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Recommended Citation

Kerr, Jonathan C., "Press Water Reclamation Using a New High Solids Filter" (1982). *Paper Engineering Senior Theses*. 213.
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PRESS WATER RECLAMATION USING A NEW HIGH SOLIDS FILTER

by

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A Thesis Submitted
in partial fulfillment of
the course requirements for
the Bachelor of Science Degree

Western Michigan University
Kalamazoo, Michigan
April, 1982

ABSTRACT

Press section water cannot be reused on a fine papermachine due solely to the fact that fibrous contaminants, specifically felt fibers that are removed by the felt cleaning system, cause an inordinate amount of trailing blade coater scratches and other defects in the final product. In this study, the feasability was examined of using a Ronnigen-Petter CycloSpray high solids filter to remove felt and cellulose fibers from press water.

By maintaining a constant fiber content of 0.4 lbs./1000 gallons and increasing the filler loading from 20 lbs./1000 gallons to 40 lbs./1000 gallons, the effect of increasing filler loading on fiber removal was studied. Major trends observed were as follows:

1. Accepts solids flow rate increased with increasing inlet solids flow rate (slope = 0.68)
2. Rejects solids flow rate was essentially constant with increasing inlet solids (slope = 0.04)
3. Accepts filler flow rate increased with increasing inlet filler flow rate (slope = 0.69)
4. Rejects filler flow rate was essentially constant with increasing inlet filler flow rate (slope = 0.03).

These trend observations lead to the conclusion that as filler loading increased, fiber removal from simulated press water was accomplished, by the Ronnigen-Petter CycloSpray high solids filter.

To further accentuate these results, the felt fiber inlet content was increased, which resulted in an increase in reject solids by almost the same amount and a decreased reject ash content.

Screen size best suited for fiber removal from press water was found to be 250 mesh stainless steel.

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INTRODUCTION AND BACKGROUND

The motivation for process water reclamation on the papermachine has been well established in that fresh water supplies have been dwindling and environmental regulations on effluents have been getting annually more severe. Virtually every commercial papermaker could benefit from maximum use of white water or, for that matter, any process water that has already been used at least once in the system. According to D. C. Haynes of Buckeye Cellulose: "Today, good management demands that white water be recirculated to maximum use without separation of the components and, after separation of the fiber and filler, that the clarified water be recirculated."[1]

The most obvious and frequent use of white water are for fan pump dilution, consistency regulation, and showers (both sheet knock-off and return wire roll showers). In some cases, however, fresh water must be used instead of recycled white water. High pressure felt cleaning showers is a good example. If one could reduce the introduction of fresh water on the wet end of the papermachine by utilizing water from the felt suction (uhle) boxes, a significant savings in materials and energy could result. Not only could the water be reused, but the mineral filler could also be reclaimed. This area of recycling white water is usually the last in which reclamation is attempted; however, there are some mills which are presently straining press water to remove fibrous contaminants and are recycling it along with other white water.[2]

Ronnigen-Petter Division of Dover Corporation, located in Portage, Michigan, has been producing a high-solids (300-600 ppm) filter for use on papermachine white water systems. This particular unit, the CycloSpray, has been under development for three years, in production for two, and has found successful applications in the plastic and the metal industries in solid/liquid separations. The filter has been installed at Plainwell Paper Company in Plainwell, Michigan and has been operating quite effectively on their number three machine since mid 1980. It is used to filter white water from the clear leg of the Impco Disc Save-All to produce wire shower water, returning the rejects to the cloudy leg of the saveall.

Ronnigen-Petter's Engineering Manager, R. B. DeVisser, suggested that this unit could be used to successfully filter felt hairs, fibers, fines, and fillers from uhle box water for use on the press felt showers, thereby reducing fresh water consumption and waste water treatment plant load. It has been seen in the past that fresh water is an absolute necessity for use on press felt showers, but if the synthetic felt fibers could be separated from uhle box water, this water could be reused with the tray water on the wet end of the papermachine.

