. However, the steeper angle also promotes loss of ultra fine slurry by enabling the unfiltered slurries to flow towards the screen feed end where cake formation has not yet been completed. In order to achieve maximum residence time, hence available filtration time of the ultra fine slurries under the circumstances, a special procedure was developed to overcome this problem. However, in the case of industrial scale dewatering screen, the above-mentioned problem does not exist and one can simply add the ultra fine slurry onto the fine coal cake co-currently at the point at which cake formation is complete.

Ultra fine slurry addition procedure in the pilot plant :

The thickener product was introduced counter-currently and gently to the fine cake. The thickener product from the flow rate setter was gravity-fed to the thickener product feeding pan which hung above the screen. The feed-end of the pan had the same width as the screen and the length was about 4 panels (the screen has 7 panels).

: Method of estimating the retention of - 150 um material of thickener product of tests performed by the new technique).

3.2.2 . Test procedure

Start-up procedure :

The start-up procedure of the pilot plant was easy. One must ensure that there is an adequate amount of material present in the thickener to maintain the steady state condition in the event of the flocculant dosing system stopping accidentally (more than 1 ton to be cautious). It is also necessary to ensure that there is sufficient flocculant supplies for the day. The flow rate control box must be set-up in such a way that there is no feed to the screen during this stage and the screen must be empty.

The mixer in the sump was started so as to agitate the material. The screen was then started. Once the screen was running, the sump suction valve could be opened and the pump started. The flocculant dosing system was then started. Once the cyclone overflow began reaching the screen discharge collecting pan, the valve underneath the thickener was opened slowly and the Sala pump started. When steady state was reached (usually within 20 minutes, the settling time of the flocculant was 13 minutes) the flow rate of the two feed streams to the screen were manipulated as required (by the control devices of the flow rate control box) and the system was allowed to reach the new steady state. The required test work then commenced (see 3-2-1 : experimental method, 3-2-3 : method of thickener product addition, 3-3 : Sampling scheme and flow rate measurement).

Shut-down procedure :
The shut-down procedure of the pilot plant was very important to prevent coal particles accumulating and blocking the pipework.

The two feed streams to the screen were stopped. All the cyclone underflow and thickener product would then report to the sump through the flow rate setter. The dosing system of the flocculant was then stopped. The screen was allowed to run clean after which the feed to the thickener was stopped and all the cyclone overflow reported to the by-pass pipe . The valve underneath the thickener was closed and water was introduced to the sala pump sump to run clean. After this the Sala pump was stopped. Then water was added to the system at the screen discharge collecting pan until the returning streams contained very little solid. By doing so all the pipework should be free of solids. The sump pump could then be

Scn dis : screen discharge

From the above equation , it is obvious that in order to determine the % retention of material of a particular size class from the thickener product, it is essential to know the retention of the same class material from the cyclone underflow. As the cyclone underflow still goes through the same routines as in the conventional process (see 3-2-2, method of introducing the thickener product), one would assume that the retention values obtained from RUN 7 could be used for estimation of the retention of the material from the cyclone underflow. However, in reality it is not that easy. Although much effort was made to ensure that all the parameters remained as constant as possible, except for the controlled parameter (critical ratio), the parameters do differ from test to test to some extent. (Appendix D : Detailed data for each pilot plant test) An attempt was made by applying the retention values of material from the cyclone underflow obtained during RUN 7 to equation 1 to calculate the retention of the material from the thickener product of RUN 4, 5 and 6. However, calculated results indicated that this approach was not accurate. (Appendix A : Method of estimating the retention of -150 um material of thickener product of tests performed by the new technique.)

A different approach was used. Instead of running the tests independently, three tests were run consecutively (one working day is only sufficient for three tests). The first test would be called ExT1 (e.g. experiment x test 1), and it was a conventional run (i.e. no ultra fines addition). During this first test, all the thickener product would go to stream No.13 (see flow sheet) and the circuit was run conventionally. After the ExT1 test had been completed, thickener product, at a certain flow rate, was added and the system was allowed to come to a steady state before commencing ExT2. After the completion of ExT2, the thickener feed to the dewatering screen was stopped and the system was allowed to come to the same steady state experienced during ExT1 (or as closely as possible). Then a different flow rate of thickener product was introduced and the system was yet again allowed to reach a new steady state. Test ExT3 was performed as test ExT2.

By using this new approach, four experiments, each made up of three tests, were completed. The advantages of this new approach was that the performance of each unit during the three tests should remain similar. Therefore the retention values obtained during ExT1 could be substituted into Equation 1 to calculate the retention values of material from thickener product during tests ExT2 and ExT3. The method proved successful (Appendix A

3.2 : Experimental Methods And Test Procedures

3.2.1 : Experimental methods

The pilot plant operated on a closed circuit with a constant feed being supplied to the dewatering screen. With the set-up of the pilot plant it was possible to apply the new techniques up to the primary dewatering process in a continuous fashion. Since there was only one dewatering screen available, mixing and secondary dewatering could only be carried out batchwise after the completion of the primary dewatering stage. The only equipment used after the completion of primary dewatering stage was the dewatering screen. Mixing was performed manually.

Efforts were made to ensure that the only variable during all the test work was the controlled parameter i.e. the uf/f ratio. The other parameters e.g. % particle size distribution in all streams, slurry flow rates (except thickener product), % solid in all streams (except screen discharge and equipment set-up was maintained as constant as possible. By doing so, one can compare the results obtained from the different tests.

Initially four tests (RUN 4, RUN 5, RUN 6 and RUN 7) were performed separately. Except for RUN 7, all the other three tests were performed using the new technique. RUN 7 was performed using the conventional method (no ultra fine addition) and its result serves as a comparison. However, one problem is apparent, namely the estimation of the % retention of the ultra fines material (- 150 um) from the thickener product. Consider the following equation :

Equation 1 :

$$F_{scn\ dis} * X_{scn\ dis} = F_{cyc\ uf} * X_{cyc\ uf} * R_{cyc\ uf,\ x} + F_{thk\ pd} * X_{thk\ pd} * R_{thk\ pd,\ x}$$

where F : solid flow rate of a particular stream (t/hr)

X : size fraction of size class X (in fraction) of the particular stream

R : fraction retention of size class X of the particular stream

Cyc uf : cyclone underflow

Thk pd : thickener product

TABLE 1

Calculation of Boundaries of % Retention Values of - 150 um Material of Thickener Product and Cyclone Underflow for Tests Employed by the New Method

Test I.D.	Thk Pd. Max (ret. cyc uf = 0 %)	Thk pd. Min (ret. cyc uf = 100 %)	Cyc uf. Max (ret thk pd = 0 %)	Cyc uf. Min (ret thk pd = 100 %)
E1T2	56.50	-3.804	93.69	-72.13
E1T3	86.62	-85.153	50.43	-7.791
E2T2	123.71	-42.742	74.32	14.243
E2T3	125.55	-66.845	65.26	13.279
E3T2	71.77	-58.269	55.19	-21.71
E3T3	157.11	-170.08	48.02	17.46
E4T2	55.25	-104.15	34.66	-28.07
E4T3	110.33	-106.25	50.94	4.77
RUN 4	121.48	-57.94	67.71	11.97
RUN 5	48.08	-3.02	95.00	-101.63
RUN 6	57.44	-7.01	89.13	-66.04

From the above table, it is obvious that the calculated boundaries are too wide to have any practical purposes in helping the estimation of the retention values. The values that are more than 100 % or less than 0 % should be ignored since the real values only lie in the region between 0 % and 100 %.

The following table lists the estimation of the retention of - 150 um material of thickener product using different retention values of - 150 um material of cyclone underflow.

steady state of ExT1 (or as closely as possible). Then a different flow rate of thickener product to dewatering screen was introduced and the system would reach a new steady state before test ExT3 commenced.

By using this new technique, four experiments each with three tests were completed. The advantages of this new approach allows the retention values of cyclone underflow material of test ExT1 to be applied to test ExT2 and ExT3.

Using equation one, one can at least calculate the boundaries of the retention values of cyclone underflow and thickener product by assuming one of them to be 0 % or 100 % and the calculated values are listed in the following table.

Consider the following equation :

$$F_{scn\ dis} * X_{scn\ dis,i} = F_{cyc\ uf} * X_{cyc\ uf,i} * R_{cyc\ uf,i} + F_{thk\ pd} * X_{thk\ pd,i} * R_{thk\ pd,i}$$

- equation (1)

where
- F = solid flow rate of the particular stream in t/hr
- X = size distribution of size class i in fraction
- R = the retention of size class i in particular stream in fraction

Scn dis = screen discharge
Cyc uf = cyclone underflow
Thk pd = thickenex product

It is clear from equation (1) that to estimate the retention of - 150 um material from the thickener product in the tests employing the new technique, one needs to know the retention of - 150 um material from the cyclone underflow for the same tests. However, it is not possible to determine this value in the pilot plant as there is only one screen underflow stream. The value is therefore estimated from tests carried out using the conventional system without ultra fines additions.

In the earlier stage of the pilot plant test work, four independent tests were performed, viz : RUN 4, RUN 5 and RUN 6 (new technique) ; RUN 7 (conventional method). However, applying the retention values of the cyclone underflow material of RUN 7 to equation 1 to estimate the retention of -150 um material of thickener product of RUN 4 to RUN 6 did not yield satisfactory results since the running conditions of RUN 7 were not as close to those of RUN 4 to 5 without thickener product addition.

Later, a different approach was made. Instead of running the tests independently, three tests were performed sequentially (one working day). The first test would be called ExT1 (e.g. experiment 1 test 1) and this would be a conventional run (i.e. no ultra fine addition). During this first test, all the thickener products would go to stream 10 (see Chapter Three, flow sheet description) and the circuit would run conventionally. After this first test had been completed, thickener product at a certain flow rate was added and the system was allowed to reach a new steady state before test ExT2 began. After the completion of test ExT2, the feed of the thickener product to the dewatering screen was stopped again and the system was brought back to the original

Appendix A : Method Of Estimating The Retention Of - 150 um Material Of Thickener Product For Tests Performed By The New Technique

REFERENCES

1 Horsfall, D.W., *lecture notes*, University of the Witwatersrand, 1990

2 Du Preez, I.S. "*Dewatering of Fine Coal*", Douglas Colliery Limited

3 Horsfall, D.W., " *An Investigation of a New Method of Disposal for the Fine Coal Obtained by Froth Flotation*", University of Leeds, 1957

4 Graton, L.C. and Frazer, N.J., 1937, "*Systematic Packings of Spheres with Particular Relation to Porosity and Permeability*", J. Geo., 43, 785-910

5 Heywood, H. " *The packing of Spheres*", J. Imperial College Chem. Eng. 1946

6 Harris, C.C. and H. G. Smith, "*The Moisture Retention Properties of Fine Coal ; A Study by Permeability and Suction Retention Methods*", 2nd Symposium on Coal Preparation, University of Leeds, 1957, Paper 3

due to the limiting factors mentioned in the previous paragraph, under the circumstances the advantage of mixing and secondary dewatering could not be demonstrated as in the laboratory scale tests.

In order to be able to add more ultra fines, a greater filtration zone is required. This should increase the ultra fine content in the product significantly, and as a result product moisture content should be less due to the reduction in the moisture holding ability of the coal particulate system. Tests should also be performed to establish the saturation point (hence the max. ultra fine addition rate) under the new conditions.

The available filtration zone could be increased by having a greater screen surface area. However, dewatering screens are dynamically balanced and subsequently detailed studies have to be performed before considering any alterations. It is certainly an aspect worthwhile considering since the sum of capital and operating costs for dewatering screen is 24 times less than that of the belt filter with the equivalent capacity (capacity : 50 t/hr, R0.26/t vs R6.39/t).

5.2 : The Benefit Of Mixing And Secondary Dewatering

Results from the laboratory scale test work clearly illustrated point 5.2. The absolute reduction in moisture of the primary dewatering product by mixing and secondary dewatering was between 3.5 % to 15 % depending on the conditions. The corresponding saturation point obtained happened to be at a uf/f ratio of 1.0 (50 % ultra fine : 50 % fine). Any further increase in the ultra fine content increased the specific surface areas of the mixture and consequently increased the water retention ability of the system.

However, as mentioned in 5.1, under pilot plant testing conditions, the final moisture attainable by the specific screen under the conventional operation conditions was already achieved during the double layer formation stage by the new method.

No loss of material was observed during secondary dewatering and the mixture conglomerated during the process into small round balls.

5.3 : Recommendations

The laboratory scale test work demonstrated that further reduction in moisture of the double layer was possible by mixing and secondary dewatering, provided that the forces applied are strong enough. Under the laboratory testing conditions, saturation was achieved with a mix of 50 % fines : 50 % ultra fines. At uf/f ratios below this saturation point, the product moisture would decrease with increasing ultra fine content.

However, due to the limiting factors experienced during the pilot plant tests, the highest achievable ultra fine addition rate was 0.7 t/hr which corresponds to a uf/f ratio of 0.1 to 0.15. In addition, the retention values achieved of the - 150 um fraction of the ultra fines was 63 % instead of almost 100.0 %. The result was that the increase in ultra fine content in the product is not high enough to yield a negative correlation between the two parameters (% H2O and % - 150 um content). Nevertheless a weak correlation was obtained from the pilot plant results between the % product moisture and the -150 um content in the product. The trend is there but not pronounced enough.

The vibratory forces experienced on the dewatering screen were strong enough to reduce the moisture level of the double layer to the lowest level attainable by the specific screen used under the circumstances. However,

CHAPTER FIVE : CONCLUSIONS

The two fundamental concepts underlining the new technique were tested both in the laboratory and in a pilot plant. Results obtained showed the potential of the new technique.

Tests under a wide range of uf/f ratios were conducted under laboratory conditions. However, it was not possible to test such a wide range under pilot plant conditions due to the limited filtration zone available for the ultra fine slurry. Nevertheless, from the promising results obtained from the pilot plant test work positive conclusions can be made.

5.1 : The Feasibility Of Using Fine Coal Cake As Filtration Medium For Ultra Fine Slurry

The two important concerns here are the retention of - 150 um material from the ultra fine slurry and the moisture level of the resultant double layer.

Excellent results were obtained from the laboratory scale test work. From the wide range of uf/f ratio tested, the loss of the - 150 um material from the ultra fine slurry was less than 5 % w.r.t. the solid mass of ultra fines and the lost particles were mainly - 45 um. The static conditions of the experimental set-up in the laboratory were thought to be responsible for this phenomenon. Natural drainage takes too long hence vacuum was used to increase the rate of filtration process. Excess water was removed through the filtration medium together with a small amount of - 45 um material from the slurry. The resultant double layer had a moisture content of between 20 % and 30 % depending on the testing conditions.

However, under pilot plant conditions, the highest ultra fine slurry addition rate was 0.7 t/hr (0.2 t/hr solid). Higher addition rates resulted in the loss of unfiltered ultra fines in the region where cake formation was not yet completed. A 0.7 t/hr addition rate corresponds to uf/f ratio of between 10 % to 15 %. At this addition rate, on average 63 % of the - 150 um material from the ultra fines can be recovered.
The material lost was with the excess water filtering through the cake.

The resultant double layer (screen discharge) had a moisture content similar to that of the normal screen discharge during conventional screening. In other words, the lowest moisture level was attained during the double layer formation stage.

4.3.2 : Moisture difference between primary and secondary dewatering stages

Data and analysis suggests that there was no significant difference between the moisture levels from primary dewatering and secondary dewatering products for the uf/f ranges tested.

This finding agrees with observations made during the tests. The moisture level of the double layer has already been reduced to levels attainable by the specific dewatering screen. Any further moisture reduction would probably require equipment with stronger forces than the dewatering screen.

4.3 : Conclusion

4.3.1 : The fine cake proves to be a reasonable filtration medium for the ultra fine slurry under the pilot plant conditions.

The resultant double layer has a moisture content of 25 % which is the normal moisture level obtained with conventional screens. The excess water from the slurry was easily filtered through the cake by the vibratory force of the screen. The limiting factor was the available filtration time.

With the pilot plant set-up, the highest attainable ultra fine slurry addition rate was 0.7 t/hr (0.2 t/hr solid) with a corresponding uf/f ratio, in %, 10 % to 15 %. The retention of the - 150 um material from the ultra fine was 63 %. The double layer (screen discharge) yield had a moisture content of 25.0 % which was the level normally obtained during the conventional runs. Ultra fine slurry addition rate beyond this point resulted in a loss of unfiltered ultra fines through the screen apertures at the 'non-cake ' forming region of the screen.

Simple calculation in 4.1.1 suggests that in a normal 1200 t/hr plant, six industrial size dewatering screens would handle all the ultra fines. The resultant product has a final moisture similar to that of the normal dewatering screen product. At this moisture level, further dewatering or handling costs are much lower and consequently more options become open. The relatively cheap capital and operating costs of dewatering screen make the new technique attractive.

4.2.1 : Product moisture level from primary dewatering stage (double layer formation stage)

The average moisture level of the double layer obtained from the tests employing the new technique was 24.8 % with a relative standard deviation of 0.75 %. With the conventional application, the same screen gives an average discharge moisture of 25.5 % with a relative standard deviation of 1.4 %. It appears that during the double layer formation stage, the product moisture level was already lower than that achieved during conventional screening.

Two-Sample statistical analysis was applied to compare the mean moisture levels between the two sets of data. However, the result (see Appendix F) suggests that there was no significant difference between the two sets of data.

From the result it can be stated that the fine cake does act as a good filtration medium for the ultra fine slurry in terms of excess water removal. The resultant double layer moisture was at least not higher than the conventional dewatering screen product.

Laboratory scale test results suggested that before the saturation point was reached, the % moisture level should decrease with increasing ultra fine content. The saturation point was obtained, under the special experimental conditions, with 50 % fines and 50 % ultra fines. Also under laboratory conditions there was almost no - 150 um material lost during the double layer formation stage. However, the ultra fine addition rates in the pilot plant tests were greatly restricted by the available filtration time. The highest uf/f ratio attainable in the pilot plant, without losing unfiltered ultra fines to the 'non-cake' region of the screen, was between 0.1 to 0.15 (or 10 % to 15 %). As was mentioned previously this low addition rate does not allow the % - 150 um material in the double layer to increase significantly. Therefore at this stage only a weak correlation between the % moisture level of screen discharge and the % - 150 um material present was obtained (Appendix F).

4.2.2 : Product moisture level from secondary dewatering stage

From table 4-2-A, it seems that there is no significant difference between the moisture levels of the primary and secondary dewatering products. Two-Sample statistical analysis was again performed, the result (Appendix F) confirming that there was no significant differences between the two sets of data.

Table 4-2-A

Product Moisture Results

test I.D.	uf/f ratio in %	% - 150 um mat. in prod.	% H2O primary dewatering	% H2O secondary dewatering
E1T1	0.0	8.5	24.2	N.A.
E2T1	0.0	9.0	24.3	N.A.
E3T1	0.0	6.6	25.5	N.A.
E4T1	0.0	5.1	25.8	N.A.
RUN7	0.0	4.7	27.7	N.A.
E1T2	42.0	11.4	24.0	24.8
E1T3	16.2	9.1	24.8	24.8
E2T2	15.3	12.3	24.6	24.2
E2T3	14.6	8.7	25.2	25.3
E3T2	24.2	11.7	24.2	23.7
E3T3	10.9	8.4	25.1	24.9
E4T2	23.3	9.1	24.4	24.2
E4T3	13.9	7.9	25.6	25.4
RUN4	10.7	9.2	25.9	24.7
RUN5	29.6	8.4	23.5	24.3
RUN6	19.1	6.2	25.6	25.3

	average % H2O primary dewatering	average % H2O secondary dewatering
conventional	25.5 +- 1.4 %	N.A.
new technique	24.8 +- 0.75 %	24.7 +- 0.54 %

N.B. the first 6 rows are from tests employing conventional method
N.A. All standard deviations are reported as relative %

Exp. 1 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	30.8	30.8	30.7	30.7
- 45 - 53	2	2.3	33.1	2.3	33.0
+ 53 - 63	3	1.8	35.0	2.3	35.4
- 63 75	4	4.1	39.1	4.2	39.6
+ 75 - 106	5	6.9	46.0	6.9	46.5
+ 106 - 150	6	9.3	55.3	9.3	55.8
+ 150 - 212	7	11.8	67.0	11.5	67.3
+ 212 - 300	8	11.9	78.9	11.9	79.3
+ 300 - 425	9	12.7	91.6	12.4	91.6
+ 425 - 500	10	4.1	95.7	4.1	95.7
+ 500 - 600	11	2.7	98.5	2.6	98.4
+ 600 - 850	12	1.5	100.0	1.4	99.8
+ 850 - 1180	13	0.0	100.0	0.1	99.9
+ 1180	14	0.0	100.0	0.1	100.0
total		100.0		100.0	

Exp. 1 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis.A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	3.4	3.4	3.1	3.1	3.0	3.0
+ 45 - 53	2	0.2	3.6	0.3	3.4	0.2	3.3
+ 53 - 63	3	0.2	3.8	0.3	3.7	0.2	3.5
+ 63 - 75	4	0.5	4.3	0.7	4.4	0.3	3.8
+ 75 - 106	5	1.4	5.7	1.4	5.7	1.0	4.8
+ 106 - 150	6	2.8	8.4	2.8	8.5	2.2	7.1
+ 150 - 212	7	5.1	13.5	5.2	13.7	4.6	11.7
+ 212 - 300	8	7.9	21.4	7.9	21.7	7.6	19.3
+ 300 - 425	9	14.6	36.0	14.7	36.4	14.4	33.7
+ 425 - 500	10	9.6	45.7	9.7	46.1	9.9	43.5
+ 500 - 600	11	13.2	58.9	13.0	59.1	13.8	57.4
+ 600 - 850	12	26.2	85.1	25.7	84.8	27.3	84.6
+ 850 - 1180	13	10.7	95.8	10.7	95.5	11.1	95.7
+ 1180	14	4.2	100.0	4.5	100.0	4.3	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Appendix D : Detailed Data For Each Pilot Plant Test

coefficient of analyses = 0.994 therefore, this is a good fit.

6 : Flocculant Dosing System

Flocculant used : ANIKEM 4816 (same as Goodehoop colliery where the coal used for testing came from).

set-up : supply buckets and small pump.

The following table lists the setting of the dosing system.

flocculant concentration : 25 %
vol used for each test : 500 ml

pump setting	time (seconds)	l/hr
10	40.69	44.24
10	40.86	44.05
10	40.83	44.09
9	44.51	40.44
9	44.80	40.18
8	49.79	36.15
8	49.20	36.59
7	59.27	30.37
7	59.51	30.25
9.5	42.35	42.50
9.5	42.81	42.05
8.5	46.43	38.77
8.5	46.24	38.93
7.5	53.46	33.67
7.5	53.96	33.36
6.5	62.53	28.79
6.5	62.43	28.83

If one plots the l/hr (flow rate) vs pump setting, one will discover that it is a straight line. Least Square Analyses were performed on the data to obtain the following equation for setting of the pump :

$$l/hr = -0.154 + setting * 4.47$$

was performed the next day. After that the coal was spread on top of a tough plastic sheet to the thickness of less than 1 cm. The sample was air-dried for two to five days (depending on the % solid level). When the sample was non-sticky and free when touched with paper, the weight was again taken. The free moisture is calculated by the following formula :

% free H2O = 100 * mass of H2O removed / wet mass

The air-dried sample was then ready for sample preparation.

Decanting was not necessary for the dewatering screen product due to the lower moisture content. Air-drying procedure could be commenced immediately after sample collection.

4 : Particle Size Distribution Determination

A sample size of +- 50.0 g was weighed and wet screened using the screens in the following order : 45um, 63 um, 75 um and 106 um. When one obtained a clear flow of water (test by white paper) free from any coal one could then commence the screening of the next larger size.

The + 106 um fraction was dried and then vibrated for 20 minutes through screens of the following sizes : 150um, 212um, 300um, 425um, 500um, 600um, 850um and 1180um. The dried mass of each size class was measured. The % particle size distribution was calculated as follows :

% of class X = 100 * mass of class X / original sample mass

Duplicate tests were performed.

5 : Ash Level Determination

Same as the method described in ISO1171.
Duplicate tests were performed.

1 : Special Devices For Flow Rate Control / Sampling / Thickener Product Addition

- Flow rate control by means of a simple mechanical device

This is basically a split box which allows the incoming stream to be divided in such a way as to give a controlled feed flow rate. The inlet stream pipe is flexible and is fitted with a round hoop which allows the pipe to be positioned over the splitter to give the desired feed flow rate. The pipe is then held in position by means of a nut and bolt.

- Thickener product addition pan

The width of the pan was the same as that of the dewatering screen . The length of the pan was about the length of four panels of the screen. The height was about 6 cm. The pan was hung above the dewatering screen so that the thickener product could be added gently in a counter-current fashion to the cake of cyclone underflow.

- Special set-ups for sampling/flow rate measurement

(1) : by-pass of cyclone overflow

The by-pass consisted of a T-junction with a valve on each inlet leg which allowed control of the direction of flow of the material.

(2) : valve underneath the dewatering screen

This valve was only opened when taking samples or flow rate measurements. After opening the valve, the material was allowed to flow for 5 seconds before commencing the required task.

2 : Sample Preparation Procedures

After the sample was air-dried and the free moisture level determined, gentle rolling with a wooden rolling pin was performed to ensure that there were no lumps of material present.

The sample was then blended and mixed thoroughly by hand. Riffling was then performed until a sample weighing between 30g and 50 g was obtained.

3 : Free Moisture Determination Procedure

The slurry samples collected from the pilot plant test were weighed and allowed to settle overnight. Decanting

APPENDIX C : Operation And Control Of The Pilot Plant

It is a well known fact that due to the inevitable occurrences of experimental errors, when one performs mass balance over each unit, the total inlet mass flow is seldom equal to the total outlet mass flow. A software programme called MICROSIM developed by Mr. W. Stange of the Metallurgy Department solves this problem for the user, provided that the user has a good idea of the magnitude of errors of each measurement.

The following data with its relative standard deviation or estimated experimental errors are entered in each data smoothing sessions of MICROSIM for each test :

- the flow sheet description
- the mass flow rate of at least one stream (the writer entered all streams measured)
- the particle size distribution of at least one stream (the writer entered all streams)
- the % ash of at least one stream (the writer entered all streams)
- the % moisture level of at least one stream (the writer entered all streams)

It was found that the relative std. deviation of each measurement/analysis performed was a very good estimation of the experimental error since the iteration calculation converged very quickly with those values as experimental errors. Any error values larger than those would not enable the iteration calculation to converge. The smoothed results are very similar to those of the raw data (Appendix D ; detailed data of each pilot plant data) and this confirms that the sampling and flow rate measurement scheme is a reasonably accurate one.

APPENDIX B : Method Of Data Smoothing Of Pilot Plant Test Data

testing the feasibilities of the new technique.

TABLE 2

Estimation of the % Retention of - 150 um Material of Thickener Product by Different Estimation of % Retention Values of - 150um Material of Cyclone Underflow

Test I.D.	using ret. of corresponding ExT1's	using 14.1 % (lowest found in five conventional tests)	using 39 % (highest found in five conventional tests)
E1T2	40.0	50.0	33.0
E1T3	39.2	62.4	19.6
E2T2	64.1	100.2	58.8
E2T3	56.7	98.4	50.2
E3T2	27.7	53.4	21.0
E3T3	46.2	111.0	29.5
E4T2	32.8	32.8	-6.9
E4T3	80.0	79.8	25.9
RUN 4	N.A.	96.2	51.5
RUN 5	N.A.	40.9	28.2
RUN 6	N.A.	48.4	32.3

From the above table, it is obvious that using the retention result of cyclone underflow of the corresponding EXT1 tests gives the most reasonable result in terms of trends and observations from the experiments (based on the on-site observations, one knows that the following tests will yield good retention of thickener product : E2T2, E2T3, E3T3, E4T3 and RUN 4). As for RUN 4 to RUN 6, one uses the average of the retention values of - 150 um material of cyclone underflow of the five tests performed with conventional methods.

Attempts had been made to use the result obtained by the five conventional tests to form a model, thereby using the model to predict the retention values of - 150 um material of cyclone underflow of all the new tests. However, the data gathered is not enough to yield a model which gives accurate predictions.

It was therefore decided to calculate the retention values for - 150 um material only, not for every size class due to the complexity involved and the additional results would serve little practical purpose in terms of

Exp. 3 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	17.3	17.3	17.3	17.3
- 45 - 53	2	1.9	19.2	1.9	19.2
+ 53 - 63	3	1.5	20.7	1.5	20.7
+ 63 - 75	4	3.2	23.9	3.3	24.0
+ 75 - 106	5	5.8	29.7	5.7	29.8
+ 106 - 150	6	9.5	39.2	9.4	39.2
+ 150 - 212	7	15.2	54.4	15.0	54.2
+ 212 - 300	8	16.8	71.2	-6.6	70.9
+ 300 - 425	9	17.9	89.1	17.7	88.6
+ 425 - 500	10	5.5	94.6	5.5	94.1
+ 500 - 600	11	3.5	98.1	3.6	97.7
+ 600 - 850	12	1.9	100.0	2.1	99.8
+ 850 - 1180	13	0.0	100.0	0.2	99.9
+ 1180	14	0.0	100.0	0.1	100.0
total		100.0		100.0	

Exp. 3 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	1.7	1.7	1.8	1.8	1.5	1.5
+ 45 - 53	2	0.2	1.9	0.2	2.1	0.0	1.5
+ 53 - 63	3	0.2	2.0	0.2	2.3	0.2	1.6
+ 63 - 75	4	0.3	2.4	0.5	2.8	0.2	1.8
+ 75 - 106	5	1.1	3.5	1.1	3.9	0.8	2.6
+ 106 - 150	6	2.8	6.3	2.6	6.6	2.3	4.9
+ 150 - 212	7	6.2	12.4	5.9	12.4	5.2	10.1
+ 212 - 300	8	9.9	22.3	9.6	22.0	8.8	19.0
+ 300 - 425	9	17.7	40.0	17.4	39.4	16.8	35.8
+ 425 - 500	10	10.5	50.5	10.4	49.7	10.3	46.1
+ 500 - 600	11	12.8	63.3	12.8	62.6	13.2	59.3
+ 600 - 850	12	24.0	87.3	24.3	86.9	25.8	85.1
+ 850 - 1180	13	9.2	96.5	9.4	96.4	10.8	95.9
+ 1180	14	3.5	100.0	3.6	100.0	4.1	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 2 : Test 1

General running conditions (data as is and smoothed data)

	cyclone underflow	screen discharge	screen underflow
solid t/hr	1.590	1.020	0.410
Solid t/hr smoothed	1.590	1.180	0.410
slurry t/hr smoothed	3.240	1.558	1.681
% H2O surface	50.42	24.36	75.91
% H2O surface smoothed	50.92	24.28	75.61
% ash	19.33	18.52	23.02
% ash smoothed	19.56	18.39	22.93

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash screen inlet t/hr	ash screen outlets t/hr
1.590	1.590	1.650	1.650	0.311	0.311

Exp. 2 : Test 1

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	8.0	0.128	8	0.128
+ 45 - 53	2	0.9	0.0143	0.9	0.0143
+ 53 - 63	3	0.9	0.0147	0.9	0.0147
+ 63 - 75	4	1.6	0.0248	1.6	0.0248
+ 75 - 105	5	2.8	0.0442	2.8	0.0442
+ 105 - 150	6	4.5	0.0723	4.5	0.0723
+ 150 - 212	7	7.4	0.118	7.4	0.0118
+ 212 - 300	8	9.9	0.158	9.9	0.158
+ 300 - 425	9	15.3	0.244	15.3	0.244
+ 425 - 500	10	8.6	0.137	8.6	0.137
+ 500 - 600	11	10.1	0.161	10.1	0.161
+ 600 - 850	12	18.9	0.300	18.9	0.3
+ 850 - 1180	13	7.8	0.124	7.8	0.124
+ 1180	14	3.2	0.0508	3.2	0.0508

Exp. 2 : Test 1

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	30.5	30.5	28.7	28.7
- 45 - 53	2	1.4	28.4	31.2	29.0
+ 53 - 63	3	1.4	26.6	32.8	29.3
+ 63 - 75	4	22.0	26.1	35.4	30.1
+ 75 - 105	5	4.3	27.6	40.0	32.1
+ 105 - 150	6	44.0	31.6	47.3	35.8
+ 150 - 212	7	54.4	38.1	56.8	41.7
+ 212 - 30	8	63.3	45.1	64.8	48.0
+ 300 - 425	9	74.1	54.0	74.5	56.0
+ 425 - 500	10	84.2	58.5	84.0	60.0
+ 500 - 600	11	91.4	63.5	90.7	64.4
+ 600 - 850	12	97.3	70.9	97.1	71.4
+ 850 - 1180	13	98.7	73.3	97.7	73.5
+ 1180	14	98.4	74.1	96.6	74.2
total		74.1		74.2	

Exp. 2 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	8.4	8.4	8.0	8.0
- 45 - 53	2	0.6	9.0	0.9	8.9
+ 53 - 63	3	0.6	9.6	0.9	9.8
- 63 - 75	4	1.3	10.9	1.6	11.4
+ 75 - 106	5	2.6	13.5	2.8	14.2
+ 106 - 150	6	4.3	17.8	4.5	18.7
+ 150 - 212	7	7.1	24.9	7.4	26.1
+ 212 - 300	8	9.6	34.6	9.9	36.0
+ 300 - 425	9	15.3	49.8	15.3	51.4
+ 425 - 500	10	8.7	58.5	8.6	60.0
+ 500 - 600	11	10.5	69.0	10.1	70.1
+ 600 - 850	12	19.5	88.4	18.9	89.0
+ 850 - 1180	13	8.2	96.6	7.8	96.8
+ 1180	14	3.4	100.0	3.2	100.0
total		100.0		100.0	

Exp. 2 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	22.4	22.4	22.2	22.2
- 45 - 53	2	2.4	24.9	2.4	24.6
+ 53 - 63	3	2.4	27.3	2.4	27.0
- 63 - 75	4	3.9	31.2	3.9	30.9
+ 75 - 106	5	6.5	37.8	6.5	37.4
+ 106 - 150	6	9.4	47.1	9.3	46.6
+ 150 - 212	7	12.4	59.6	12.4	59.0
+ 212 - 300	8	13.7	73.3	13.5	72.6
+ 300 - 425	9	15.3	88.6	15.2	87.7
+ 425 - 500	10	5.3	93.9	5.3	93.1
+ 500 - 600	11	3.5	97.3	3.6	96.7
+ 600 - 850	12	2.0	99.4	2.1	98.9
+ 850 - 1180	13	0.4	99.8	0.7	99.6
+ 1180	14	0.2	100.0	0.4	100.0
total		100.0		100.0	

Exp. 2 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	2.8	2.8	3.1	3.1	2.5	2.5
+ 45 - 53	2	0.1	3.0	0.4	3.5	0.2	2.7
+ 53 - 63	3	0.3	3.3	0.4	3.9	0.0	2.7
+ 63 - 75	4	0.6	3.8	0.7	4.6	0.4	3.0
+ 75 - 106	5	1.5	5.3	1.5	6.1	1.1	4.1
+ 106 - 150	6	3.0	8.3	2.9	9.0	2.5	6.6
+ 150 - 212	7	5.9	14.2	5.7	14.7	5.3	11.9
+ 212 - 300	8	9.0	23.2	8.6	23.3	8.5	20.4
+ 300 - 425	9	15.8	39.1	15.4	38.7	15.8	36.2
+ 425 - 500	10	9.8	48.8	9.7	48.5	10.1	46.3
+ 500 - 600	11	12.3	61.1	12.4	60.9	13.3	59.6
+ 600 - 850	12	25.0	86.1	24.7	85.6	25.7	85.3
+ 850 - 1180	13	10.1	96.2	10.3	95.8	10.6	95.9
+ 1180	14	3.8	100.0	4.2	100.0	4.1	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 1 : Test 1

General running conditions (data as is and smoothed data)

	cyclone underflow	screen discharge	screen underflow
solid t/hr	1.750	0.880	0.500
solid t/hr smoothed	1.728	1.233	0.495
slurry t/hr smoothed	3.630	1.627	2.003
% H2O surface	51.63	24.35	75.78
% H2O surface smoothed	52.40	24.23	75.29
% ash	19.40	21.10	21.50
% ash smoothed	19.54	18.79	21.41

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash screen inlet t/hr	ash screen outlets t/hr
1.728	1.728	1.902	1.902	0.338	0.338

Exp. 1 : Test 1

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	11.0	0.19	11.0	0.19
- 45 - 53	2	0.9	0.015	0.9	0.015
+ 53 - 63	3	0.9	0.0155	0.9	0.0155
+ 63 - 75	4	1.7	0.0293	1.7	0.0293
+ 75 - 105	5	3.0	0.0513	3.0	0.0513
+ 105 - 150	6	4.7	0.0805	4.7	0.0805
+ 150 - 212	7	7.0	0.121	7.0	0.121
+ 212 - 300	8	9.1	0.157	9.1	0.157
+ 300 - 425	9	14.1	0.243	14.1	0.243
+ 425 - 500	10	8.1	0.139	8.1	0.139
+ 500 - 600	11	10.1	0.174	10.1	0.174
+ 600 - 850	12	18.7	0.324	18.7	0.324
+ 850 - 1180	13	7.7	0.132	7.7	0.132
+ 1180	14	3.2	0.0561	3.2	0.0561

Exp. 1 : Test 1

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	16.5	16.5	20.0	20.0
+ 45 - 53	2	22.5	16.9	33.0	20.3
+ 53 - 63	3	29.1	17.7	25.0	20.6
+ 63 - 75	4	20.3	17.9	28.4	21.5
+ 75 - 105	5	33.5	20.7	33.4	23.5
+ 105 - 150	6	42.7	25.5	42.8	27.6
+ 150 - 212	7	53.2	32.5	52.9	33.7
+ 212 - 300	8	62.9	39.9	62.4	40.5
+ 300 - 425	9	74.6	49.5	74.8	49.8
+ 425 - 500	10	85.5	54.4	85.4	54.5
+ 500 - 600	11	92.0	59.6	92.5	59.9
+ 600 - 850	12	97.6	67.6	97.9	67.9
+ 850 - 1180	13	100.0	70.2	99.7	70.4
+ 1180	14	100.0	71.3	98.7	71.4
total		71.3		71.4	

Exp. 1 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	10.6	10.6	11.0	11.0
- 45 - 53	2	0.8	11.4	0.9	11.9
+ 53 - 63	3	0.7	12.2	0.9	12.8
- 63 - 75	4	1.5	13.7	1.7	14.4
+ 75 - 106	5	3.0	16.6	3.0	17.4
+ 106 - 150	6	4.7	21.3	4.7	22.1
+ 150 - 212	7	7.2	28.5	7.0	29.1
+ 212 - 300	8	9.2	37.7	9.1	38.2
+ 300 - 425	9	14.3	52.0	14.1	52.2
+ 425 - 500	10	8.2	60.2	8.1	60.3
+ 500 - 600	11	9.9	70.0	10.1	70.4
+ 600 - 850	12	18.5	88.6	18.7	89.1
+ 850 - 1180	13	7.7	96.3	7.7	96.8
+ 1180	14	3.7	100.0	3.2	100.0
total		100.0		100.0	

Run 7

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	11.5	11.5	11.3	11.3
+ 45 - 53	2	1 2	12.7	1.3	12.6
+ 53 - 63	3	1.2	13.8	1.3	14.0
+ 63 - 75	4	1.9	15.7	2.0	16.0
+ 75 - 106	5	4.6	20.3	4.6	20.6
+ 106 - 150	6	7.5	27.9	7.5	28.1
+ 150 - 212	7	12.6	40.5	12.4	40.5
+ 212 - 300	8	16.8	57.2	16.6	57.1
+ 300 - 425	9	22.6	79.9	22.2	79.3
+ 425 - 500	10	8.8	88.7	8.8	88.1
+ 500 - 600	11	6.5	95.2	6.5	94.7
+ 600 - 850	12	4.2	99.4	4.4	99.0
+ 850 - 1180	13	0.4	99.8	0.7	99.7
+ 1180	14	0.2	100.0	0.3	100.0
total		100.0		100.0	

Run 7

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis frac %	screen dis cum %	screen dis frac % smooth	screen dis cum % smooth
- 45	1	1.9	1.9	1.6	1.6
+ 45 - 53	2	0.0	1.9	0.2	1.8
+ 53 - 63	3	0.0	1.9	0.2	2.0
+ 63 - 75	4	0.3	2.2	0.3	2.4
+ 75 - 106	5	0.6	2.8	0.8	3.1
+ 106 - 150	6	1.5	4.3	1.5	4.7
+ 150 - 212	7	3.9	8.2	3.7	8.4
+ 212 - 300	8	7.3	15.5	7.0	15.4
+ 300 - 425	9	15.8	31.3	15.3	30.7
+ 425 - 500	10	10.7	42.0	10.6	41.4
+ 500 - 600	11	14.2	56.2	14.2	55.6
+ 600 - 850	12	28.5	84.7	28.9	84.5
+ 850 - 1180	13	10.8	95.5	11.1	95.5
+ 1180	14	4.5	100.0	4.5	100.0
total		100.0		100.0	