As is noted in Dan Kaiser's report for Ronnigen-Petter, the common denominator in all papermachine wet presses is the fact that they all use felts and most use some type of felt-cleaning.[3] In a 1971 survey of 181 white paper machines, only 16 machines reported having no felt cleaning equipment, and of the machines that did have felt cleaning, most used uhle boxes and/or felt showers.[4]

Felt-cleaning showers are normally used in a series of two or three, depending on the felt run. The first shower, the felt-cleaning shower, is usually an oscillating needle jet or narrow fan shower and is used on the inside of the felt to loosen the accumulated dirt from the fabric for subsequent removal by the uhle box. This primary shower is a high pressure (80-150 psi) shower and as such, requires contaminant levels below one-quarter pound of solids per thousand gallons.[5] The performance of high pressure needle jet felt showers were surveyed by a Canadian firm, and it was seen that the most significant operating problems were in filtering the water. That is, the high pressure pumps were not adequately protected, and the water was not always sufficiently filtered after the pump to prevent nozzle plugging.[6] If one or more of the felt showers becomes plugged, it is intuitively obvious that non-uniform cleaning will result, thereby causing uneven water removal from the sheet and consequent wet streaks in the final product.

In a study done by a major producer of papermachines fabrics, five main categories of felt contaminants are identified: alkaline solubles, paper fines, ash, extractables, and wet strength additives.[7] Alkaline solubles are those substances which can be removed from a felt by dissolution in strong caustic (lignin, starch, rosin size, etc.) and appear to be the most prominent contaminant of kraft and tissue machine press felts. Paper fines, defined as small fiber particles not dissolvable in any safe chemical, are always present to some degree in felts and if not removed, will completely blind the felt. Fillers, identified as ash, respond well to acid cleaning, and are the major component of fine papermachine felt debris. Extractables, most prevalent in newsprint felts, are those substances which are soluble in resinous or polymeric materials. These are most often things like pitch, tar, asphalt, latex, and some printing inks. Finally wet strength additives such as urea formaldehydes and/or melamine formaldehydes show up in the felts from those machines that use those resins. Below is a table showing the results of this survey, the numbers indicating the typical distribution of contaminants relative to the indicated paper grades as a percentage of the total sample:

TABLE 1

COMMON CONTAMINANTS OF PAPERMACHINE WET PRESS FELTS

	Board	Kraft	Tissue	News	Fine Paper	Roofing
% Alkaline Soluables	2.3	3.6	4.6	3.0	2.9	1.0
% Paper Fines	2.8	2.8	1.5	2.1	3.3	1.8
% Ash	3.7	1.2	1.0	3.5	10.1	2.3
% Extractables	2.1	0.5	2.5	12.4	1.0	4.7