Exp. 4 : Test 1

General running conditions (data as is and smoothed data)

	cyclone underflow	screen discharge	screen underflow
solid t/hr	2.050	1.000	0.700
solid t/hr smoothed	1.830	1.127	0.703
slurry t/hr smoothed	5.507	1.518	3.990
% H2O surface	66.39	25.79	82.61
% H2O surface smoothed	66.77	25.76	82.38
% ash	17.76	16.21	19.80
% ash smoothed	17.68	16.34	19.83

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash screen inlet t/hr	ash screen outlets t/hr
1.830	1.830	3.677	3.678	0.324	0.324

Exp. 4 : Test 1

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	11.4	0.209	11.4	0.209
+ 45 - 53	2	1.0	0.0183	1.0	0.0183
+ 53 - 63	3	1.1	0.0202	1.1	0.0202
+ 63 - 75	4	1.4	0.0253	1.4	0.0253
+ 75 - 105	5	2.8	0.0504	2.8	0.0504
+ 105 - 150	6	4.6	0.0837	4.6	0.0837
+ 150 - 212	7	7.6	0.138	7.6	0.138
+ 212 - 300	8	10.3	0.188	10.3	0.188
+ 300 - 425	9	16.0	0.293	16.0	0.293
+ 425 - 500	10	8.4	0.154	8.4	0.154
+ 500 - 600	11	10.0	0.182	10.0	0.182
+ 600 - 850	12	17.3	0.316	17.3	0.316
+ 850 - 1180	13	6.3	0.116	6.3	0.116
+ 1180	14	1.9	0.0357	1.9	0.0357

Exp. 4 : Test 1

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	20.4	20.4	8.1	8.1
+ 45 - 53	2	21.2	20.5	11.0	8.3
+ 53 - 63	3	38.7	21.8	13.1	8.7
+ 63 - 75	4	29.9	22.6	15.9	9.4
+ 75 - 105	5	24.4	22.9	20.3	11.1
+ 105 - 150	6	36.6	25.7	25.9	14.1
+ 150 - 212	7	44.1	30.4	36.5	19.8
+ 212 - 300	8	56.3	37.1	50.2	27.6
+ 300 - 425	9	69.3	46.4	65.2	38.3
+ 425 - 500	10	81.8	51.0	79.3	43.7
+ 500 - 600	11	87.9	55.8	86.7	49.4
+ 600 - 850	12	95.9	63.1	96.1	58.2
+ 850 - 1180	13	98.6	65.3	98.9	60.8
+ 1180	14	100.0	65.9	99.6	61.6
total		65.9		61.6	

Exp. 4 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	11.7	11.7	11.4	11.4
+ 45 - 53	2	1.0	12.7	1.0	12.4
+ 53 - 63	3	1.0	13.7	1.1	13.5
- 63 - 75	4	1.5	15.1	1.4	14.9
+ 75 - 106	5	2.6	17.7	2.8	17.7
+ 106 - 150	6	4.7	22.4	4.6	22.3
+ 150 - 212	7	7.6	30.1	7.6	29.8
+ 212 - 300	8	10.6	40.7	10.3	40.1
+ 300 - 425	9	16.4	57.1	16.0	56.1
+ 425 - 500	10	8.5	65.5	8.4	64.5
+ 500 - 600	11	9.9	75.4	10.0	74.4
+ 600 - 850	12	16.7	92.2	17.3	91.7
+ 850 - 1180	13	6.0	98.2	6.3	98.1
+ 1180	14	1.8	100.0	1.9	100.0
total		100.0		100.0	

Exp. 4 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	27.3	27.3	27.4	27.4
+ 45 - 53	2	2.0	29.6	2.3	29.7
+ 53 - 63	3	1.8	31.3	2.5	32.2
+ 63 - 75	4	3.0	34.3	3.0	35.2
+ 75 - 106	5	5.8	40.1	5.7	40.9
+ 106 - 150	6	8.8	48.9	8.8	49.8
+ 150 - 212	7	12.5	61.4	12.5	62.3
+ 212 - 300	8	13.5	74.9	13.3	75.6
+ 300 - 425	9	14.8	89.7	14.5	90.1
+ 425 - 500	10	4.5	94.2	4.5	94.6
+ 500 - 600	11	3.5	97.7	3.5	98.1
+ 600 - 850	12	2.0	99.7	1.7	99.8
+ 850 - 1180	13	0.3	100.0	0.2	100.0
+ 1180	14	0.0	100.0	0.0	100.0
total		100.0		100.0	

Exp. 4 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	1.4	1.4	1.5	1.5	1.5	1.5
+ 45 - 53	2	0.0	1.4	0.2	1.7	0.1	1.6
+ 53 - 63	3	0.1	1.5	0.2	1.9	0.1	1.8
+ 63 - 75	4	0.3	1.8	0.4	2.3	0.3	2.0
+ 75 - 106	5	0.8	2.6	0.9	3.2	1.0	3.0
+ 106 - 150	6	1.9	4.5	1.9	5.1	2.3	5.3
+ 150 - 212	7	4.5	9.0	4.5	9.6	4.9	10.2
+ 212 - 300	8	8.2	17.2	8.4	17.9	8.6	18.8
+ 300 - 425	9	16.8	34.1	17.0	34.9	16.9	35.7
+ 425 - 500	10	10.8	44.9	10.8	45.7	10.8	46.5
+ 500 - 600	11	14.1	59.0	14.0	59.7	14.0	60.5
+ 600 - 850	12	27.4	86.3	27.0	86.7	26.3	86.8
+ 850 - 1180	13	10.4	96.7	10.1	96.8	10.0	96.7
+ 1180	14	3.3	100.0	3.2	100.0	3.3	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 3 : Test 1

General running conditions (data as is and smoothed data)

	cyclone underflow	screen discharge	screen underflow
solid t/hr	1.630	1.130	0.400
solid t/hr smoothed	1.627	1.227	0.400
slurry t/hr smoothed	3.572	1.647	1.925
% H2O surface	53.74	25.62	79.61
% H2O surface smoothed	54.45	25.50	79.22
% ash	18.23	17.08	22.31
% ash smoothed	18.36	17.08	22.30

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash screen inlet t/hr	ash screen outlets t/hr
1.627	1.627	1.945	1.945	0.299	0.299

Exp. 3 : Test 1

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	5.6	0.0914	5.6	0.0914
+ 45 - 53	2	0.7	0.0106	0.7	0.0106
+ 53 - 63	3	0.5	0.00875	0.5	0.00875
+ 63 - 75	4	1.2	0.0197	1.2	0.0197
+ 75 - 105	5	2.3	0.0367	2.3	0.0367
+ 105 - 150	6	4.3	0.0700	4.3	0.07
+ 150 - 212	7	8.1	0.132	8.1	0.132
+ 212 - 300	8	11.3	0.184	11.3	0.184
+ 300 - 425	9	17.5	0.284	17.5	0.284
+ 425 - 500	10	9.2	0.149	9.2	0.149
+ 500 - 600	11	10.6	0.172	10.6	0.172
+ 600 - 850	12	18.9	0.307	18.9	0.307
+ 850 - 1180	13	7.2	0.117	7.2	0.117
+ 1180	14	2.8	0.0450	2.8	0.045

Exp. 3 : Test 1

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	26.9	26.9	24.5	24.5
+ 45 - 53	2	4.7	25.2	27.2	24.8
+ 53 - 63	3	6.4	24.1	29.9	25.2
+ 63 - 75	4	18.3	23.3	33.1	26.4
+ 75 - 105	5	30.3	24.8	37.4	28.8
+ 105 - 150	6	42.5	30.0	46.2	33.9
+ 150 - 212	7	51.9	37.9	54.6	41.3
+ 212 - 300	8	62.4	46.2	63.8	48.8
+ 300 - 425	9	74.6	56.0	75.0	57.7
+ 425 - 500	10	85.2	60.5	85.3	61.8
+ 500 - 600	11	92.0	65.4	91.7	66.3
+ 600 - 850	12	97.7	72.5	97.3	72.8
+ 850 - 1180	13	100.0	74.7	99.5	74.7
+ 1180	14	100.0	75.4	99.2	75.4
total		75.4		75.4	

Exp. 3 : Test 1

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	5.8	5.8	5.6	5.6
- 45 - 53	2	0.5	6.3	0.7	6.3
+ 53 - 63	3	0.4	6.7	0.5	6.8
- 63 - 75	4	1.0	7.7	1.2	8.0
+ 75 - 106	5	2.0	9.7	2.3	10.3
+ 106 - 150	6	4.1	13.8	4.3	14.6
+150 - 212	7	7.8	21.6	8.1	22.7
+ 212 - 300	8	11.0	32.6	11.3	34.0
+ 300 - 425	9	17.3	49.9	17.5	51.5
+ 425 - 500	10	9.1	59.9	9.2	60.6
+ 500 - 600	11	10.8	69.8	10.6	71.2
+ 600 - 850	12	19.7	89.5	18.9	90.1
+ 850 - 1180	13	7.6	97.1	7.2	97.2
+ 1180	14	2.9	100.0	2.8	100.0
total		100.0		100.0	

Exp. 1 : Test 2

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr smoothed	1.518	1.547	0.609	0.637
slurry t/hr smoothed	3.667	2.035	3.096	1.462
% H2O surface	59.79	23.79	79.54	56.89
% H2O surface smoothed	58.60	23.98	80.33	56.44
% ash	20.40	18.10	22.32	13.50
% ash smoothed	21.03	17.59	22.02	13.62

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
2.155	2.156	2.974	2.975	0.406	0.406

Exp. 1 : Test 2

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	11.2	0.242	11.2	0.242
+ 45 - 53	2	1.0	0.0226	1.1	0.0226
+ 53 - 63	3	1.1	0.0230	1.1	0.0230
+ 63 - 75	4	1.8	0.0395	1.8	0.0395
+ 75 - 105	5	3.3	0.0708	3.3	0.0709
+ 105 - 150	6	4.8	0.103	4.8	0.0103
+ 150 - 212	7	7.3	0.157	7.3	0.157
+ 212 - 300	8	9.2	0.197	9.2	0.198
+ 300 - 425	9	13.8	0.298	13.8	0.298
+ 425 - 500	10	8.3	0.179	8.3	0.179
+ 500 - 600	11	10.1	0.218	10.1	0.218
+ 600 - 850	12	18.1	0.391	18.1	0.391
+ 850 - 1180	13	7.4	0.158	7.4	0.159
+ 1180	14	2.6	0.0563	2.6	0.0563

Exp. 1 : Test 2

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	26.1	26.1	27.5	27.5
+ 45 - 53	2	39.7	27.4	31.3	27.8
+ 53 - 63	3	27.5	27.4	32.8	28.2
+ 63 - 75	4	40.3	29.0	36.9	29.2
+ 75 - 105	5	47.4	32.5	42.4	31.6
+ 105 - 150	6	51.4	36.5	48.7	35.1
+ 150 - 212	7	59.6	42.1	57.0	40.3
+ 212 - 300	8	66.3	47.8	64.4	45.9
+ 300 - 425	9	74.3	54.6	73.1	52.9
+ 425 - 500	10	84.0	58.6	83.1	56.9
+ 500 - 600	11	90.0	62.9	90.0	61.6
+ 600 - 850	12	96.2	69.4	96.8	68.7
+ 850 - 1180	13	99.1	71.5	99.9	71.0
+ 1180	14	97.3	72.1	99.9	71.8
total		74.5		99.9	

Exp. 1 ; Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	23.9	23.9	24.0	24.0
+ 45 - 53	2	2.7	26.7	2.6	26.7
+ 53 - 63	3	2.2	28.9	2.1	28.8
+ 63 - 75	4	3.9	32.8	3.8	32.6
+ 75 - 106	5	7.4	40.2	7.3	39.8
+ 106 - 150	6	9.2	49.4	9.1	49.0
+ 150 - 212	7	12.3	61.7	12.1	61.1
+ 212 - 300	8	11.6	73.3	11.6	72.7
+ 300 - 425	9	12.1	85.5	12.1	84.8
+ 425 - 500	10	4.6	90.1	4.5	89.2
+ 500 - 600	11	3.9	94.0	3.9	93.1
+ 600 - 850	12	4.6	98.6	4.9	98.0
+ 850 - 1180	13	1.0	99.7	1.5	99.5
+ 1180	14	0.3	100.0	0.5	100.0
total		100.0		100.0	

Exp. 1 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	5.5	5.5	5.9	5.9
+ 45 - 53	2	0.5	6.0	0.4	6.2
+ 53 - 63	3	0.5	6.5	0.6	6.9
+ 63 - 75	4	1.0	7.5	1.0	7.9
+ 75 - 106	5	1.9	9.4	1.6	9.5
+ 106 - 150	6	3.1	12.5	2.9	12.4
+ 150 - 212	7	5.6	18.1	5.3	17.7
+ 212 - 300	8	8.6	26.7	8.1	25.8
+ 300 - 425	9	14.9	41.6	14.6	40.4
+ 425 - 500	10	10.1	51.7	9.9	50.3
+ 500 - 600	11	12.7	64.4	12.7	63.0
+ 600 - 850	12	23.0	87.4	23.7	86.7
+ 850 - 1180	13	9.4	96.8	9.8	96.5
+ 1180	14	3.1	99.9	3.5	100.0
total		100.0		100.0	

Exp. 1 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	29.0	29.0	28.8	28.8
+ 45 - 53	2	2.5	31.5	2.6	31.4
+ 53 - 63	3	2.6	34.1	2.5	33.9
+ 63 - 75	4	4.0	38.1	4.1	38.0
+ 75 - 106	5	6.6	44.6	6 7	44.7
+ 106 - 150	6	8.6	53.2	8.7	53.4
+ 150 - 212	7	11.0	64.2	11.1	64.5
+ 212 - 300	8	11.4	75.7	11.6	76.1
+ 300 - 425	9	13.0	88.7	13.2	89.3
+ 425 - 500	10	4.9	93.5	5.0	94.3
+ 500 - 600	11	3.6	97.2	3.6	97.9
+ 600 - 850	12	2.4	99.5	2.1	100.0
+ 850 - 1180	13	0.2	99.8	0.0	100.0
+ 1180	14	0.2	100.0	0.0	100.0
total		100.0		100.0	

Exp. 1 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	4.7	4.7	4.3	4.3	4.7	4.7
+ 45 - 53	2	0.3	5.0	0.5	4.8	0.5	5.2
+ 53 - 63	3	0.2	5.2	0.7	5.2	0.3	5.5
+ 63 - 75	4	0.6	5.8	0.9	6.2	0.6	6.1
+ 75 - 106	5	1.7	7.5	1.9	8.1	1.8	8.0
+ 106 - 150	6	3.1	10.6	3.2	11.4	3.2	11.2
+ 150 - 212	7	5.5	16.1	5.8	17.1	5.7	16.8
+ 212 - 300	8	7.8	23.9		25.4	8.3	25.1
+ 300 - 425	9	13.8	37.7	14.1	39.4	14.7	39.8
+ 425 - 500	10	9.4	47.1	9.6	49.0	9.5	49.3
+ 500 - 600	11	12.7	59.8	12.7	61.7	12.6	61.9
+ 600 - 850	12	25.4	85.2	24.5	86.1	24.5	86.4
+ 850 - 1180	13	10.7	95.9	10.2	96.4	10.0	96.3
+ 1180	14	4.1	100.0	3.6	100.0	3.7	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Run 7

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	cyclone o/f	feed to cyclone
solid t/hr	1.650	0.990	0.370	0.610	N.A.
solid t/hr smoothed	1.698	1.347	0.350	0.613	2.310
slurry t/hr smoothed	3.853	1.864	1.986	7.643	11.491
% H2O surface	54.53	28.02	83.06	91.90	80.13
% H2O surface smoothed	55.93	27.74	82.38	91.98	79.90

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	solid inlets to sump t/hr	solid outlet sump t/hr
1.698	1.697	2.155	2.153	2.310	2.310
H2O surface sump inlets t/hr	**H2O surface sump outlet t/hr**	**solid cyclone inlet t/hr**	**solid cyclone outlets t/hr**	**H2O surface cyclone inlet t/hr**	**H2O surface cyclone outlets t/hr**
9.183	9.181	2.310	2.311	9.181	9.185

Run 7

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	27.4	27.4	35.4	35.4
+ 45 - 53	2	0.2	25.3	36.5	35.5
+ 53 - 63	3	0.2	23.5	37.5	35.7
+ 63 - 75	4	33.6	24.9	38.6	36.1
+ 75 - 105	5	22.3	24.3	39.7	36.9
+ 105 - 150	6	34.1	27.2	44.0	39.0
+ 150 - 212	7	44.9	33.8	53.4	44.3
+ 212 - 300	8	54.9	41.6	62.0	50.9
+ 300 - 425	9	66.6	51.8	72.6	59.8
+ 425 - 500	10	78.1	57.0	82.3	64.3
+ 500 - 600	11	86.5	62.7	89.3	69.3
+ 600 - 850	12	94.9	71.3	96.2	76.6
+ 850 - 1180	13	98.2	73.7	98.4	78.6
+ 1180	14	98.6	74.5	98.4	79.3
total		74.5		79.3	

Run 7

% Particle Size Distribution (data as is and smoothed)

size um	size class	feed to cyclone frac %	feed to cyclone cum %	feed to cyclone frac % smooth	feed to cyclone cum % smooth
- 45	1	9.5	9.5	9.0	9.0
+ 45 - 53	2	0.7	10.1	1.0	10.0
+ 53 - 63	3	0.7	10.8	0.9	10.8
+ 63 - 75	4	1.1	11.9	1.3	12.1
+ 75 - 106	5	2.5	14.4	2.8	14.9
+ 106 - 150	6	4.3	18.7	4.4	19.3
+ 150 - 212	7	7.2	25.9	7.4	26.7
+ 212 - 300	8	10.0	35.8	10.0	36.7
+ 300 - 425	9	16.2	52.0	16.0	52.6
+ 425 - 500	10	8.8	60.9	8.8	61.5
+ 500 - 600	11	10.8	71.7	10.4	71.9
+ 600 - 850	12	19.5	91.2	18.6	90.5
+ 850 - 1180	13	6.7	97.9	6.8	97.3
+ 1180	14	2.1	100.0	2.7	100.0
total		100.0		100.0	

Run 7

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone o/f frac %	cyclone o/f cum %	cyclone o/f frac % smooth	cyclone o/f cum % smooth
- 45	1	24.0	24.0	23.8	23.8
+ 45 - 53	2	2.5	26.4	2.6	26.4
+ 53 - 63	3	1.9	28.3	2.0	28.4
+ 63 - 75	4	2.9	31.2	2.9	31.3
+ 75 - 106	5	6.2	37.4	6.1	37.5
+ 106 - 150	6	9.0	46.4	8.9	46.4
+ 150 - 212	7	12.7	59.1	12.5	58.9
+ 212 - 300	8	13.0	72.1	12.9	71.8
+ 300 - 425	9	14.0	86.1	13.8	85.6
+ 425 - 500	10	4.9	91.0	4.9	90.5
+ 500 - 600	11	4.2	95.2	4.3	94.8
+ 600 - 850	12	3.9	99.1	4.1	98.9
+ 850 - 1180	13	0.6	99.7	0.8	99.7
+ 1180	14	0.3	100.0	0.3	100.0
total		100.0		100.0	

Run 7

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	2.8	2.8	3.6	3.6
+ 45 - 53	2	0.4	3.3	0.4	4.0
+ 53 - 63	3	0.3	3.6	0.4	4.5
+ 63 - 75	4	0.9	4.4	0.7	5.2
+ 75 - 106	5	1.4	5.8	1.6	6.7
+ 106 - 150	6	2.7	8.5	2.8	9.5
+ 150 - 212	7	5.4	14.0	5.5	15.0
+ 212 - 300	8	8.8	22.8	9.0	24.0
+ 300 - 425	9	16.5	39.3	16.7	40.8
+ 425 - 500	10	10.4	49.7	10.2	51.0
+ 500 - 600	11	12.8	62.5	12.7	63.7
+ 600 - 850	12	24.4	86.9	23.8	87.5
+ 850 - 1180	13	9.4	96.3	8.9	96.4
+ 1180	14	3.7	100.0	3.6	100.0
total		100.0		100.0	

Exp. 2 : Test 2

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	36.8	36.8	39.2	39.2
+ 45 - 53	2	8.7	34.6	40.9	39.4
+ 53 - 63	3	10.6	33.2	43.8	39.8
+ 63 - 75	4	20.2	31.7	46.4	40.8
+ 75 - 105	5	47.5	34.8	52.9	43.1
+ 105 - 150	6	50.3	38.4	57.5	46.5
+ 150 - 212	7	60.2	44.7	65.0	51.7
+ 212 - 300	8	66.2	50.6	70.5	56.8
+ 300 - 425	9	76.7	58.4	78.9	63.2
+ 425 - 500	10	86.4	62.5	86.7	66.4
+ 500 - 600	11	92.8	67.0	92.4	70.0
+ 600 - 850	12	97.4	73.5	96.7	75.1
+ 850 - 1180	13	98.8	75.5	96.9	76.6
+ 1180	14	100.0	76.1	97.7	77.0
total		76.1		77.0	

Exp. 2 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	28.9	28.9	28.4	28.4
+ 45 - 53	2	3.5	32.4	3.6	32.0
+ 53 - 63	3	2.5	34.9	2.6	34.6
+ 63 - 75	4	4.9	39.8	4.9	39.5
+ 75 - 106	5	7.4	47.2	7.4	16.9
+ 106 - 150	6	10.9	58.1	10.9	57.8
+ 150 - 212	7	13.7	71.8	13.6	71.4
+ 212 - 300	8	11.3	83.1	11.3	82.8
+ 300 - 425	9	9.2	92.3	9.3	92.0
+ 425 - 500	10	2.8	95.1	2.9	94.9
+ 500 - 600	11	2.1	97.2	2.1	97.1
+ 600 - 850	12	2.1	99.3	2.0	99.0
+ 850 - 1180	13	0.7	100.0	0.9	99.9
+ 1180	14	0.0	100.0	0.1	100.0
total		100.0		100.0	

Exp. 2 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	5.9	5.9	5.6	5.6
+ 45 - 53	2	0.3	6.2	0.7	6.4
+ 53 - 63	3	0.3	6.5	0.7	7.1
+ 63 - 75	4	0.8	7.3	1.5	8.5
+ 75 - 106	5	2.1	9.5	2.3	10.8
+ 106 - 150	6	3.4	12.9	3.9	14.7
+ 150 - 212	7	6.7	19.6	7.2	21.9
+ 212 - 300	8	9.6	29.2	10.4	32.3
+ 300 - 425	9	16.3	45.5	16.9	49.2
+ 425 - 500	10	9.6	55.1	9.5	58.8
+ 500 - 600	11	11.7	66.9	11.3	70.1
+ 600 - 850	12	21.5	88.4	19.7	89.8
+ 850 - 1180	13	8.6	97.1	7.6	97.4
+ 1180	14	2.9	100.0	2.6	100.0
total		100.0		100.0	

Exp. 2 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	23.2	23.2	22.9	22.9
+ 45 - 53	2	2.8	26.0	2.9	25.8
+ 53 - 63	3	2.2	28.2	2.3	28.1
+ 63 - 75	4	4.5	32.7	4.5	32.6
+ 75 - 106	5	6.1	38.8	6.1	38.7
+ 106 - 150	6	9.1	47.9	8.9	47.6
+ 150 - 212	7	12.6	60.5	12.3	59.9
+ 212 - 300	8	13.9	74.4	13.5	73.5
+ 300 - 425	9	15.0	89.4	14.6	88.1
+ 425 - 500	10	5.0	94.4	5.0	93.1
+ 500 - 600	11	3.2	97.6	3.3	96.4
+ 600 - 850	12	2.0	99.6	2.5	98.9
+ 850 - 1180	13	0.4	100.0	0.9	99.8
+ 1180	14	0.0	100.0	0.2	100.0
total		100.0		100.0	

Exp. 2 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	4.2	4.2	4.4	4.4	4.0	4.0
+ 45 - 53	2	0.4	4.6	0.6	5.0	0.4	4.4
+ 53 - 63	3	0.4	5.0	0.5	5.5	0.4	4.8
+ 63 - 75	4	0.8	5.8	1.2	6.7	0.8	5.5
+ 75 - 106	5	2.1	7.9	2.0	8.7	1.9	7.4
+ 106 - 150	6	4.0	11.9	3.6	12.3	3.8	11.3
+ 150 - 212	7	7.4	19.2	6.8	19.1	6.7	17.9
+ 212 - 300	8	10.8	29.8	9.6	28.7	9.9	27.9
+ 300 - 425	9	17.3	47.0	16.3	45.0	16.8	44.7
+ 425 - 500	10	9.9	56.9	9.7	54.8	10.1	54.8
+ 500 - 600	11	12.0	68.9	12.1	66.9	12.0	66.8
+ 600 - 850	12	20.9	89.9	21.8	88.7	21.9	88.7
+ 850 - 1180	13	7.6	97.5	8.4	97.1	8.2	96.9
+ 1180	14	2.5	100.0	2.9	100.0	3.1	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 1 : Test 3

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.450	0.910	0.500	0.230
solid t/hr smoothed	1.451	1.190	0.496	0.235
slurry t/hr smoothed	3.791	1.582	2.734	0.525
% H2O surface	61.20	24.87	82.20	55.20
% H2O surface smoothed	61.72	24.80	81.86	55.24
% ash	18.30	17.70	21.50	13.60
% ash smoothed	19.26	17.21	21.49	13.60

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
1.686	1.686	2.630	2.631	0.311	0.311

Exp. 1 : Test 3

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	9.4	0.159	9.4	0.159
+ 45 - 53	2	1.0	0.0164	1.0	0.0164
+ 53 - 63	3	0.9	0.0151	0.9	0.0151
+ 63 - 75	4	1.9	0.0319	1.9	0.0319
+ 75 - 105	5	2.7	0.0449	2.7	0.0449
+ 105 - 150	6	4.3	0.0719	4.3	0.0719
+ 150 - 212	7	6.7	0.113	6.7	0.113
+ 212 - 300	8	9.3	0.156	9.3	0.156
+ 300 - 425	9	14.9	0.251	14.9	0.251
+ 425 - 500	10	8.7	0.147	8.7	0.147
+ 500 - 600	11	10.4	0.175	10.4	0.175
+ 600 - 850	12	19.1	0.323	19.1	0.323
+ 850 - 1180	13	7.7	0.129	7.7	0.129
+ 1180	14	3.1	0.0527	3.1	0.0527

Exp. 1 : Test 3

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	16.8	16.8	25 9	25.9
+ 45 - 53	2	2.3	15.3	26.5	25.9
+ 53 - 63	3	16.2	15.3	29.6	26.2
+ 63 - 75	4	18.5	15.7	32.6	27.1
+ 75 - 105	5	37.1	19.7	36.0	28.6
+ 105 - 150	6	41.8	24.7	43.5	31.8
+ 150 - 212	7	50.5	31.6	50.7	36.5
+ 212 - 300	8	58.1	38.7	58.5	42.1
+ 300 - 425	9	70.3	48.3	70.0	50.3
+ 425 - 500	10	81.3	53.3	80.5	54.7
+ 500 - 600	11	88.9	58.8	88.3	59.7
+ 600 - 850	12	96.2	67.2	95.6	67.4
+ 850 - 1180	13	98.8	69.7	97.8	69.8
+ 1180	14	96.9	70.6	95.1	70.6
total		70.6		70.6	

Exp. 1 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	25.2	25.2	25.0	25.0
+ 45 - 53	2	2.8	28.0	2.9	27.9
+ 53 - 63	3	2.3	30.3	2.4	30.2
+ 63 - 75	4	5.0	35.3	5.0	35.2
+ 75 - 106	5	7.6	42.9	7.6	42.8
+ 106 - 150	6	10.5	53.4	10.4	53.2
+ 150 - 212	7	13.3	66.7	13.2	66.4
+ 212 - 300	8	11.9	78.6	11.9	78.3
+ 300 - 425	9	11.1	89.8	11.0	89.3
+ 425 - 500	10	3.6	93.3	3.7	93.0
+ 500 - 600	11	2.9	96.3	2.9	95.9
+ 600 - 850	12	2.9	99.2	2.9	98.8
+ 850 - 1180	13	0.5	99.7	0.7	99.6
+ 1180	14	0.3	100.0	0.4	100.0
total		100.0		100.0	

Exp. 1 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	6.0	6.0	6.9	6.9
+ 45 - 53	2	0.5	6.5	0.7	7.6
+ 53 - 63	3	0.5	7.0	0.7	8.2
+ 63 - 75	4	1.0	8.0	1.4	9.6
+ 75 - 106	5	1.9	9.8	1.9	11.5
+ 106 - 150	6	3.2	13.0	3.3	14.8
+ 150 - 212	7	5.7	18.7	5.7	20.4
+ 212 - 300	8	8.8	27.4	8.8	29.2
+ 300 - 425	9	15.8	43.3	15.5	44.8
+ 425 - 500	10	9.7	53.0	9.5	54.3
+ 500 - 600	11	11.9	64.9	11.6	65.9
+ 600 - 850	12	22.6	87.5	21.8	87.7
+ 850 - 1180	13	9.0	96.5	8.8	96.4
+ 1180	14	3.5	100.0	3.6	100.0
total		100.0		100.0	

Exp. 1 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	24.4	24.4	23.8	23.8
+ 45 - 53	2	2.7	27.1	2.4	26.2
+ 53 - 63	3	2.1	29.2	2.1	28.3
+ 63 - 75	4	4.2	33.4	4.3	32.7
+ 75 - 106	5	5.7	39.1	5.8	38.5
+ 106 - 150	6	8.2	47.3	8.2	46.6
+ 150 - 212	7	11.3	58.6	11.2	57.9
+ 212 - 300	8	13.1	71.7	13.1	71.0
+ 300 - 425	9	15.3	87.1	15.2	86.1
+ 425 - 500	10	5.7	92.7	5.8	91.9
+ 500 - 600	11	4.0	96.8	4.1	96.1
+ 600 - 850	12	2.6	99.4	2.8	98.9
+ 850 - 1180	13	0.3	99.7	0.6	99.5
+ 1180	14	0.3	100.0	0.5	100.0
total		100.0		100.0	

Exp. 1 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	4.2	4.2	3.5	3.5	3.8	3.8
+ 45 - 53	2	0.2	4.4	0.4	3.8	0.2	4.0
+ 53 - 63	3	0.2	4.7	0.4	4.2	0.2	4.2
+ 63 - 75	4	0.5	5.1	0.9	5.1	0.4	4.6
+ 75 - 106	5	1.2	6.3	1.4	6.4	1.1	5.6
+ 106 - 150	6	2.6	8.8	2.6	9.1	2.3	7.9
+ 150 - 212	7	4.8	13.6	4.8	13.9	4.6	12.5
+ 212 - 300	8	7.8	21.4	7.7	21.5	7.3	19.8
+ 300 - 425	9	14.9	36.3	14.8	36.3	14.6	34.4
+ 425 - 500	10	10.0	46.3	10.0	46.3	10.1	44.5
+ 500 - 600	11	13.0	59.4	13.0	59.3	13.8	58.2
+ 600 - 850	12	26.2	85.6	25.9	85.2	26.9	85.1
+ 850 - 1180	13	10.6	96.2	10.6	95.8	10.4	95.5
+ 11 0	14	3.8	100.0	4.2	100.0	4.5	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 2 : Test 3

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.550	0.820	0.390	0.200
solid t/hr smoothed	1.443	1.288	0.367	0.211
slurry t/hr smoothed	3.070	1.722	1.945	0.594
% H2O surface	52.94	25.23	81.17	64.46
% H2O surface smoothed	53.00	25.22	81.13	64.47
% ash	18.38	16.88	21.88	12.93
% ash smoothed	18.68	16.82	21.88	12.93

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
1.654	1.655	2.010	2.012	0.297	0.297

Exp. 2 : Test 3

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	6.2	0.103	6.2	0.103
+ 45 - 53	2	0.9	0.0154	0.9	0.0154
+ 53 - 63	3	0.6	0.00998	0.6	0.00999
+ 63 - 75	4	1.7	0.0273	1.7	0.0274
+ 75 - 105	5	2.2	0.0366	2.2	0.0366
+ 105 - 150	6	4.2	0.0696	4.2	0.0697
+ 150 - 212	7	8.2	0.135	8.2	0.135
+ 212 - 300	8	11.5	0.190	11.5	0.190
+ 300 - 425	9	17.5	0.290	17.5	0.290
+ 425 - 500	10	8.9	0.148	8.9	0.148
+ 500 - 600	11	10.6	0.175	10.6	0.175
+ 600 - 850	12	18.1	0.300	18.1	0.300
+ 850 - 1180	13	6.9	0.114	6.9	0.114
+ 1180	14	2.4	0.0404	2.4	0.0404

Exp. 2 : Test 3

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	26.4	26.4	36.1	36.1
+ 45 - 53	2	38.8	28.2	37.4	36.2
+ 53 - 63	3	44.5	29.8	40.1	36.5
+ 63 - 75	4	5.6	26.5	41.9	37.5
+ 75 - 105	5	49.0	31.5	45.4	39.0
+ 105 - 150	6	53.9	38.0	53.1	42.8
+ 150 - 212	7	63.1	47.1	61.8	49.3
+ 212 - 300	8	69.4	54.6	68.8	55.6
+ 300 - 425	9	79.0	62.9	78.1	63.0
+ 425 - 500	10	87.4	66.5	87.1	66.5
+ 500 - 600	11	92.0	70.3	91.8	70.2
+ 600 - 850	12	97.3	75.8	97.3	75.6
+ 850 - 1180	13	99.4	77.3	99.8	77.3
+ 1180	14	98.1	77.8	99.3	77.9
total		77 8		77.9	

Exp. 2 : Test 3

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	26.4	26.4	36.1	36.1
+ 45 - 53	2	38.8	28.2	37.4	36.2
+ 53 - 63	3	44.5	29.8	40.1	36.5
+ 63 - 75	4	5.6	26.5	41.9	37.5
+ 75 - 105	5	49.0	31.5	45.4	39.0
+ 105 - 150	6	53.9	38.0	53.1	42.8
+ 150 - 212	7	63.1	47.1	61.8	49.3
+ 212 - 300	8	69.4	54.6	68.8	55.6
+ 300 - 425	9	79.0	62.9	78.1	63.0
+ 425 - 500	10	87.4	66.5	87.1	66.5
+ 500 - 600	11	92.0	70.3	91.8	70.2
+ 600 - 850	12	97.3	75.8	97.3	75.6
+ 850 - 1180	13	99.4	77.3	99.8	77.3
+ 1180	14	98.1	77.8	99.3	77.9
total		77.8		77.9	

Exp. 2 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	19.4	19.4	19.5	19.5
+ 45 - 53	2	2.6	22.0	2.5	22.0
+ 53 - 63	3	2.0	24.0	1.9	24.0
+ 63 - 75	4	3.8	27.9	3.8	27.8
+ 75 - 106	5	5.4	33.2	5.3	33.1
+ 106 - 150	6	9.2	42.5	9.2	42.3
+ 150 - 212	7	13.8	56.3	13.7	56.0
+ 212 - 300	8	14.1	70.3	14.0	70.0
+ 300 - 425	9	14.6	84.9	14.5	84.5
+ 425 - 500	10	4.9	89.8	4.9	89.4
+ 500 - 600	11	4.3	94.1	4.3	93.6
+ 600 - 850	12	4.9	99.0	4.8	98.5
+ 850 - 1180	13	1.0	100.0	1.5	100.0
+ 1180	14	0.0	100.0	0.0	100.0
total		100.0		100.0	

Exp. 2 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	19.4	19.4	19.5	19.5
+ 45 - 53	2	2.6	22.0	2.5	22.0
+ 53 - 63	3	2.0	24.0	1.9	24.0
+ 63 - 75	4	3.8	27.9	3.8	27.8
+ 75 - 106	5	5.4	33.2	5.3	33.1
+ 106 - 150	6	9.2	42.5	9.2	42.3
+ 150 - 212	7	13.8	56.3	13.7	56.0
+ 212 - 300	8	14.1	70.3	14.0	70.0
+ 300 - 425	9	14.6	84.9	14.5	84.5
+ 425 - 500	10	4.9	89.8	4.9	89.4
+ 500 - 600	11	4.3	94.1	4.3	93.6
+ 600 - 850	12	4.9	99.0	4.8	98.5
+ 850 - 1180	13	1.0	100.0	1.5	100.0
+ 1180	14	0.0	100.0	0.0	100.0
total		100.0		100.0	

Exp. 2 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	3.6	3.6	4.3	4.3
+ 45 - 53	2	0.7	4.3	0.7	5.0
+ 53 - 63	3	0.5	4.8	0.4	5.4
+ 63 - 75	4	0.7	5.6	1.3	6.7
+ 75 - 106	5	1.9	7.5	1.8	8.5
+ 106 - 150	6	3.6	11.1	3.5	11.9
+ 150 - 212	7	7.7	18.8	7.4	19.3
+ 212 - 300	8	11.4	30.2	11.1	30.4
+ 300 - 425	9	18.6	48.8	18.0	48.4
+ 425 - 500	10	9.7	58.5	9.5	57.9
+ 500 - 600	11	11.6	70.0	11.5	69.4
+ 600 - 850	12	20.3	90.3	20.1	89.5
+ 850 - 1180	13	7.2	97.6	7.7	97.2
+ 1180	14	2.4	100.0	2.8	100.0
total		100.0		100.0	

Exp. 2 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	18.1	18.1	17.9	17.9
+ 45 - 53	2	2.6	20.7	2.6	20.5
+ 53 - 63	3	1.7	22.3	1.6	22.2
+ 63 - 75	4	4.6	26.9	4.3	26.5
+ 75 - 106	5	5.4	32.3	5.4	32.0
+ 106 - 150	6	8.9	41.1	8.9	40.9
+ 150 - 212	7	14.0	55.2	14.1	55.0
+ 212 - 300	8	16.1	71.2	16.2	71.1
+ 300 - 425	9	17.2	88.4	17.3	88.5
+ 425 - 500	10	5.2	93.5	5.2	93.7
+ 500 - 600	11	3.9	97.4	3.9	97.6
+ 600 - 850	12	2.2	99.6	2.2	99.8
+ 850 - 1180	13	0.2	99.8	0.1	99.9
+ 1180	14	0.2	100.0	0.1	100.0
total		100.0		100.0	

Exp. 2 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	18.1	18.1	17.9	17.9
+ 45 - 53	2	2.6	20.7	2.6	20.6
+ 53 - 63	3	1.7	22.3	1.6	22.2
+ 63 - 75	4	4.6	26.9	4.3	26.5
+ 75 - 106	5	5.4	32.3	5.4	32.0
+ 106 - 150	6	8.9	41.1	8.9	40.9
+ 150 - 212	7	14.0	55.2	14.1	55.0
+ 212 - 300	8	16.1	71.2	16.2	71.1
+ 300 - 425	9	17.2	88.4	17.3	88.5
+ 425 - 500	10	5.2	93.5	5.2	93.7
+ 500 - 600	11	3.9	97.4	3.9	97.6
+ 600 - 850	12	2.2	99.6	2.2	99.8
+ 850 - 1180	13	0.2	99.8	0.1	99.9
+ 1180	14	0.2	100.0	0.1	100.0
total		100.0		100.0	

Exp. 2 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	3.6	3.6	2.9	2.9	2.5	2.5
+ 45 - 53	2	0.4	4.0	0.4	3.3	0.4	2.8
+ 53 - 63	3	0.0	4.0	0.3	3.6	0.4	3.2
+ 63 - 75	4	0.4	4.3	0.9	4.5	0.4	3.5
+ 75 - 106	5	1.1	5.4	1.3	5.8	1.4	4.9
+ 106 - 150	6	2.9	8.3	2.9	8.7	3.2	8.1
+ 150 - 212	7	6.3	14.7	6.5	15.2	6.8	14.9
+ 212 - 300	8	10.0	24.6	10.1	25.3	10.5	25.4
+ 300 - 425	9	17.2	41.8	17.6	42.9	17.5	42.9
+ 425 - 500	10	10.0	51.8	10.0	52.9	10.2	53.1
+ 500 - 600	11	12.5	64.3	12.5	65.4	12.6	65.7
+ 600 - 850	12	22.6	87.0	22.7	88.0	22.2	87.9
+ 850 - 1180	13	9.4	96.4	8.8	96.9	8.6	96.5
+ 1180	14	3.6	100.0	3.1	100.0	3.5	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 2 : Test 2