Equipment

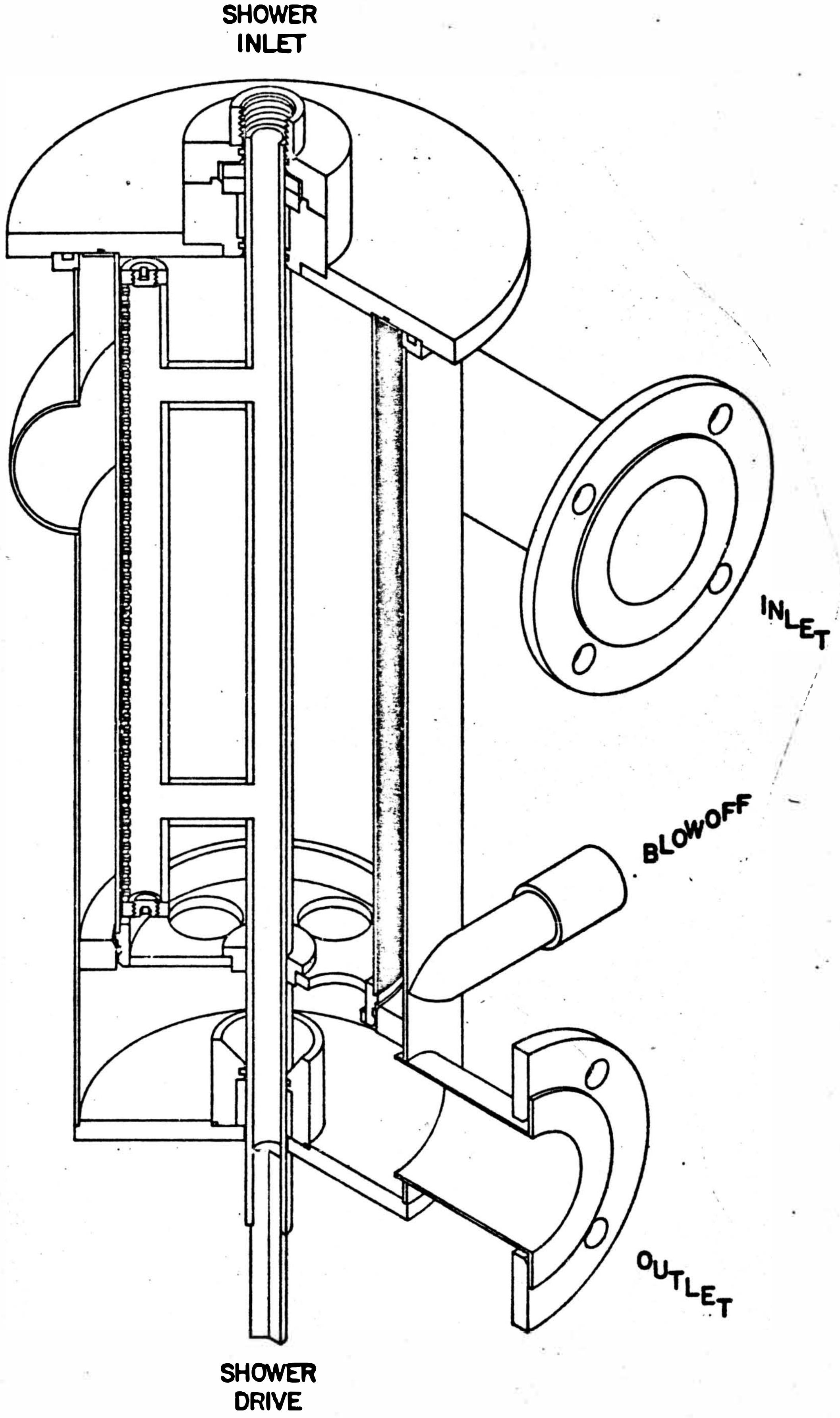
As mentioned previously, the equipment that is proposed to be used for press water filterint is a new unit, trade named CycloSpray, manufactured by Ronnigen-Petter. The filter, as described in the manufacturer's preliminary product summary, consists of "one Ronnigen-Petter filter with 8" - 304 stainless steel housing, Buna 'N' elastometers, and woven filter media. Unit is equipped with 304 stainless perforated backing and internal rotating spray assembly. Automatic purging system includes Delta Gard controls, pump, motor, and gearbox."[8] (See Figure 1).

The water to be filtered is introduced under pressure (maximum inlet pressure is 125 psi) and tangentially into the top of the unit. The liquid swirls counterclockwise and flows, by gravity, downward toward the bottom of the screen. Some solids in the water are retained on the fabric that covers the perforated backing and the filtrate passes inward through the fabric and out through the accepts port. The retained solids are backwashed off the fabric by the rotating shower and are carried away by the flow across the surface of the medium. The "blowoff," or rejects, are channelled off tangentially and are (depending on the application) sewered or are reintroduced to the system inlet.

The constantly rotating shower moves in a counterclockwise fashion and develops a pressure differential of about 100 psi over the inlet pressure. The assembly has 50 nozzles, each being a 0.046" round hole, and rotates at 115 rpm, thus dislodging the solids off the woven filter fabric. The water supply for the shower assembly can be either internal or external; if internal, it is drawn from the accepts side of the filter. In addition to constant spray cleaning, intermittent back flushing may become necessary. When the pressure drop across the entire unit (from inlet to outlet) exceeds

THE RONNIGEN-PETTER CYCLOSPRAY FILTER

Figure 1



a preset limit (usually 4-5 psi), the outlet valve closes and the blowoff valve is fully opened, thereby eliminating all flow from the outside to the inside of the screen and subsequently maximizing the effect of spray cleaning.