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.670	1.130	0.460	0.240
solid t/hr smoothed	1.682	1.494	0.445	0.257
slurry t/hr smoothed	3.505	1.981	2.177	0.651
% H2O surface	52.00	24 58	79.57	60.52
% H2O surface smoothed	52.02	24.57	79.56	60.52
% ash	19.99	17.02	23.00	13.68
% ash smoothed	19.47	17.36	23.18	1[illegible].64

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
1.939	1.939	2.217	2.219	0.363	0.363

Exp. 2 : Test 2

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	8.7	0.168	8.7	0.168
+ 45 - 53	2	1.1	0.0217	1.1	0.0217
+ 53 - 63	3	0.9	0.0180	0.9	0.0180
+ 63 - 75	4	1.9	0.0376	1.9	0.0376
+ 75 - 105	5	3.0	0.0573	3.0	0.0573
+ 105 - 150	6	4.8	0.0934	4.8	0.0934
+ 150 - 212	7	8.1	0.157	8.1	0.157
+ 212 - 300	8	10.5	0.204	10.5	0.204
+ 300 - 425	9	15.9	0.308	15.9	0.308
+ 425 - 500	10	8.7	0.168	8.7	0.168
+ 500 - 600	11	10.1	0.195	10.1	0.195
+ 600 - 850	12	17.4	0.337	17.4	0.337
+ 850 - 1180	13	6.7	0.129	6.7	0.129
+ 1180	14	2.3	0.0444	2.3	0.0444

Exp. 3 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	17.8	17.8	17.8	17.8
+ 45 - 53	2	2.5	20.3	2.5	20.3
+ 53 - 63	3	2.1	22.3	2.1	22.4
+ 63 - 75	4	3.2	25.5	3.2	25.6
+ 75 - 106	5	5.5	31.0	5.5	31.1
+ 106 - 150	6	9.3	40.3	9.3	40.4
+ 150 - 212	7	13.9	54.2	13.9	54.4
+ 212 - 300	8	14.4	68.6	14.4	68.8
+ 300 - 425	9	14.8	83.4	14.8	83.6
+ 425 - 500	10	5.2	88.6	5.2	88.8
+ 500 - 600	11	4.8	93.4	4.8	93.6
+ 600 - 850	12	5.2	98.6	5.1	98.7
+ 850 - 1180	13	1.1	99.8	1.1	99.8
+ 1180	14	0.2	100.0	0.2	100.0
total		100.0		100.0	

Exp. 3 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	6.1	6.1	5.9	5.9
+ 45 - 53	2	0.6	6.7	0.7	6.6
+ 53 - 63	3	0.5	7.1	0.6	7.2
+ 63 - 75	4	0.8	7.9	1.2	8.4
+ 75 - 106	5	1.8	9.7	1.9	10.3
+ 106 - 150	6	3.8	13.5	4.0	14.3
+ 150 - 212	7	7.5	21.0	7.9	22.3
+ 212 - 300	8	10.8	31.8	11.2	33.4
+ 300 - 425	9	17.0	48.8	17.3	50.7
+ 425 - 500	10	9.1	57.9	9.1	59.8
+ 500 - 600	11	11 2	69.2	10.9	70.7
+ 600 - 850	12	20.1	89.3	19.4	90.1
+ 850 - 1180	13	7.8	97.1	7.3	97.4
+ 1180	14	2.8	100.0	2.6	100.0
total		100.0		100.0	

Exp. 3 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	19.8	19.8	19.8	19.8
+ 45 - 53	2	2.4	22.2	2.4	22.2
+ 53 - 63	3	1.8	24.0	1.8	24.1
+ 63 - 75	4	3.4	27.4	3.4	27.5
+ 75 - 106	5	5.0	32.5	5.0	32.5
+ 106 - 150	6	8.7	41.1	8.6	41.1
+ 150 - 212	7	14.3	55.4	14.2	55.2
+ 212 - 300	8	15.7	71.2	15.6	70.8
+ 300 - 425	9	16.7	87.9	16.6	87.4
+ 425 - 500	10	5.2	93.1	5.2	92.6
+ 500 - 600	11	3.6	96.8	3.7	96.3
+ 600 - 850	12	2.4	99.2	2.6	98.9
+ 850 - 1180	13	0.4	99.6	0.6	99.5
+ 1180	14	0.4	100.0	0.5	100.0
total		100.0		100.0	

Exp. 3 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	2.5	2.5	2.6	2.6	2.1	2.1
+ 45 - 53	2	0.2	2.7	0.3	3.0	0.2	2.3
+ 53 - 63	3	0.3	3.1	0.3	3.3	0.2	2.5
+ 63 - 75	4	0.5	3.6	0.7	4.1	0.4	3.0
+ 75 - 106	5	1.4	5.0	1.3	5.3	1.2	4.2
+ 106 - 150	6	3.3	8.3	3.1	8.4	2.9	7.0
+ 150 - 212	7	7.0	15.3	6.6	15.0	6.3	13.3
+ 212 - 300	8	10.4	25.7	10.0	25.1	9.7	22.9
+ 300 - 425	9	17.5	43.2	17.2	42.2	16.7	39.6
+ 425 - 500	10	10.1	53.4	10.0	52.2	9.9	49.5
+ 500 - 600	11	12.4	65.8	12.6	64.8	12.7	62.2
+ 600 - 850	12	22.8	88.6	23.3	88.1	24.1	86.4
+ 850 - 1180	13	8.5	97.1	8.8	97.0	9.9	96.3
+ 1180	14	2.9	100.0	3.0	100.0	3.7	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 3 : Test 2

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.490	1.020	0.620	0.360
solid t/hr smoothed	1.490	1.230	0.620	0.360
slurry t/hr smoothed	3.346	1.623	2.679	0.956
% H2O surface	55.51	24.20	76.82	62.34
% H2O surface smoothed	55.47	24.21	76.85	62.33
% ash	19.14	16.73	20.07	13.42
% ash smoothed	19.12	16.98	20.07	13.42

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
1.850	1.850	2.452	2.451	0.323	0.333

Exp. 3 : Test 2

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	11.4	0.211	11.4	0.211
+ 45 - 53	2	1.4	0.0251	1.4	0.0251
+ 53 - 63	3	1.2	0.0226	1.2	0.0226
+ 63 - 75	4	2.0	0.0367	2.0	0.0367
+ 75 - 105	5	3.3	0.0613	3.3	0.0613
+ 105 - 150	6	5.6	0.103	5.6	0.103
+ 150 - 212	7	8.7	0.162	8.7	0.162
+ 212 - 300	8	10.7	0.198	10.7	0.198
+ 300 - 425	9	15.6	0.288	15.6	0.288
+ 425 - 500	10	7.8	0.144	7.8	0.144
+ 500 - 600	11	9.1	0.168	9.1	0.168
+ 600 - 850	12	15.5	0.286	15.5	0.286
+ 850 - 1180	13	5.7	0.105	5.7	0.105
+ 1180	14	2.1	0.0382	2.1	0.0382

Exp. 3 : Test 2

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	18.8	18.8	21.9	21.9
+ 45 - 53	2	17.5	18.6	26.9	22.4
+ 53 - 63	3	0.9	17.5	29.6	23.0
+ 63 - 75	4	21.3	17.9	32.0	24.1
+ 75 - 105	5	34.7	20.8	39.5	26.8
+ 105 - 150	6	41.8	25.6	46.5	31.2
+ 150 - 212	7	49.1	31.8	52.4	36.7
+ 212 - 300	8	58.2	38.3	59.9	42.3
+ 300 - 425	9	69.1	46.5	70.3	49.6
+ 425 - 500	10	80.7	50.4	81.4	53.3
+ 500 - 600	11	87.8	54.9	88.0	57.4
+ 600 - 850	12	95.4	61.8	95.2	63.7
+ 850 - 1180	13	100.0	64.0	99.7	65.8
+ 1180	14	100.0	64.7	99.2	66.5
total		64.7		77.9	

Exp. 3 : Test 2

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	18.8	18.8	21.9	21.9
+ 45 - 53	2	17.5	18.6	26.9	22.4
+ 53 - 63	3	0.9	17.5	29.6	23.0
+ 63 - 75	4	21.3	17.9	32.0	24.1
+ 75 - 105	5	34.7	20.8	39.5	26.8
+ 105 - 150	6	41.8	25.6	46.5	31.2
+ 150 - 212	7	49.1	31.8	52.4	36.7
+ 212 - 300	8	58.2	38.3	59.9	42.3
+ 300 - 425	9	69.1	46.5	70.3	49.6
+ 425 - 500	10	80.7	50.4	81.4	53.3
+ 500 - 600	11	87.8	54.9	88.0	57.4
+ 600 - 850	12	95.4	61.8	95.2	63.7
+ 850 - 1180	13	100.0	64.0	99.7	65.8
+ 1180	14	100.0	64.7	99.2	66.5
total		64.7		77.9	

Exp. 3 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	28.5	28.5	28.2	28.2
+ 45 - 53	2	3.1	31.6	3.0	31.2
+ 53 - 63	3	2.6	34.2	2.6	33.9
+ 63 - 75	4	4.3	38.5	4.3	38.2
+ 75 - 106	5	7.1	45.6	7.1	45.3
+ 106 - 150	6	10.4	56.1	10.4	55.7
+ 150 - 212	7	13.2	69.3	13.1	68.8
+ 212 - 300	8	11.3	80.5	11.2	80.0
+ 300 - 425	9	10.3	90.8	10.2	90.3
+ 425 - 500	10	3.1	93.9	3.1	93.4
+ 500 - 600	11	2.8	96.7	2.8	96.2
+ 600 - 850	12	2.8	99.4	2.8	99.0
+ 850 - 1180	13	0.6	100.0	0.9	99.9
+ 1180	14	0.0	100.0	0.1	100.0
total		100.0		100.0	

Exp. 3 : Test 2

% Particle Size Distribution (data as is and moothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	7.6	7.6	7.4	7.4
+ 45 - 53	2	0.8	8.4	1.0	8.3
+ 53 - 63	3	0.5	8.9	0.9	9.2
+ 63 - 75	4	1.2	10.1	1.4	10.6
+ 75 - 106	5	2.3	12.4	2.4	13.0
+ 106 - 150	6	4.3	16.7	4.4	17.5
+ 150 - 212	7	7.6	24.3	7.7	25.1
+ 212 - 300	8	10.7	35.1	10.6	35.7
+ 300 - 425	9	17.1	52.1	16.8	52.6
+ 425 - 500	10	9.0	61.1	8.9	61.5
+ 500 - 600	11	10.7	71.9	10.6	72.1
+ 600 - 850	12	18.8	90.7	18.5	90.6
+ 850 - 1180	13	6.8	97.6	6.8	97.5
+ 1180	14	2.4	100.0	2.5	100.0
total		100.0		100.0	

Exp. 3 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	26.8	26.8	26.6	26.6
+ 45 - 53	2	2.9	29.7	3.0	29.6
+ 53 - 63	3	2.5	32.2	..6	32.2
+ 63 - 75	4	4.0	36.2	4.0	36.2
+ 75 - 106	5	6.0	42.2	6.0	42.2
+ 106 - 150	6	9.0	51.3	8.9	51.1
+ 150 - 212	7	12.5	63.8	12.4	63.5
+ 212 - 300	8	12.9	76.7	12.8	76.3
+ 300 - 425	9	13.8	90.5	13.8	90.1
+ 425 - 500	10	4.3	94.8	4.3	94.4
+ 500 - 600	11	3.2	97.9	3.3	97.7
+ 600 - 850	12	2.1	100.0	2.2	99.9
+ 85') - 1180	13	0.0	100.0	0.1	100.0
+ 1180	14	0.0	100.0	0.0	100.0
total		100.0		100.0	

Exp. 3 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	3.6	3.6	3.8	3.8	3.6	3.6
+ 45 - 53	2	0.4	4.0	0.5	4.3	0.7	4.0
+ 53 - 63	3	0.4	4.3	0.5	4.9	0.5	4.5
+ 63 - 75	4	0.7	5.0	1.0	5.8	0.8	5.3
+ 75 - 106	5	2.0	7.0	3.0	7.8	1.9	7.2
+ 106 - 150	6	4.0	11.0	3.9	11.7	3.7	10.9
+ 150 - 212	7	7.0	18.0	6.9	18.6	6.7	17.6
+ 212 - 300	8	9.7	27.7	9.7	28.2	9.5	27.2
+ 300 - 425	9	16.5	44.2	16.4	44.7	16.3	43.4
+ 425 - 500	10	9.6	53.9	9.6	54.2	9.5	53.0
+ 500 - 600	11	12.1	65.9	12.0	66.3	12.3	65.2
+ 600 - 850	12	22.3	88.3	22.2	88.4	23.1	88.3
+ 850 - 1180	13	8.6	96.9	8.5	96.9	8.7	97.0
+ 1180	14	3.1	100.0	3.1	100.0	3.0	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 4 : Test 3

% Particle Size Distribution (data as in and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	2.3	2.3	1.9	1.9	2.1	2.1
+ 45 - 53	2	0.3	2.6	0.3	2.2	0.4	2.5
+ 53 - 63	3	0.3	2.9	0.3	2.5	0.4	2.9
+ 63 - 75	4	0.6	3.5	0.8	3.3	0.4	3.2
+ 75 - 106	5	1.5	5.0	1.4	4.7	1.4	4.6
+ 106 - 150	6	3.4	8.4	3.2	7.9	3.0	7.7
+ 150 - 212	7	7.3	15.6	7.0	14.9	7.1	14.8
+ 212 - 300	8	11.3	26.9	11.0	25.8	11.3	26.1
+ 300 - 425	9	18.5	45.5	18.3	44.2	19.1	45.2
+ 425 - 500	10	10.3	55.8	10.4	54.5	10.4	55.5
+ 500 - 600	11	12.4	68.2	12.6	67.2	12.9	68.4
+ 600 - 850	12	21.8	90.0	22.3	89.4	22.1	90.5
+ 850 - 1180	13	7.7	97.7	7.9	97.3	7.3	97.9
+ 1180	14	2.3	100.0	2.7	100.0	2.1	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 4 : Test 2

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.450	0.820	0.720	0.376
solid t/hr smoothed	1.420	1.033	0.719	0.331
slurry t/hr smoothed	3.280	1.366	2.827	0.909
% H2O surface	54.96	24.63	76.50	63.05
% H2O surface smoothed	56.71	24.36	74.57	63.60
% ash	17.68	16.16	20.05	13.14
% ash smoothed	18.65	15.95	20.00	13.14

solid screen inlet t/hr	solic screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
1.751	1.752	2.439	2.441	0.308	0.309

Exp. 4 : Test 2

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	11.4	0.200	11.4	0.201
+ 45 - 53	2	1.4	0.0240	1.4	0.0240
+ 53 - 63	3	1.2	0.0208	1.2	0.0208
+ 63 - 75	4	2.1	0.0374	2.1	0.0375
+ 75 - 105	5	3.4	0.0596	3.4	0.0597
+ 105 - 150	6	5.7	0.0999	5.7	0.100
+ 150 - 212	7	9.1	0.160	9.1	0.160
+ 212 - 300	8	11.6	0.202	11.6	0.202
+ 300 - 425	9	16.2	0.284	16.2	0.285
+ 425 - 500	10	7.7	0.136	7.7	0.136
+ 500 - 600	11	8.9	0.155	8.9	0.155
+ 600 - 850	12	14.3	0.250	14.3	0.250
+ 850 - 1180	13	5.0	0.0878	5.0	0.0878
+ 1180	14	1.9	0.0330	1.9	0.0330

Exp. 4 : Test 2

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	11.1	11.1	11.0	11.0
+ 45 - 53	2	4.5	10.5	19.1	11.9
+ 53 - 63	3	26.6	11.9	19.3	12.5
+ 63 - 75	4	19.6	12.9	26.4	14.4
+ 75 - 105	5	28.4	15.6	29.3	17.0
+ 105 - 150	6	36.9	20.5	36.2	21.3
+ 150 - 212	7	46.6	27.7	44.3	27.4
+ 212 - 300	8	54.4	34.6	52.0	33.6
+ 300 - 425	9	64.0	42.4	62.0	41.0
+ 425 - 500	10	77.5	46.4	75.6	44.8
+ 500 - 600	11	86.1	51.0	84.2	49.3
+ 600 - 850	12	94.5	57.7	93.9	56.1
+ 850 - 1180	13	98.0	59.8	97.9	58.3
+ 1180	14	100.0	60.6	96.7	59.0
total		64.7		59.0	

Exp. 4 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	25.7	25.7	25.9	25.9
+ 45 - 53	2	2.1	27.8	2.1	27.9
+ 53 - 63	3	2.5	30.3	2.4	30.4
+ 63 - 75	4	4.5	34.8	4.6	34.9
+ 75 - 106	5	6.8	41.5	6.8	41.8
+ 106 - 150	6	9.6	51.2	9.6	51.4
+ 150 - 212	7	12.8	64.0	12.8	64.2
+ 212 300	8	12.1	76.1	12.1	76.3
+ 300 - 425	9	11.8	87.9	11.7	88.0
+ 425 - 500	10	3.9	91.8	3.8	91.8
+ 500 - 600	11	3.6	95.4	3.5	95.3
+ 600 - 850	12	3.6	98.9	3.5	98.8
+ 850 - 1180	13	0.7	99.6	0.9	99.7
+ 1180	14	0.4	100.0	0.3	100.0
total		100.0		100.0	

Exp. 4 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	7.4	7.4	8.1	8.1
+ 45 - 53	2	0.9	8.2	1.2	9.3
+ 53 - 63	3	0.9	9.1	0.9	10.2
+ 63 - 75	4	1.3	10.4	1.6	11.8
+ 75 - 106	5	2.4	12.8	2.6	14.4
+ 106 - 150	6	4.6	17.4	4.8	19.1
+ 150 - 212	7	8.2	25.6	8.3	27.4
+ 212 - 300	8	11.5	37.1	11.4	38.9
+ 300 - 425	9	17.6	54.7	17.3	56.2
+ 425 - 500	10	8.9	63.6	8.6	64.8
+ 500 - 600	11	10.6	74.2	10.1	75.0
+ 600 - 850	12	17.1	91.3	16.8	91.8
+ 850 - 1180	13	6.1	97.4	6.0	97.7
+ 1180	14	2.6	100.0	2.3	100.0
total		100.0		100.0	

Exp. 4 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	25.2	25.2	24.8	24.8
+ 45 - 53	2	2.7	27.9	2.7	27.5
+ 53 - 63	3	2.2	30.2	2.3	29.9
+ 63 - 75	4	4.0	34.2	3.8	33.7
+ 75 - 106	5	6.0	40.1	5.9	39.6
+ 106 - 150	6	9.0	49.1	8.9	48.3
+ 150 - 212	7	12.5	61.6	12.4	60.9
+ 212 - 300	8	13.5	75.1	13.5	74.4
+ 300 - 425	9	15.0	90.0	15.1	89.5
+ 425 - 500	10	4.5	94.5	4.6	94.1
+ 500 - 600	11	3.2	97.8	3.4	97.5
+ 600 - 850	12	2.0	99.8	2.1	99.6
+ 850 - 1180	13	0.2	100.0	0.3	99.8
+ 1180	14	0.0	100.0	0.2	100.0
total		100.0		100.0	

Exp. 4 : Test 2

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen dis. A frac %	screen dis. A cum %	screen dis. A frac % smooth	screen dis. A cum % smooth	screen dis. B frac %	screen dis B cum %
- 45	1	2.7	2.7	2.1	2.1	3.2	3.2
+ 45 - 53	2	0.4	3.1	0.4	2.6	0.3	3.5
+ 53 - 63	3	0.2	3.4	0.4	3.0	0.3	3.9
+ 63 - 75	4	0.9	4.2	1.0	3.9	0.8	4.7
+ 75 - 106	5	1.9	6.1	1.7	5.6	1.9	6.6
+ 106 - 150	6	3.7	9.8	3.5	9.1	4.0	10.6
+ 150 - 212	7	7.0	16.8	6.9	16.0	7.4	18.0
+ 212 - 300	8	10.2	27.0	10.2	26.2	10.4	28.4
+ 300 - 425	9	17.0	44.0	17.1	43.2	16.9	45.3
+ 425 - 500	10	9.8	53.9	9.9	53.2	9.8	55.1
+ 500 - 600	11	12.4	66.3	12.7	65.8	12.0	67.1
+ 600 - 850	12	22.5	88.8	22.8	88.6	22.2	89.2
+ 850 - 1180	13	8.3	97.1	8.3	96.9	8.0	97.3
+ 1180	14	2.9	100.0	3.1	100.0	2.7	100.0
total		100.0		100.0		100.0	