Previous Applications of the Technology

Although mention can be found of instances where a mill strains and recycles its press water, the literature search did not produce any distinct methods for accomplishing this. A similar filtering technique to the one used by Ronnigen-Petter has been applied, however, by Albany Engineered Systems, the manufacturers of the AES 3600 series of white water strainers.[9] These units are gravity flow strainers that remove impurities in process water, specifically white water, in three United States paper mills.

The AES 3600 screen is 55-114 inches in diameter and is capable of handling an 800-4360 gallon per minute filtering rate. The white water input flows up an annulus, over a wier, and onto a distributor plate where it is spread evenly over a 100-150 mesh screen as shown in Figure 2. The screen is sloped toward the center and is constantly backwashed from below by a rotating shower which is fed by the screen accepts; the shower is used to eliminate fiber and stapling and screen blinding. The unit is currently in use at the Chesapeake Corporation in West Point, Virginia to filter vacuum water and there have been no reports of problems, either operational or mechanical. Also in use at the Stevens & Thompson Paper Company in Greenwich, New York, the AES 3600 removes impurities from the incoming river water for use in heat exchangers and like processes. Two units are utilized at a Georgia-Pacific mill in Corsett, Arkansas to purify white water from the clear leg of the saveall for use in cleaning showers. The two screens, piped in series, serve to produce two types of shower waters: knock off, to remove the fiber mat from the returning wire, and felt fan showers. The rejects from

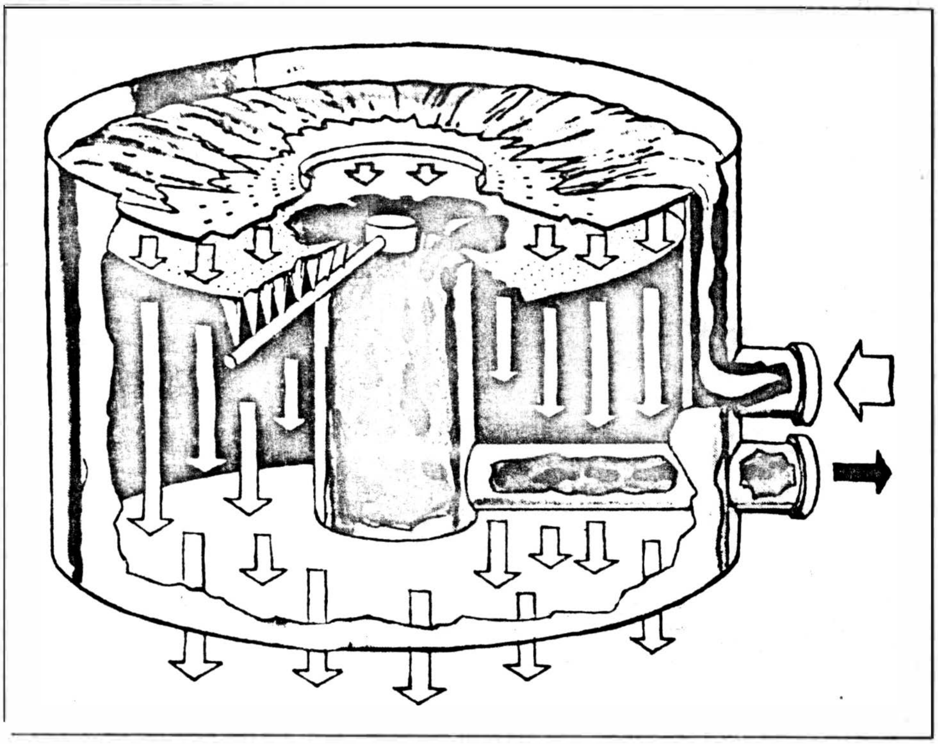


FIGURE 2

The AES 3600 Screen

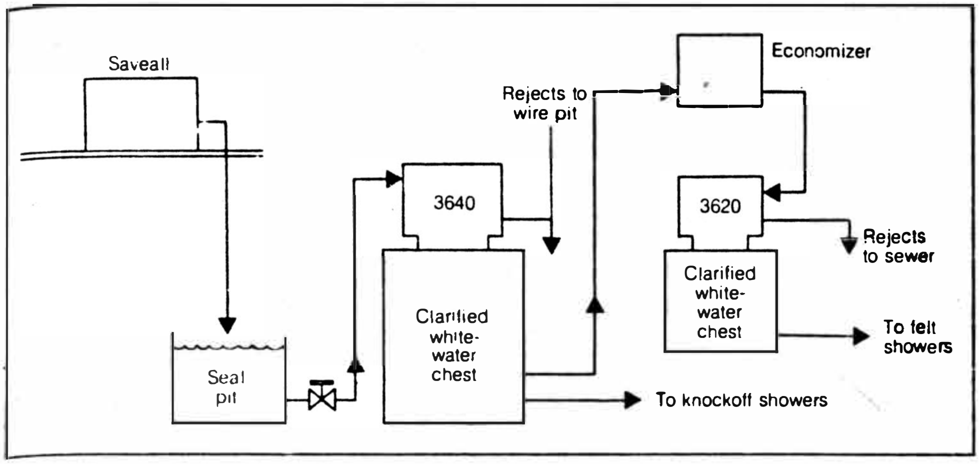


FIGURE 3

AES Screen System at Corsett, Arkansas

the first screen are sent to the wire pit and rejects from the second are sewered (see Figure 3).

Previous Testing of the CycloSpray Filter

The high solids filter installed at Plainwell Paper had been tested extensively by the manufacturer prior to its implementation as a white water filter. It is on these tests that experimental work was based for applying this unit to press water reclamation.

In a test run completed in January 1980, shredded paper contaminant was added in measured amounts to 100 gallons of clean water. Samples of each contaminant level were taken to check the level via a weight difference measurement. The results of this test led to some mechanical modification and to the rejection of the possibility of prefiltering the shower supply. With slotted nozzles of 0.031" equivalent open area, and a mesh size of 250, the filter reached contaminant levels of 360 ppm inlet, 80 ppm outlet, and 5380 ppm blowoff at 160 gpm outlet flow.[10] The filter demonstrated good separations ability, so it was tested on-site at Plainwell from June 26, 1980 to August 6, 1980, accumulating 102 total hours of run time over several grades of paper. Again, good test results prompted further testing, this time allowing the filtered water to be used on two wire showers and a Jonsson screen shower.[11] Mechanical problems again prompted minor changes, and a change in blowoff flow rate was made due to the unit remaining in the automatic backwash mode. By January 12, 1981, the high solids filter was performing satisfactorily and required little maintenance or operator attention. Some increase in shower pressure indicated plugging, so on July 6, 1981, the filter was dismantled and inspected. The 250 stainless steel Dutch twill screen had six splits, one very severe. This prompted reversal of the screen to that the main wires ran vertically instead of horizontally.[12]

EXPERIMENTAL PROCEDURE

In order to run a controlled experiment to determine the applicability of the Ronnigen-Petter filter to press water reclamation, samples of known concentration of contaminants were made up in the laboratory. Upon suggestion of H. Tom Sanders, Technical Applications Manager for Ascoe Felts, samples of the uhle box water were collected from Plainwell's number four machine and analyzed to facilitate accurate model representation. Once the composition of the white water was known, the components were acquired from Ascoe and known samples prepared for testing.

The operating variables of the unit are as follows:

1. Inlet flow rate
2. Outlet flow rate
3. Blowoff flow rate
4. Filter medium mesh size and material
5. Contaminant loading level and type

The efficiency of the filter was measured by comparing the inlet solids loading to outlet solids content (by weight) at constant flow rate for the input stream.