N.B. screen discharge A : primary dewatering product
screen discharge B : secondary dewatering product

Exp. 3 : Test 3

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.470	1.020	0.420	0.160
solid t/hr smoothed	1.479	1.209	0.421	0.160
slurry t/hr smoothed	3.332	1.614	2.192	0.473
% H2O surface	56.38	25.00	80.51	66.26
% H2O surface smoothed	55.88	25.08	80.79	66.19
% ash	17.64	15.31	22.17	12.12
% ash smoothed	17.63	15.32	22.17	12.12

solid screen inlet t/hr	solid screen outlets t/hr	H2O surface screen inlet t/hr	H2O surface screen outlets t/hr	ash inlets screen t/hr	ash outlet screen t/hr
1.630	1.630	2.175	2.175	0.279	0.279

Exp. 3 : Test 3

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	7.1	0.115	7.1	0.115
+ 45 - 53	2	0.9	0.0144	0.9	0.0144
+ 53 - 63	3	0.7	0.0117	0.7	0.0117
+ 63 - 75	4	1.4	0.0234	1.4	0.0234
+ 75 - 105	5	2.2	0.0366	2.2	0.0366
+ 105 - 150	6	4.5	0.0737	4.5	0.0737
+ 150 - 212	7	8.5	0.139	8.5	0.139
+ 212 - 300	8	11.5	0.187	11.5	0.187
+ 300 - 425	9	17.0	0.278	17.0	0.278
+ 425 - 500	10	8.8	0.143	8.8	0.143
+ 500 - 600	11	10.3	0.168	10.3	0.168
+ 600 - 850	12	18.0	0.293	18.0	0.293
+ 850 - 1180	13	6.7	0.109	6.7	0.109
+ 1180	14	2.4	0.0386	2.4	0.0386

Exp. 3 : Test 3

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	19.0	19.0	27.5	27.5
+ 45 - 53	2	4.4	17.7	29.2	27.7
+ 53 - 63	3	13.5	17.4	34.8	28.3
+ 63 - 75	4	3.0	15.3	38.6	29.8
+ 75 - 105	5	30.2	18.0	42.7	32.1
+ 105 - 150	6	40.2	23.9	50.7	37.1
+ 150 - 212	7	47.9	32.0	57.2	43.8
+ 212 - 300	8	58.2	4[illegible]	64.9	50.4
+ 300 - 425	9	70 5	50.0	74.8	58.1
+ 425 - 500	10	82.3	54.7	84.7	61.8
+ 500 - 600	11	89.9	59.9	90.7	65.9
+ 600 - 850	12	96.2	67.4	96.2	71.9
+ 850 - 1180	13	98.3	69.7	97.6	73.7
+ 1180	14	95.4	70.4	94.8	74.2
total		64.7		74.2	

Exp. 3 : Test 3

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	19.0	19.0	27.5	27.5
+ 45 - 53	2	4.4	17.7	29.2	27.7
+ 53 - 63	3	13.5	17.4	34.8	28.3
+ 63 - 75	4	3.0	15.3	38.6	29.8
+ 75 - 105	5	30.2	18.0	42.7	32.1
+ 105 - 150	6	40.2	23.9	50.7	37.1
+ 150 - 212	7	47.9	32.0	57.2	43.9
+ 212 - 300	8	58.2	40.3	64.9	50.4
+ 300 - 425	9	70.5	50.0	74.8	58.1
+ 425 - 500	10	82.3	54.7	84.7	61.8
+ 500 - 600	11	89.9	59.9	90.7	65.9
+ 600 - 850	12	96.2	67.4	96.2	71.9
+ 850 - 1180	13	98.3	69.7	97.6	73.7
+ 1180	14	95.4	70.4	94.8	74.2
total		64.7		74.2	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	feed to cyclone frac %	feed to cyclone cum %	feed to cyclone frac % smooth	feed to cyclone cum % smooth
- 75	1	N.A.	N.A.	12.5	12.5
+ 75 - 106	2	N.A.	N.A.	2.7	15.2
+ 106 - 150	3	N.A.	N.A.	4.8	20.0
+ 150 - 212	4	N.A.	N.A.	9.3	29.4
+ 212 - 300	5	N.A.	N.A.	12.2	41.6
+ 300 - 425	6	N.A.	N.A.	17.2	58.8
+ 425 - 500	7	N.A.	N.A.	8.6	67.3
+ 500 - 600	8	N.A.	N.A.	9.5	76.9
+ 600 - 850	9	N.A.	N.A.	15.7	92.5
+ 850 - 1180	10	N.A.	N.A.	5.5	98.1
+ 1180	11	N.A.	N.A.	1.9	100.0
total		N.A.		100.0	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	cyclone o/f frac %	cyclone o/f cum %	cyclone o/f frac % smooth	cyclone o/f cum % smooth
- 75	1	54.0	54.0	55.3	55.3
+ 75 - 106	2	6.6	60.6	6.4	61.7
+ 106 - 150	3	9.2	69.7	8.6	70.3
+ 150 - 212	4	11.7	81.4	11.2	81.5
+ 212 - 300	5	9.9	91.3	9.5	90.9
+ 300 - 425	6	6.5	97.8	6.0	97.0
+ 425 - 500	7	1.4	99.2	1.4	98.4
+ 500 - 600	8	0.5	99.7	0.8	99.2
+ 600 - 850	9	0.2	99.9	0.4	99.6
+ 850 - 1180	10	0.1	100.0	0.3	99.8
+ 1180	11	0.0	100.0	0.2	100.0
total		100.0		100.0	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 75	1	N.A.	N.A.	41.1	41.1
+ 75 - 106	2	N.A.	N.A.	7.7	48.8
+ 106 - 150	3	N.A.	N.A.	12.1	60.9
+ 150 - 212	4	N.A.	N.A.	13.9	74.8
+ 212 - 300	5	N.A.	N.A.	11.8	86.6
+ 300 - 425	6	N.A.	N.A.	9.2	95.8
+ 425 - 500	7	N.A.	N.A.	2.1	97.9
+ 500 - 600	8	N.A.	N.A.	1.1	99.0
+ 600 - 850	9	N.A.	N.A.	0.5	99.5
+ 850 - 1180	10	N.A.	N.A.	0.3	99.8
+ 1180	11	N.A.	N.A.	0.2	100.0
total		N.A.		100.0	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 75	1	5.3	5.3	5.4	5.4
+ 75 - 106	2	1.8	7.1	2.1	7.5
+ 106 - 150	3	4.1	11.2	4.2	11.7
+ 150 - 212	4	9.3	20.6	9.0	20.7
+ 212 - 300	5	13.2	33.8	12.7	33.4
+ 300 - 425	6	19.6	53.4	19.0	52.4
+ 425 - 500	7	9.8	63.2	9.8	62.2
+ 500 - 600	8	10.9	74.1	11.0	73.2
+ 600 - 850	9	17.9	92.0	18.2	91.4
+ 850 - 1180	10	6 1	98.1	6.4	97.8
+ 1180	11	1.9	100.0	2.2	100.0
total		100.0		100.0	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 75	1	27.3	27.3	26.8	26.8
+ 75 - 106	2	5.9	33.2	5.9	32.8
+ 106 - 150	3	9.1	42.3	9.1	41.9
+ 150 - 212	4	14.5	56.8	14.5	56.4
+ 212 - 300	5	15.6	72.4	15.7	72.1
+ 300 - 425	6	16.4	88.8	16.4	88.5
+ 425 - 500	7	5.1	93.9	5.2	93.6
+ 500 - 600	8	3.5	97.4	3.6	97.2
+ 600 - 850	9	2.0	99.4	2.0	99.2
+ 850 - 1180	10	0.3	99.7	0.4	99.6
+ 1180	11	0.3	100.0	0.4	100.0
total		100.0		100.0	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	screen disch. frac %	screen disch. cum %	screen disch. frac % smooth	screen disch. cum % smooth
- 75	1	3.9	3.9	3.7	3.7
+ 75 - 106	2	1.7	5.6	1.7	5.4
+ 106 - 150	3	3.7	9.3	3.8	9.2
+ 150 - 212	4	7.6	17.0	8.1	17.3
+ 212 - 300	5	11.0	26.0	11.7	29.0
+ 300 - 425	6	18.1	46.1	18.5	47.5
+ 425 - 500	7	10.1	56.2	10.1	57.6
+ 500 - 600	8	12.1	68.3	11.9	69.5
+ 600 - 850	9	21.5	89.8	20.6	90.2
+ 850 - 1180	10	7.6	97.4	7.3	97.5
+ 1180	11	2.6	100.0	2.5	100.0
total		100.0		100.0	

Exp. 4 : Test 3

General running conditions (data as is and smoothed data)

	cyclone u/f	screen disch.	screen u/f	thickener prod
solid t/hr as is	1.430	0.930	0.490	0.200
solid t/hr smoothed	1.432	1.145	0.486	0.199
slurry t/hr smoothed	3.294	1.538	2.462	0.706
% H2O surface	55.88	25.67	80.74	71.68
% H2O surface smoothed	56.53	25.56	80.26	71.83
% ash	17.12	15.33	21.67	12.31
% ash smoothed	17.58	15.04	21.42	12.34

solid screen inlet t/hr	solid screen outlet t/hr	H2O surface screen inlet t/hr	H2O surface screen outlet t/hr	ash inlet screen t/hr	ash outlet screen t/hr
1.631	1.631	2.370	2.370	0.276	0.276

Exp. 4 : Test 3

Detailed solid mass balance across unit screen for each size class

size um	size class	% size distn. screen inlet	screen inlet t/hr	% size distn. screen outlet	screen outlet t/hr
- 45	1	7.0	0.114	7.0	0.114
+ 45 - 53	2	0.9	0.0140	0.9	0.0140
+ 53 - 63	3	0.8	0.0130	0.8	0.0130
+ 63 - 75	4	1.5	0.0252	1.5	0.0252
+ 75 - 105	5	2.4	0.0394	2.4	0.0394
+ 105 - 150	6	4.8	0.0781	4.8	0.0781
+ 150 - 212	7	9.2	0.150	9.2	0.150
+ 212 - 300	8	12.6	0.205	12.6	0.205
+ 300 - 425	9	17.9	0.292	17.9	0.292
+ 425 - 500	10	8.8	0.144	8.8	0.144
+ 500 - 600	11	9.9	0.162	9.9	0.162
+ 600 - 850	12	16.4	0.267	16.4	0.267
+ 850 - 1180	13	5.7	0.0931	5.7	0.0931
+ 1180	14	2.1	0.0348	2.1	0.0348

Exp. 4 : Test 3

% Total Retention (data as is and smoothed data)

size um	size class	% frac retention	% cum retention	% frac retention smooth	% cum retention smooth
- 45	1	13.1	13.1	19.4	19.4
+ 45 - 53	2	2.3	12.1	23.4	19.8
+ 53 - 63	3	8.9	11.8	28.1	20.6
+ 63 - 75	4	15.2	12.3	34.2	22.7
+ 75 - 105	5	34.3	16.6	40.0	26.0
+ 105 - 150	6	43.2	24.3	47.0	31.8
+ 150 - 212	7	50.9	33.8	53.3	39.2
+ 212 - 300	8	60.3	42.6	61.4	46.4
+ 300 - 425	9	71.4	52.0	71.7	54.3
+ 425 - 500	10	83.3	56.5	82.6	58.1
+ 500 - 600	11	90.1	61.1	89.4	62.2
+ 600 - 850	12	96.4	67.7	95.7	68.1
+ 850 - 1180	13	97.7	69.6	96.8	69.8
+ 1180	14	93.0	70.2	88.4	70.2
total		64.7		59.0	

Exp. 4 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 45	1	18.7	18.7	18.7	18.7
+ 45 - 53	2	1.9	20.6	1.9	20.6
+ 53 - 63	3	2.2	22.8	2.2	22.8
+ 63 - 75	4	3.2	26.0	3.2	26.0
+ 75 - 106	5	5.6	31.6	5.6	31.6
+ 106 - 150	6	9.6	41.2	9.6	41.2
+ 150 - 212	7	14.2	55.4	14.2	55.4
+ 212 - 300	8	14.6	70.0	14.6	70.0
+ 300 - 425	9	15.0	85.0	14.9	84.9
+ 425 - 500	10	4.9	89.9	4.9	89.8
+ 500 - 600	11	4.3	94.2	4.2	94.0
+ 600 - 850	12	4.3	98.5	4.2	98.2
+ 850 - 1180	13	0.9	99.4	1.3	99.5
+ 1180	14	0.6	100.0	0.5	100.0
total		100.0		100.0	

Exp. 4 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 45	1	4.9	4.9	5.4	5.4
+ 45 - 53	2	0.5	5.4	0.7	6.1
+ 53 - 63	3	0.4	5.9	0.6	6.7
+ 63 - 75	4	0.9	6.8	1.3	8.0
+ 75 - 106	5	1.8	8.6	2.0	9.9
+ 106 - 150	6	3.9	12.4	4.1	14.1
+ 150 - 212	7	8.2	20.6	8.5	22.6
+ 212 - 300	8	12.0	32.6	12.3	34.9
+ 300 - 425	9	18.3	50.9	18.3	53.2
+ 425 - 500	10	9.6	60.6	9.4	62.6
+ 500 - 600	11	11.1	71.7	10.7	73.3
+ 600 - 850	12	18.9	90.6	18.0	91.3
+ 850 - 1180	13	6.6	97.2	6.3	97.6
+ 1180	14	2.8	100.0	2.4	100.0
total		100.0		100.0	

Exp. 4 : Test 3

% Particle Size Distribution (data as is and smoothed)

size um	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 45	1	19.1	19.1	18.9	18.9
+ 45 - 53	2	2.2	21.3	2.2	21.1
+ 53 - 63	3	1.9	23.2	1.9	23.0
+ 63 - 75	4	3.4	26.7	3.4	26.4
+ 75 - 106	5	4.9	31.6	4.9	31.3
+ 106 - 150	6	8.6	40.2	8.5	39.8
+ 150 - 212	7	14.6	54.8	14.4	54.2
+ 212 - 300	8	16.4	71.2	16.2	70.5
+ 300 - 425	9	17.1	88.4	17.0	87.5
+ 425 - 500	10	5.1	93.4	5.2	92.6
+ 500 - 600	11	3.4	96.9	3.5	96.2
+ 600 - 850	12	2.1	99.0	2.4	98.6
+ 850 - 1180	13	0.4	99.4	0.6	99.2
+ 1180	14	0.6	100.0	0.8	100.0
total		100.0		100.0	

Run 5

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 75	1	40.9	40.9	39.6	39.6
+ 75 - 106	2	7.4	48.3	7.5	47.1
+ 106 - 150	3	9.0	57.3	9.1	56.2
+ 150 - 212	4	11.2	68.5	11.2	67.4
+ 212 - 300	5	10.1	78.7	10.2	77.6
+ 300 - 425	6	10.6	89.2	10.5	88.1
+ 425 - 500	7	3.6	92.8	3.7	91.8
+ 500 - 600	8	3.4	96.2	3.3	95.2
+ 600 - 850	9	3.4	99.6	3.3	98.5
+ 850 - 1180	10	0.4	100.0	1.1	99.6
+ 1180	11	0.0	100.0	0.4	100.0
total		100.0		100.0	

Run 5

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 75	1	4.8	4.8	3.9	3.9
+ 75 - 106	2	1.6	6.4	1.7	5.6
+ 106 - 150	3	2.8	9.2	2.9	8.5
+ 150 - 212	4	4.8	14.0	4.9	13.4
+ 212 - 300	5	7.8	21.8	7.8	21.2
+ 300 - 425	6	15.3	37.1	15.4	36.6
+ 425 - 500	7	10.0	47.1	10.0	46.6
+ 500 - 600	8	12.9	60.0	12.8	59.4
+ 600 - 850	9	25.4	85.4	25.5	84.9
+ 850 - 1180	10	9.8	95.2	10.3	95.2
+ 1180	11	4.8	100.0	4.8	100.0
total		100.0		100.0	

Run 5

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 75	1	36.3	36.3	35.2	35.2
+ 75 - 106	2	6.3	42.5	6.5	41.6
+ 106 - 150	3	8.3	50.8	8.4	50.0
+ 150 - 212	4	10.6	61.4	10.6	60.6
+ 212 - 300	5	11.4	72.8	11.4	71.9
+ 300 - 425	6	14.2	87.1	14.0	85.9
+ 425 - 500	7	5.6	92.7	5.7	91.6
+ 500 - 600	8	4.1	96.9	4.3	96.0
+ 600 - 850	9	2.8	99.7	2.9	98.9
+ 850 - 1180	10	0.3	100.0	0.6	99.5
+ 1180	11	0.0	100.0	0.5	100.0
total		100.0		100.0	

Run 5

% Particle Size Distribution (data as is and smoothed)

size (um)	size ass	scn dis A frac %	scn dis A cum %	scn dis A frac % smooth	scn dis A cum % smooth	scn dis B frac %	scn dis B cum %
- 75	1	3.7	3.9	3.7	3.7	5.1	5.1
+ 75 - 106	2	1.3	5.6	1.7	5.5	1.4	6.4
+ 106 - 150	3	2.5	9.3	3.8	8.4	2.7	9.2
+ 150 - 212	4	4.6	17.0	8.1	13.1	5.1	14.2
+ 212 - 300	5	7.0	26.0	11.7	20.4	6.0	22.2
+ 300 - 425	6	14.6	46.1	18.5	34.8	15.2	37.2
+ 425 - 500	7	9.7	56.2	10.1	44.4	10.1	47.6
+ 500 - 600	8	13.0	68.3	11.9	57.3	12.9	60.4
+ 600 - 850	9	27.9	89.8	20.6	84.1	26.1	86.5
+ 850 - 1180	10	11.3	97.4	7.3	95.1	10.1	96.7
+ 1180	11	4.2	100.0	2.5	100.0	3.3	100.0
total		100.0		100.0		100.0	

Run 4

General Running Conditions (Data as is and smoothed)

	cyc u/f	thk prod	scn dis	scn u/f	feed to cyc	cyc o/f	thk o/f
solid t/hr	1.135	N.A.	1.121	0.277	N.A.	0.187	N.A.
solid t/hr smooth	1.130	0.121	0.973	0.278	1.318	0.188	0.067
slurry t/hr	2.400	N.A.	1.510	1.260	N.A.	7.995	N.A.
slurry t/hr smooth	2.298	0.339	1.313	1.325	9.661	7.378	7.025
% H2O	52.86	N.A.	25.47	77.98	N.A.	97.66	N.A.
% H2O smooth	50.83	64.32	25.88	79.03	86.36	97.45	99.05
% solid	47.14	N.A.	74.53	22.02	N.A.	2.55	N.A.
% solid smooth	49.17	35.68	74.12	20.97	13.64	2.55	0.95

N.B. % H2O = surface moisture

solid scn inlet t/hr	solid scn outlet t/hr	H2O scn inlet t/hr	H2O scn outlet t/hr	solid cyc inlet t/hr	solid cyc outlet t/hr	H2O cyc inlet t/hr	H2O cyc outlet t/hr
1.251	1.251	1.386	1.387	1.318	1.318	8.343	8.358

solid thk inlet t/hr	solid thk outlet t/hr	H2O thk inlet t/hr	H2O thk outlet t/hr	solid sump inlet t/hr	solid sump outlet t/hr	H2O sump inlet t/hr	H2O sump outlet t/hr
0.188	0.188	7.190	7.176	1.318	1.318	8.345	8.343

Run 4

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. sump inlet	sump inlet solid flow rate t/hr	% size distri. sump outlet	sump outlet solid flow rate t/hr
- 75	1	12.5	0.165	12.5	0.165
+ 75 - 106	2	2.7	0.0355	2.7	0.0355
+ 106 - 150	3	4.8	0.0639	4.8	0.0639
+ 150 - 212	4	9.4	0.123	9.3	0.123
+ 212 - 300	5	12.2	0.161	12.2	0.161
+ 300 - 425	6	17.2	0.226	17.2	0.226
+ 425 - 500	7	8.6	0.113	8.6	0.113
+ 500 - 600	8	9.5	0.126	9.5	0.126
+ 600 - 850	9	15.7	0.206	15.7	0.206
+ 850 - 1180	10	5.5	0.0726	5.5	0.0726
+ 1180	11	1.9	0.0257	1.9	0.0257