The filter was tested in two experiments: the first examined the effect of ash loading on felt and cellulose fiber removal and the second determined optimum screen size for a given press water makeup. All experiments were performed in the Secondary Fiber Resources Laboratory at the Paper Science and Engineering Department at Western Michigan University in Kalamazoo, Michigan, under the advisorship of John M. Fisher.

Experiment 1: The Effects of Filler Loading

A sample from No. 4 papermachine at Plainwell Paper company was analyzed for total suspended solids using slow-filtering Whatman #42 ashless filter-paper in a Buchner Funnel. The amount of filler in the sample was calculated after ashing the sample in a 900°C muffle furnace for one hour and using the filler factor of 0.795 lbs. ash/lbs. filler. Using these results as a median operating point around which to make up an initial sample, press section water from the uhle box of a fine papers machine was simulated.

Ascoe Felt Company in Clinton, South Carolina, supplied two boxes of synthetic fibers used in the making of Plainwell's felts. These fibers were first passed through a Wiley mill to reduce fiber length and permit dispersion in water prior to their addition to the sample.

Sample Preparation. In an effort to reduce the effect of size reduction of the particles from passing repeatedly through the pump, a 2000 gallon sample was used throughout the test. Initially, 34 pounds of Klondyke filler clay and 8 pounds of Omya Hydrocarb 30 calcium carbonate were dispersed in the hydrapulper with 1000 gallons of water and pumped to a 3000 gallon tile chest. A microscopic examination of the Plainwell sample revealed that there were more fines than felt hairs, so of the 0.80 pounds of fibrous contaminants to be added, 0.07 pounds were felt fibers, and 0.73 pounds were Espanola Bleached Kraft Hardwood that had been dispersed in a Voith-Morden slush-maker. Both fibers were separately dispersed, each in five gallons of clean water, and then added to the filler laden water in the chest. The sample was then diluted to 2000 gallons.

Equipment Preparation. The CycloSpray arrived complete with all guages, valves, and motor, but had to be connected to 80±10 psi air, 220 volt, three phase and 120 volt, single phase electricity. University electricians performed the necessary tie-ins and hookups, and the unit was piped so that the pump from the chest discharged directly into the filter through a 3 inch stainless pipe. In the run of inlet pipe was a paddle-type flowmeter supplied by Ronnigen-Petter, and a sample pipe with a ball valve for taking the inlet sample. The outlet for the accepts was sampled directly from the filter housing via a sample pipe (with valve) supplied with the unit. The 3 inch discharge of the filter accepts was fitted with a Foxboro air-controlled valve for backpressure development, and was returned to the supply chest. The rejects from the filter were sampled by a T-fitting with a valve and were also returned to the supply chest to maintain a constant contaminant loading for each run. Rejects flow rate was measured using a stopwatch and timing the flow into a five gallon bucket. The sample was constantly agitated throughout the entire experiment.

Operating Procedure

Before startup of the unit, the inlet pressure hose to the shower from the pump on the unit was disconnected and its outlet put back into the chest. The inlet to the shower was capped to avoid plugging the shower on the startup. Once the unit was filled with sample, it was shut down and the pressure hose reconnected.

To begin the experiment, the chest pump was started with the control valve fully closed. Once inlet pressure was developed, the unit was started, thus starting the shower action, and the control valve opened to allow an inlet flow rate of 160 gpm.

In the fashion of the experimental procedure outlined by J. Rishel in Ronnigen-Petter's memo of the January 26, 1979 test run,[13] the contaminant mixture was added to the feed every 15 minutes, allowing the filter to achieve steady state. At this time, samples were taken of inlet, outlet, and blowoff streams, using 4-ounce screw top glass jars. Each sample jar was filled to the maximum, sealed, and labeled for testing later. At sample time, the inlet flow rate (from the flowmeter), blowoff flow rate, inlet pressure, outlet pressure, and shower pressure were noted for future analysis.