Run 4

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. thickener inlet	thickener inlet solid flow rate t/hr	% size distri. thickener outlet	thickener outlet solid flow rate t/hr
- 75	1	55.3	0.104	55.3	0.104
+ 75 - 106	2	6.4	0.0121	6.4	0.0121
+ 106 - 150	3	8.6	0.0162	8.6	0.0162
+ 150 - 212	4	11.2	0.210	11.2	0.0210
+ 212 - 300	5	9.5	0.178	9.5	0.0178
+ 300 - 425	6	6.0	0.113	6.0	0.0113
+ 425 - 500	7	1.4	0.00267	1.4	0.00267
+ 500 - 600	8	0.8	0.00147	0.8	0.00147
+ 600 - 850	9	0.4	0.000763	0.4	0.000763
+ 850 - 1180	10	0.3	0.000479	0.3	0.000479
+ 1180	11	0.2	0.000318	0.2	0.000318

Run 4

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. cyclone inlet	cyclone inlet solid flow rate t/hr	% size distri. cyclone outlet	cyclone outlet solid flow rate t/hr
- 75	1	12.5	0.165	12.5	0.165
+ 75 - 106	2	2.7	0.0355	2.7	0.0355
+ 106 - 150	3	4.8	0.0639	4.8	0.0639
+ 150 - 212	4	9.3	0.123	9.3	0.123
+ 212 - 300	5	12.2	0.161	12.2	0.161
+ 300 - 425	6	17.2	0.226	17.2	0.226
+ 425 - 500	7	8.6	0.113	8.6	0.113
+ 500 - 600	8	9.5	0.126	9.5	0.126
+ 600 - 850	9	15.7	0.206	15.7	0.206
+ 850 - 1180	10	5.5	0.0726	5.5	0.0726
+ 1180	11	1.9	0.0257	1.9	0.0257

Run 4

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. screen inlet	screen inlet solid flow rate t/hr	% size distri. screen outlet	screen outlet solid flow rate t/hr
- 75	1	8.9	0.111	8.8	0.111
+ 75 - 106	2	2.6	0.0327	2.6	0.0327
+ 106 - 150	3	5.0	0.0623	5.0	0.0623
+ 150 - 212	4	9.5	0.119	9.5	0.119
+ 212 - 300	5	12.6	0 158	12.6	0.158
+ 300 - 425	6	18.1	0.226	18.1	0.226
+ 425 - 500	7	9.0	0.113	9.0	0.113
+ 500 - 600	8	10.0	0.126	10.0	0.126
+ 600 - 850	9	16.5	0.206	16.5	0.206
+ 850 - 1180	10	5.8	0.0725	5.8	0.0725
+ 1180	11	2.0	0.0255	2.0	0.0255

Run 4

% Total Retention (data as is and smoothed)

size (um)	size class	total % retention frac.	total % retention cum %	total % retention frac smooth	total % retention cum smooth
- 75	1	36.6	36.6	32.6	32.6
+ 75 - 106	2	53.8	40.6	49.8	36.5
+ 106 - 150	3	62.2	47.1	59.4	43.4
+ 150 - 212	4	68.0	54.8	66.1	51.7
+ 212 - 300	5	74.1	61.0	72.3	58.5
+ 300 - 425	6	81.7	67.8	79.8	65.3
+ 425 - 500	7	88.9	70.8	87.2	68.3
+ 500 - 600	8	93.3	73.9	92.1	71.5
+ 600 - 850	9	97.8	78.5	97.4	76.1
+ 850 - 1180	10	99.0	79.8	98.3	77.4
+ 1180	11	97.2	80.2	95.6	77.8
total		80.2		77.8	

Run 4

% Total Retention (data as is and smoothed)

size (um)	size class	total % retention frac.	total % retention cum %	total % retention frac smooth	total % retention cum smooth
- 75	1	36.6	36.6	32.6	32.6
+ 75 - 106	2	53.8	40.6	49.8	36.5
+ 106 - 150	3	62.2	47.1	59.4	43.4
+ 150 - 212	4	68.0	54.8	66.1	51.7
+ 212 - 300	5	74.1	61.0	72.3	58.5
+ 300 - 425	6	81.7	67.8	79.8	65.3
+ 425 - 500	7	88.9	70.8	87.2	68.3
+ 500 - 600	8	93.3	73.9	92.1	71.5
+ 600 - 850	9	97.8	78.5	97.4	76.1
+ 850 - 1180	10	99.0	79.8	98.3	77.4
+ 1180	11	97.2	80.2	95..	77.8
total		80.2		77.8	

Run 4

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	thickener o/f frac %	thickener o/f cum %	thickener o/f frac % smooth	thickener o/f cum % smooth
- 75	1	N.A.	N.A.	80.8	80.8
+ 75 - 106	2	N.A.	N.A.	4.2	85.0
+ 106 - 150	3	N.A.	N.A.	2.3	87.3
+ 150 - 212	4	N.A.	N.A.	6.2	93.5
+ 212 - 300	5	N.A.	N.A.	5.2	98.7
+ 300 - 425	6	N.A.	N.A.	0.4	99.1
+ 425 - 500	7	N.A.	N.A.	0.2	99.3
+ 500 - 600	8	N.A.	N.A.	0.2	99.5
+ 600 - 850	9	N.A.	N.A.	0.2	99.6
+ 850 - 1180	10	N.A.	N.A.	0.2	99.8
+ 1180	11	N.A.	N.A.	0.2	100.0
total		N.A.		100.0	

Run 6

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	cyclone u/f frac %	cyclone u/f cum %	cyclone u/f frac % smooth	cyclone u/f cum % smooth
- 75	1	3.7	3.7	3.1	3.1
+ 75 - 106	2	1.3	5.0	1.2	4.3
+ 106 - 150	3	2.5	7.5	2.3	6.7
+ 150 - 212	4	4.8	12.3	4.5	11.1
+ 212 - 300	5	8.1	20.3	7.7	18.9
+ 300 - 425	6	15.9	36.3	15.7	34.5
+ 425 - 500	7	10.3	46.6	10.4	44.9
+ 500 - 600	8	13.2	59.8	13.6	58.5
+ 600 - 850	9	26.1	85.9	26.6	85.1
+ 850 - 1180	10	10.4	96.3	10.7	95.8
+ 1180	11	3.7	100.0	4.2	100.0
total		100.0		100.0	

Run 6

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	screen u/f frac %	screen u/f cum %	screen u/f frac % smooth	screen u/f cum % smooth
- 75	1	34.5	34.5	33.7	33.7
+ 75 - 106	2	6.8	41.3	6.8	40.4
+ 106 - 150	3	8.2	49.5	8.1	48.5
+ 150 - 212	4	10.8	60.2	10.6	59.1
+ 212 - 300	5	11.8	72.0	11.6	70.8
+ 300 - 425	6	14.6	86.6	14.4	85.2
+ 425 - 500	7	5.6	92.2	5.7	90.9
+ 500 - 600	8	4.3	96.5	4.4	95.3
+ 600 - 850	9	3.0	99.5	3.5	98.8
+ 850 - 1180	10	0.3	99.8	0.7	99.5
+ 1180	11	0.2	100.0	0.5	100.0
total		100.0		100.0	

Run 6

% Particle Size Distribution (data as is and smoothed)

size (um)	size class	scn dis A frac %	scn dis A cum %	scn dis A frac % smooth	scn dis A cum % smooth	scn dis B frac %	scn dis B cum %
- 75	1	3.4	3.4	2.3	2.3	5.3	5.3
+ 75 - 106	2	1.5	4.9	1.3	3.6	1.4	6.7
+ 106 - 150	3	2.9	7.8	2.6	6.2	3.0	9.7
+ 150 - 212	4	5.3	13.1	4.7	10.9	5.4	15.1
+ 212 - 300	5	8.1	21.2	7.7	18.6	8.6	23.7
+ 300 - 425	6	15.3	36.4	15.0	33.6	15.4	39.2
+ 425 - 500	7	10.0	46.4	10.1	43.7	10.0	49.2
+ 500 - 600	8	13.4	59.8	13.6	57.3	13.1	62.3
+ 600 - 850	9	26.1	85.9	27.3	84.6	25.0	87.3
+ 850 - 1180	10	10.3	96.3	11.1	95.7	9.4	96.7
+ 1180	11	3.7	100.0	4.3	100.0	3.3	100.0
total		100.0		100.0		100.0	

Run 5

General Running Conditions (Data as is and smoothed)

	cyc u/f	thk prod	scn dis	scn u/f	feed to cyc	cyc o/f	thk o/f
solid t/hr	2.030	0.590	1.580	0.640	N.A.	0.610	0.020
solid t/hr smooth	1.966	0.582	1.872	0.676	2.568	0.603	0.021
slurry t/hr	4.200	1.490	2.060	2.980	N.A.	7.090	N.A.
slurry t/hr smooth	4.110	1.469	2.447	3.133	11.393	7.288	5.897
% H2O	51.86	60.40	23.47	78.34	78.80	91.37	99.64
% H2O smooth	52.17	60.37	23.49	78.43	77.46	91.73	99.64
% solid	48.14	39.60	76.53	21.66	21.20	8.63	0.36
% solid smooth	47.83	33.63	76.51	21.57	22.54	8.27	0.36

N.B. % H2O = surface moisture

solid scn inlet t/hr	solid scn outlet t/hr	H2O scn inlet t/hr	H2O scn outlet t/hr	solid cyc inlet t/hr	solid cyc outlet t/hr	H2O cyc inlet t/hr	H2O cyc outlet t/hr
2.548	2.548	3.031	3.032	2.568	2.569	8.825	8.825

solid thk inlet t/hr	solid thk outlet t/hr	H2O thk inlet t/hr	H2O thk outlet t/hr	solid sump inlet t/hr	solid sump outlet t/hr	H2O sump inlet t/hr	H2O sump outlet t/hr
0.603	0.603	6.685	6.763	2.569	2.568	8.908	8.825

Run 5

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. sump inlet	sump inlet solid flow rate t/hr	% size distri. sump outlet	sump outlet solid flow rate t/hr
- 75	1	12.2	0.313	12.2	0.312
+ 75 - 106	2	3.0	0.0781	3.0	0.0781
+ 106 - 150	3	4.4	0.114	4.4	0.113
+ 150 - 212	4	6.5	0.167	6.5	0.167
+ 212 - 300	5	8.5	0.218	8.5	0.218
+ 300 - 425	6	14.1	0.363	14.1	0.363
+ 425 - 500	7	8.5	0.219	8.5	0.219
+ 500 - 600	8	10.6	0.272	10.6	0.272
+ 600 - 850	9	20.3	0.521	20.3	0.521
+ 850 - 1180	10	8.1	0.209	8.1	0.209
+ 1180	11	3.7	0.0960	3.7	0.0960

Run 5

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. thickener inlet	thickener inlet solid flow rate t/hr	% size distri. thickener outlet	thickener outlet solid flow rate t/hr
- 75	1	39.1	0.236	39.1	0.236
+ 75 - 106	2	7.4	0.0445	7.4	0.0445
+ 106 - 150	3	9.3	0.0563	9.3	0.0564
+ 150 - 212	4	11.7	0.0706	11.7	0.0706
+ 212 - 300	5	10.7	0.0648	7	0.0648
+ 300 - 425	6	10.2	0.0612	10.2	0.0612
+ 425 - 500	7	3.6	0.0218	3.6	0.0218
+ 500 - 600	8	3.2	0.0195	3.2	0.0195
+ 600 - 850	9	3.2	0.0193	3.2	0.0193
+ 850 - 1180	10	1.1	0.006437	1.1	0.00646
+ 1180	11	0.4	0.00264	0.4	0.00264

Run 5

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. cyclone inlet	cyclone inlet solid flow rate t/hr	% size distri. cyclone outlet	cyclone outlet solid flow rate t/hr
- 75	1	12.2	0.312	12.2	0.313
+ 75 - 106	2	3.0	0.0781	3.0	0.0781
+ 106 - 150	3	4.4	0.113	4.4	0.114
+ 150 - 212	4	6.5	0.167	6.5	0.167
+ 212 - 300	5	8.5	0.218	8.5	0.218
+ 300 - 425	6	14.1	0.363	14.1	0.363
+ 425 - 500	7	8.5	0.219	8.5	0.219
+ 500 - 600	8	10.6	0.272	10.6	0.272
+ 600 - 850	9	20.3	0.521	20.3	0.521
+ 850 - 1180	10	8.1	0.209	8.1	0.209
+ 1180	11	3.7	0.0960	3.7	0.0961

Run 5

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. screen inlet	screen inlet solid flow rate t/hr	% size distri. screen outlet	screen outlet solid flow rate t/hr
- 75	1	12.1	0.307	12.1	0.308
+ 75 - 106	2	3.0	0.0770	3.0	0.0770
+ 106 - 150	3	4.3	0.110	4.3	0.110
+ 150 - 212	4	6.3	0.162	6.4	0.162
+ 212 - 300	5	8.3	0.212	8.3	0.212
+ 300 - 425	6	14.2	0.363	14.2	0.363
+ 425 - 500	7	8.6	0.219	8.6	0.219
+ 500 - 600	8	10.7	0.272	10.7	0.272
+ 600 - 850	9	20.4	0.521	20.4	0.521
+ 850 - 1180	10	8.2	0.209	8.2	0.209
+ 1180	11	3.8	0.0960	3.8	0.0960

Run 5

% Total Retention (data as is and smoothed)

size (um)	size class	total % retention frac.	total % retention cum %	total % retention frac smooth	total % retention cum smooth
- 75	1	27.5	27.5	22.7	22.7
+ 75 - 106	2	48.5	31.8	43.2	26.8
+ 106 - 150	3	52.6	36.4	48.6	31.7
+ 150 - 212	4	59.0	41.9	55.9	37.6
+ 212 - 300	5	66.5	47.9	63.8	44.0
+ 300 - 425	6	75.7	56.0	74.0	52.9
+ 425 - 500	7	84.1	60.3	82.3	57.3
+ 500 - 600	8	90.6	65.0	89.2	62.3
+ 600 - 850	9	96.7	72.4	96.2	70.2
+ 850 - 1180	10	99.1	74.6	98.0	72.6
+ 1180	11	100.0	75.6	96.4	73.5

Run 5

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	thickener o/f frac %	thickener o/f cum %	thickener o/f frac % smooth	thickener o/f cum % smooth
- 75	1	24.3	24.3	24.3	24.3
+ 75 - 106	2	5.4	29.7	5.4	29.7
+ 106 - 150	3	17.1	46.8	17.1	46.8
+ 150 - 212	4	24.9	71.6	24.9	71.6
+ 212 - 300	5	26.2	97.8	26.2	97.8
+ 300 - 425	6	0.4	98.2	0.4	98.2
+ 425 - 500	7	0.4	98.6	0.4	98.6
+ 500 - 600	8	0.4	98.9	0.4	98.9
+ 600 - 850	9	0.3	99.3	0.3	99.3
+ 850 - 1180	10	0.4	99.6	0.4	99.6
+ 1180	11	0.4	100.0	0.4	100.0
total		100.0		100.0	

Run 5

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	cyclone feed frac %	cyclone feed cum %	cyclone feed frac % smooth	cyclone feed cum % smooth
- 75	1	10.6	10.6	12.2	12.2
+ 75 - 106	2	2.8	13.4	3.0	15.2
+ 106 - 150	3	4.2	17.6	4.4	19.6
+ 150 - 212	4	6.4	24.0	6.5	26.1
+ 212 - 300	5	8.6	32.6	8.5	34.6
+ 300 - 425	6	14.7	47.3	14.1	48.7
+ 425 - 500	7	8.6	56.0	8.5	57.3
+ 500 - 600	8	10.9	66.9	10.6	67.8
+ 600 - 850	9	21.2	88.1	20.3	88.1
+ 850 - 1180	10	8.5	96.6	8.1	96.3
+ 1180	11	3.4	100.0	3.7	100.0
total		100.0		100.0	

Run 5

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	cyclone o/f frac %	cyclone o/f cum %	cyclone o/f frac % smooth	cyclone o/f cum % smooth
- 75	1	40.7	40.7	39.1	39.1
+ 75 - 106	2	7.4	48.1	7.4	46.5
+ 106 - 150	3	9.5	57.7	9.3	55.8
+ 150 - 212	4	12.0	69.7	11.7	67.5
+ 212 - 300	5	11.0	80.6	10.7	78.3
+ 300 - 425	6	10.1	90.7	10.2	88.4
+ 425 - 500	7	3.3	94.0	3.6	92.1
+ 500 - 600	8	2.7	96.7	3.2	95.3
+ 600 - 850	9	2.4	99.1	3.2	98.5
+ 850 - 1180	10	0.6	99.7	1.1	99.6
+ 1180	11	0.3	100.0	0.4	100.0
total		100.0		100.0	

Table 1 : Detailed Results of Experiment A

test I.D.	uf/f ratio	fine bed depth, mm	double layer depth, mm	double layer final % H2O	% H2O after mixing and vibration	% uf reten. w.r.t. feed ultra fine mass
A 1.1	0.20	33.00	34.00	19.59	11.73	100.00
A 1.2	0.20	35.00	35.00	21.58	14.65	100.00
A 2.1	0.22	39.00	35.00	19.58	18.37	100.00
A 2.2	0.22	35.00	34.00	20.11	15.18	100.00
A 3.1	0.25	35.00	32.00	23.56	16.80	88.82
A 3.2	0.25	30.00	31.00	24.80	20.87	85.12
A 3.3	0.25	35.00	33.00	24.28	14.39	88.33
A 3.4	0.25	35.00	32.80	23.51	19.31	95.21
A 4.1	0.29	36.00	40.00	28.95	17.50	78.45
A 4.2	0.29	34.50	39.70	25.45	23.90	77.86
A 4.2	0.29	34.50	38.70	24.87	28.58	87.60
A 4.4	0.29	34.00	38.00	24.97	22.60	84.06
A 4.5	0.29	34.00	38.50	23.32	22.70	88.99
A 4.6	0.29	35.00	39.00	27.82	22.70	81.40
A 4.7	0.29	35.00	38.50	25.85	23.60	81.49
A 4.8	0.29	30.00	34.80	25.65	22.40	82.82
A 4.9	0.29	31.50	35.00	24.75	23.10	82.99
A 4.10	0.29	34.50	38.70	26.06	22.50	81.05

APPENDIX E : Detailed Data For The Laboratory Scale Test Work

Run 6

General Running Conditions (Data as is and smoothed)

	cyc u/f	thk prod	scn dis	scn u/f	feed to cyc	cyc o/f	thk o/f
solid t/hr	1.951	0.600	1.330	0.470	N.A.	0.470	N.A.
solid t/hr smooth	2.037	0.390	1.962	0.466	2.477	0.440	0.049
slurry t/hr	4.090	1.470	1.770	2.190	N.A.	8.830	N.A.
slurry t/hr smooth	3.990	0.935	2.637	3.290	11.125	7.141	6.174
% H2O	52.32	58.86	25.08	78.54	75.68	94.54	N.A.
% H2O smooth	48.94	58.30	25.58	79.65	77.74	93.84	99.21
% solid	47.68	41.14	74.92	21.46	24.32	5.46	N.A.
% solid smooth	51.06	41.70	74.42	20.35	22.26	6.16	0.79

N.B. % H2O = surface moisture

solid scn inlet t/hr	solid scn outlet t/hr	H2O scn inlet t/hr	H2O scn outlet t/hr	solid cyc inlet t/hr	solid cyc outlet t/hr	H2O cyc inlet t/hr	H2O cyc outlet t/hr
2.427	2.428	2.498	2.499	2.477	2.477	8.648	8.648

solid thk inlet t/hr	solid thk outlet t/hr	H2O thk inlet t/hr	H2O thk outlet t/hr	solid sump inlet t/hr	solid sump outlet t/hr	H2O sump inlet t/hr	H2O sump outlet t/hr
0.440	0.439	6.700	6.670	2.477	2.477	8.623	8.648

Run 6

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. sump inlet	sump inlet solid flow rate t/hr	% size distri. sump outlet	sump outlet solid flow rate t/hr
- 75	1	9.1	0.225	9.1	0.225
+ 75 - 106	2	2.5	0.0618	2.5	0.0619
+ 106 - 150	3	3.9	0.0957	3.9	0.0957
+ 150 - 212	4	6.1	0.151	6.1	0.151
+ 212 - 300	5	8.4	0.209	8.4	0.209
+ 300 - 425	6	14.6	0.361	14.6	0.361
+ 425 - 500	7	9.1	0.226	9.1	0.225
+ 500 - 600	8	11.6	0.288	11.6	0.287
+ 600 - 850	9	22.3	0.552	22.3	0.552
+ 850 - 1180	10	8.9	0.221	8.9	0.221
+ 1180	11	3.5	0.0871	3.5	0.087

Run 6

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. thickener inlet	thickener inlet solid flow rate t/hr	% size distri. thickener outlet	thickener outlet solid flow rate t/hr
- 75	1	36.9	0.162	36.9	0.162
+ 75 - 106	2	8.3	0.0365	8.3	0.0364
+ 106 - 150	3	11.0	0.0483	11.0	0.0482
+ 150 - 212	4	13.7	0.0601	13.6	0.0599
+ 212 - 300	5	11.8	0.0519	11.8	0.0518
+ 300 - 425	6	9.6	0.0420	9.6	0.0420
+ 425 - 500	7	3.0	0.0133	3.0	0.0133
+ 500 - 600	8	2.5	0.0110	2.5	0.0110
+ 600 - 850	9	2.2	0.00982	2.2	0.00980
+ 850 - 1180	10	0.7	0.00293	0.7	0.00292
+ 1180	11	0.3	0.00153	0.3	0.00153

Run 6

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. cyclone inlet	cyclone inlet solid flow rate t/hr	% size distri. cyclone outlet	cyclone outlet solid flow rate t/hr
- 75	1	9.1	0.225	9.1	0.225
+ 75 - 106	2	2.5	0.0619	2.5	0.0619
+ 106 - 150	3	3.9	0.0957	3.9	0.0957
+ 150 - 212	4	6.1	0.151	6.1	0.151
+ 212 - 300	5	8.4	0.209	8.4	0.209
+ 300 - 425	6	14.6	0.361	14.6	0.361
+ 425 - 500	7	9.1	0.225	9.1	0.225
+ 500 - 600	8	11.6	0.287	11.6	0.287
+ 600 - 850	9	22.3	0.552	22.3	0.552
+ 850 - 1180	10	8.9	0.221	8.9	0.221
+ 1180	11	3.5	0.0871	3.5	0.0871

Run 6

Detailed Solid Mass Balance for Each Size Class

size (um)	size class	% size distri. screen inlet	screen inlet solid flow rate t/hr	% size distri. screen outlet	screen outlet solid flow rate t/hr
- 75	1	8.3	0.203	8.3	0.203
+ 75 - 106	2	2.4	0.0573	2.4	0.0573
+ 106 - 150	3	3.6	0.0877	3.6	0.0878
+ 150 - 212	4	5.8	0.142	5.8	0.142
+ 212 - 300	5	8.4	0.205	8.4	0.205
+ 300 - 425	6	14.9	0.361	14.9	0.361
+ 425 - 500	7	9.3	0.225	9.3	0.225
+ 500 - 600	8	11.8	0.287	11.8	0.287
+ 600 - 850	9	22.7	0.552	22.7	0.552
+ 850 - 1180	10	9.1	0.221	9.1	0.221
+ 1180	11	3.6	0.0870	3.6	0.0870

Run 6

% Total Retention (data as is and smoothed)

size (um)	size class	total % retention frac.	total % retention cum %	total % retention frac smooth	total % retention cum smooth
- 75	1	28.7	28.7	22.6	22.6
+ 75 - 106	2	48.4	32.9	45.1	27.5
+ 106 - 150	3	58.5	39.2	57.1	35.0
+ 150 - 212	4	65.5	46.6	65.2	43.7
+ 212 - 300	5	73.3	54.1	73.6	52.5
+ 300 - 425	6	80.9	62.9	81.4	62.4
+ 425 - 500	7	88.1	67.1	88.3	67.0
+ 500 - 600	8	92.8	71.6	92.8	71.7
+ 600 - 850	9	97.4	78.0	97.1	78.3
+ 850 - 1180	10	99.3	79.9	98.5	80.2
+ 1180	11	98.9	80.6	97.4	80.8

Run 6

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	thickener o/f frac %	thickener o/f cum %	thickener o/f frac % smooth	thickener o/f cum % smooth
- 75	1	N.A.	N.A.	45.6	45.6
+ 75 - 106	2	N.A.	N.A.	9.3	54.9
+ 106 - 150	3	N.A.	N.A.	16.1	71.0
+ 150 - 212	4	N.A.	N.A.	19.2	90.2
+ 212 - 300	5	N.A.	N.A.	8.8	99.0
+ 300 - 425	6	N.A.	N.A.	0.1	99.1
+ 425 - 500	7	N.A.	N.A.	0.1	99.3
+ 500 - 600	8	N.A.	N.A.	0.1	99.4
+ 600 - 850	9	N.A.	N.A.	0.2	99.6
+ 850 - 1180	10	N.A.	N.A.	0.2	99.8
+ 1180	11	N.A.	N.A.	0.2	100.0
total				100.0	

Run 6

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	feed to cyclone frac %	feed to cyclone cum %	feed to cyclone frac % smooth	feed to cyclone cum % smooth
- 75	1	6.7	6.7	9.1	9.1
+ 75 - 106	2	1.7	8.4	2.5	11.6
+ 106 - 150	3	2.8	11.2	3.9	15.5
+ 150 - 212	4	4.7	16.0	6.1	21.6
+ 212 - 300	5	7.4	23.3	8.4	30.0
+ 300 - 425	6	14.3	37.6	14.6	44.6
+ 425 - 500	7	9.5	47.1	9.1	53.7
+ 500 - 600	8	12.6	59.7	11.6	65.3
+ 600 - 850	9	25.6	85.3	22.3	87.6
+ 850 - 1180	10	10.4	95.7	8.9	96.5
+ 1180	11	4.3	100.0	3.5	100.0
total		100.0		100.0	

Run 6

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	cyclone o/f frac %	cyclone o/f cum %	cyclone o/f frac % smooth	cyclone o/f cum % smooth
- 75	1	38.5	38.5	36.9	36.9
+ 75 - 106	2	8.5	47.0	8.3	45.2
+ 106 - 150	3	11.4	58.4	11.0	56.2
+ 150 - 212	4	14.2	72.6	13.7	69.9
+ 212 - 300	5	12.1	84.7	11.8	81.7
+ 300 - 425	6	9.0	93.7	9.6	91.2
+ 425 - 500	7	2.3	96.0	3.0	94.2
+ 500 - 600	8	1.8	97.8	2.5	96.3
+ 600 - 850	9	1.3	99.1	2.2	99.0
+ 850 - 1180	10	0.5	99.6	0.7	99.7
+ 1180	11	0.3	100.0	0.3	100.0
total		100.0		100.0	

Run 6

% Particle Size Distribution (Data as is and smoothed)

size (um)	size class	thickener prod frac %	thickener prod cum %	thickener prod frac % smooth	thickener prod cum % smooth
- 75	1	35.6	35.6	35.8	35.8
+ 75 - 106	2	8.0	43.6	8.2	44.0
+ 106 - 150	3	10.1	53.8	10.3	54.3
+ 150 - 212	4	12.7	66.5	12.9	67.3
+ 212 - 300	5	12.1	78.6	12.2	79.5
+ 300 - 425	6	11.3	89.9	10.7	90.2
+ 425 - 500	7	3.8	93.6	3.4	93.6
+ 500 - 600	8	3.1	96.7	2.8	96.4
+ 600 - 850	9	2.9	99.7	2.5	98.9
+ 850 - 1180	10	0.3	100.0	0.7	99.6
+ 1180	11	0.0	100.0	0.4	100.0
total		100.0		100.0	

1 Porosity and Packing of Particles

1.1 Equal-Sized Spheres

Extensive research on the systematic packing of spheres was made by Graton and Fraser [4]. These authors showed that there are six ways in which spheres of equal size may be systematically packed, which were termed Cases 1 to 6.

Table 1 below shows the properties of these packed systems.

Table 1

Case No.	No. of Spheres in Contact	Description	Distances between Centres of Layers	Density of Unit Cell
1	6	cubic	2.000	0.5236
2	8	orthorhombic	1.732	0.6046
3	12	rhombohedral	1.414	0.7405
4	8	orthorhombic	2.000	0.6046
5	10	tetragonal	1.732	0.6981
6	12	rhombohedral	1.633	0.7405

As the number of spheres is increased, the density of the system will increase, except for Case 1 packing whose density remains constant.

This implies that the higher the number of spheres, the lower the porosity of the system, i.e. the 'void' volume is reduced.

1.2 Non-uniform Sized Particles

In 1946, H. Heywood [5] extended the study to packing of non-uniform sized spheres. His studies concluded that the density of a packed system increases with increasing contact points between particles. In a system composed of equal sized spheres, the number of points of contact can not exceed 12, but by introducing smaller spheres into the void spaces between the layer spheres, and still smaller spheres into the remaining voids, the number of points of contact and hence the density of the system may be increased.

APPENDIX G : Review Of Theories Concerning The Basic Concepts Involved In The Proposed Technique

Table 3 : Two-Sample Analysis of Moisture Levels of Primary and Secondary Dewatering Products of Tests Performed by the New Technique

(section 4-2-2)

Sample 1 : moisture level of primary dewatering product of tests performed by the new technique

Sample 2 : moisture level of secondary dewatering product of tests performed by the new technique

Sample statistics

	sample 1	sample 2	pooled
No. of observations	11	11	22
average	24.8091	24.6909	24.75
variance	0.562909	0.541211	0.427909
standard deviation	0.750273	0.541211	0.654148
median	24.8	24.8	24.8

Conf. Interval for Diff. in Means : 95 %

Equal Vars : Sample 1/Sample 2 = -0.463796/0.700159, 20 D.F.
Unequal Vars :Sample 1/Sample 2 = -0.467533/0.703897. 18.2 D.F.

Conf. Interval for ratio of Variance : 0 %
Sample 1 / Sample 2

Hypothesis Test for H0 : Diff. = 0

Computed t Stats. = 0.423698 vs Alt : NE
Sig. Level = 0.676308 at Alpha = 0.05
So DO NOT REJECT H0

Table 2 : Correlation Analysis Result Between % product Moisture and % - 150 um Material Content of the Product (New Technique)

(section 4-2-1)

	% moisture content	% - 150 um material
% moisture content	1.0000 11 0.0000	- 0.4923 11 0.1239
% - 150 um material	-0.4923 11 0.1239	1.0000 11 0.0000

In each cell :

1st No. = coefficient
2nd No. = sample size
3rd No. = significant level

Comments :

The correlation coefficient has a low absolute value (well below 0.99). The significant level is high (> 0.05). This is a weak correlation with low significance.

Table 1 : Two-Sample Analysis of Moisture Levels of Primary Dewatering Products of Tests Performed by the New and Conventional Techniques

(section 4-2-1)

Sample 1 : moisture level of primary dewatering product of tests performed by the conventional technique

Sample 2 : moisture level of primary dewatering product of tests performed by the new technique

Sample statistics

	sample 1	sample 2	pooled
No. of observations	5	11	16
average	28.5	24.8091	25.025
variance	2.015	0.562909	0.977792
standard deviation	1.41951	0.750273	0.988834
median	28.5	24.8	24.95

Conf. Interval for Diff. in Means : 95 %

Equal Vars : Sample 1/Sample 2 = -0.453274/1.83509,
14 D.F.
Unequal Vars :Sample 1/Sample 2 = -1.0371/2.41892.
5.0 D.F.

Conf. Interval for ratio of Variance : 0 %
Sample 1 / Sample 2

Hypothesis Test for H0 : Diff. = 0

Computed t Stats. = 1.29544 vs Alt : NE
Sig. Level = 0.216121 at Alpha = 0.05
So DO NOT REJECT H0

APPENDIX F Statistical Tests Of The Results Obtained From The Pilot Plant Test-Work

Table 5 : Detailed Result of Experiment E

initial % H2O : 29.82 %
uf/f mass ratio : 0.40

vibration time, minute	final % H2O
2"	23.58
18	23.46
16	24.46
14	24.69
12	24.16
10	24.00
8	23.81
6	24.02
4	23.04
2	25.39
1	21.97
1	23.31
0.5	22.19

Table 4 : Detailed Result of Experiment D

initial % H2O : 70.0 %
uf/f mass ratio : 0.40

vibration time, minute	final % H2O
20	25.95
18	26.85
16	30.42
14	27.85
12	28.85
10	27.66
8	28.17
6	32.00
4	30.69
2	30.59

Table 3 : Detailed Result of Experiment C

test I.D.	uf/f mass ratio	initial % H2O	final % H2O	% u/f retention w.r.t. feed uf mass
C 1.1	pure f	29.82	27.29	100.00
C 1.2	pure f	29.82	27.56	100.00
C 2.1	0.20	29.82	26.67	94.96
C 3.1	pure uf	29.82	23.10	97.35
C 3.2	pure uf	29.82	22.82	97.76

Table 2 : Detailed Result of Experiment B

test I.D.	uf/f mass ratio	initial % H2O	final % H2O	% uf retention w.r.t. feed uf mass
B 1.1	pure f	29.82	26.77	75.78
B 1.2	pure f	29.82	26.82	63.67
B 2.1	0.20	29.82	24.92	76.47
B 2.2	0.20	29.82	26.26	83.86
B 3.1	0.40	29.82	22.45	74.26
B 3.2	0.40	29.82	21.62	77.07
B 4.1	0.50	29.82	23.37	69.12
B 5.1	1.00	29.82	20.53	66.43
B 5.2	1.00	29.82	21.99	68.24
B 6.1	2.50	29.82	21.80	64.47
B 6.2	2.50	29.82	21.82	65.48
B 7.1	5.00	29.82	22.38	65.36
B 7.2	5.00	29.82	22.08	63.71
B 8.1	pure uf	29.82	22.63	60.39
B 8.2	pure uf	29.82	23.74	77.79
B 8.3	pure uf	29.82	24.36	80.53

Table 1 :Continued

test I.D.	uf/f ratio	fine bed depth, mm	double layer depth, mm	double layer final % H2O	% H2O after mixing and vibra-tion	% uf reten. w.r.t. feed ultra fine mass
A 8.1	1.20	19.00	21.00	27.54	18.72	69.09
A 8.2	1.20	18.00	27.00	24.95	18.41	83.59
A 8.3	1.20	20.00	24.00	24.63	23.26	73.99
A 8.4	1.20	19.00	28.00	24.82	26.25	88.52
A 8.5	1.20	16.00	30.00	29.87	13.38	88.01
A 9.1	1.50	20.00	30.00	22.81	17.70	98.95
A 10.1	2.00	8.00	18.00	23.89	18.57	88.14
A 10.2	2.00	9.00	25.00	28.02	11.50	72.72

Table 1 :Continued

test I.D.	uf/f ratio	fine bed depth, mm	double layer depth, mm	double layer final % H2O	% H2O after mixing and vibra-tion	% uf reten. w.r.t. feed ultra fine mass
A 5.1	0.50	35.00	36.00	22.45	19.33	80.85
A 5.2	0.50	35.80	39.00	27.76	18.85	80.75
A 5.3	0.50	35.00	40.00	27.53	17.40	66.58
A 5.4	0.50	32.00	37.50	27.07	19.18	74.56
A 6.1	0.67	35.00	43.00	26.00	18.64	66.54
A 6.2	0.67	35.00	43.00	25.49	12.55	61.75
A 6.3	0.67	35.00	45.00	24.18	N.A.	74.19
A 6.4	0.67	32.00	37.20	26.19	N.A.	66.81
A 6.5	0.67	35.00	43.00	25.18	18.76	61.59
A 6.6	0.67	30.00	40.00	23.76	10.42	93.21
A 7.1	1.00	17.00	N.A.	27.00	14.40	62.19
A 7.2	1.00	17.00	20.00	26.16	19.01	74.16
A 7.3	1.00	20.00	30.00	26.85	20.19	71.26
A 7.4	1.00	21.00	29.70	25.61	19.70	75.61
A 7.5	1.00	18.00	26.00	21.08	13.67	90.11
A 7.6	1.00	35.00	55.00	23.93	9.77	81.07

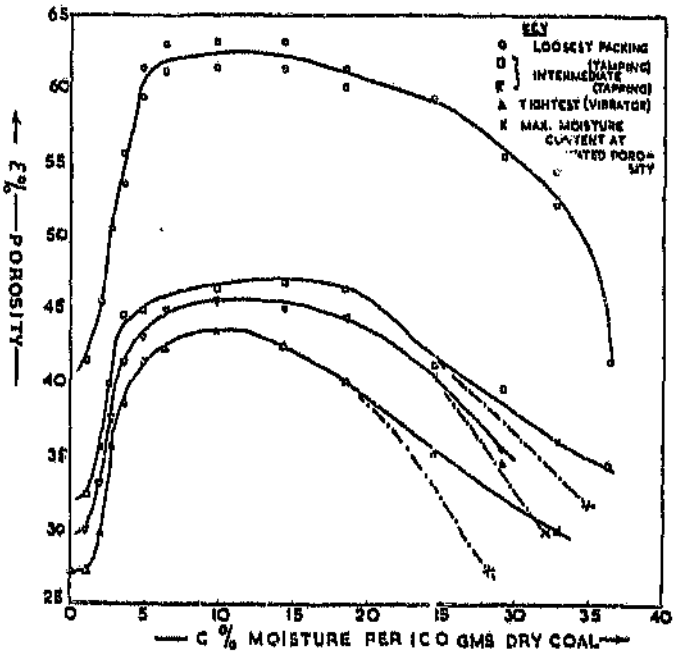
2 The Use of Fine Coal as a Filtration Medium for Ultra Fine Slurry

An investigation was conducted by Horsfall [3] between 1956 and 1957. However, the filtration medium used then was coarser 'smalls' (4" to 1 ") and the slurry used was a froth flotation product. Nevertheless, the basic principal is the same. His laboratory scale test results suggest that using ' smalls' (4 " to 1 ") as filtration medium for froth flotation fines, under static conditions, the retention of the froth flotation fines was between 70.0 % to 95.0%. During the tests, he observed a definite bed of fines on top of the 'small coal' bed.

increase the moisture holding potential of the mass, due to the additional available surface area for moisture adsorption provided by the 'free' ultra fine particles. Therefore the ratio of ultra fine content to fine content is of great importance in achieving the lowest possible moisture content.

Figure 2 . .

Relationship between Moisture Content and Porosity



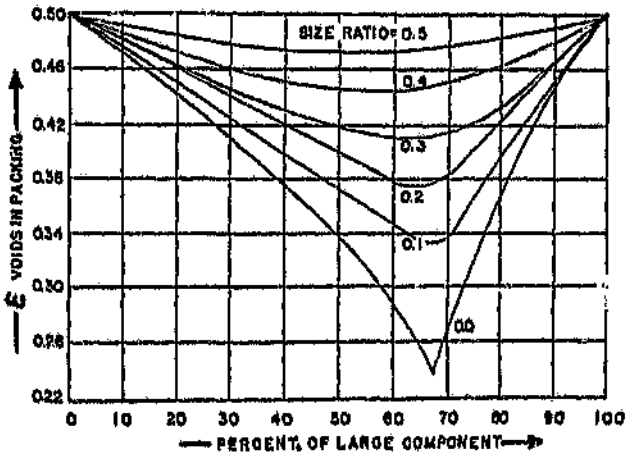
@@ extracted from C C Harris and H.G. Smith [6]

1.3 Random Packing of Particles

An extensive research programme was carried out by Furnas in which the porosity of binary mixtures of particles was determined. In general, two different sizes of particles having separately similar porosity will, when mixed together, produce a system of lower porosity than its component parts. Figure 1 below shows the relationship between porosity and size composition in a two component system.

Figure 1

Relationship between voids and size composition, two component system of broken solids



@@ Voids of single component : 0.50
@@ Notice the existence of a minimum porosity
@@ extracted form C C Harris and H.G. Smith [6]

The potential application of the above theory (1.3) on coal is clear. By mixing ultra fines and fines thoroughly, the new mixture should exhibit less void space available for moisture retention. However, one must bear in mind that in a coal mass, moisture is not only held within the 'void space' of the mass, but also on the surfaces of the coal particles.

By increasing the ultra fine content within the mixture, a saturation point will be reached whereby all available voids within the coarse coal mass has been occupied. Any additional increase in the ultra fine content will

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Name of thesis: Dewatering of fine and ultra fine coal by using-modifying conventional equipment

PUBLISHER:
University of the Witwatersrand, Johannesburg
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