To increase the filler loading, a few gallons of accepts water were collected and the increments of clay and carbonate to be added were dispersed in this sample, then dumped into the supply chest. In this way, the concentration of filler was the only parameter changed, and it could be effectively dispersed before its addition.

After each filler increase, the filter was allowed to stabilize for fifteen minutes and the samples were again taken and conditions noted. This procedure was followed for ten filler increments, designed to result in points of total suspended solids values ranging from 0.2% to 0.5% of the total 2000 gallon sample.

Because the filler level reached did not cause failure, the amount of fiber was increased in an effort to study contaminant separation with heavy felt fiber loading. The felt hair content of the sample was increased by 0.15 lbs., thus bringing the total suspended solids up to 0.49%, and of that only 1.17% was fiber (both felt and cellulose combined). The operating parameters and samples were taken, then the unit was shut down for the second experiment.

Experiment 2: Optimum Screen Size

Screens for the CycloSpray are available in a wide variety of sizes and materials. This experiment determined which screen size resulted in the highest efficiency for a given operating point at constant solids loading and input flow rate. Starting at 250 mesh stainless steel and progressing to 20 micron polypropylene, the most efficient screen size for removing fibrous contaminants from the sample was determined.

Sample Preparation. The sample consisting of 64 pounds clay, 16 pounds $CaCO_3$, 0.73 pounds bleached hardwood kraft, and 0.22 pounds felt fiber in 2000 gallons of water was used for the entire second experiment.

Equipment Preparation. The filter medium was replaced by removing the cover bolts and lifting out the entire perforated backing and shower assembly. The woven 250 mesh stainless steel fabric was torn off and a 500 mesh polypropylene medium installed. The filter was then reassembled.

Operating Procedure

The unit was started as in Experiment 1. Again, as in the first experiment, steady state was reached and samples were taken, along with the filter flow rates and pressures. For the next run, a 20 micron polypropylene screen was installed and run.

PRESENTATION OF RESULTS

Experiment 1: Effects of Filler Loading

Linear regression analysis was performed on the accumulated and calculated data, from the first ten runs (Appendices A & B). It can be seen (Appendix C) that there are strong linear relationships between percent solids in the inlet streams and the percent solids in either the accepts or rejects streams. These same tendencies are exhibited when mass flow rates in and out are compared.

The percent ash in the inlet did not display the same good correlation, as it appears that the ash in the accepts is very loosely related to inlet ash. The filler mass flow rates out of the filter do correlate reasonably well with inlet filler flow rates, however, in that the correlation coefficients are quite high.

In Table 2 is presented the designed experimental sample makeup. Of particular interest is the percent solids design point and the experimentally measured percent solids inlet (see Table 3), in that there appears to be more suspended solids in the sample than were put in the chest. The mass flow rates (Table 4) were calculated using the measured parameters and equations presented in Appendix D, in conjunction with the flow rate data collected (Appendix E).

A plot of the total suspended solids into the filter versus the solids out indicates the relative separation that occured during the experiment (Figure 4).

In an effort to determine which component the observed behavior was attributable to, the same type of data were collected for the filler as for total solids (see Tables 5 & 6, and Figure 5).

The eleventh run, made with increased fiber content instead of filler, caused no significant change in inlet percent solids, or in accepts percent solids, but did cause a 0.09% rise in rejects solids. The effect was also seen in an ash drop of over 8% in the rejects stream.

Experiment 2: Optimum Screen Size

Replacement of the 250 mesh screen with a 500 mesh screen had no appreciable effects on the solids relationships, but did cause a close to 4% rise in reject ash percent.

TABLE 2

TEST SAMPLE COMPONENTS

Total Sample Size (Constant):	2000 gal.
Bleached Kraft Hardwood (Constant):	0.73 lbs.
Synthetic Felt Fibers (Constant):	0.07 lbs.

Observation	Clay (lbs.)	$CaCO_3$ (lbs.)	Total	% Solids
1	32	8	40	0.24
2	36	9	45	0.27
3	39	10	49	0.30
4	43	11	54	0.33
5	46	12	58	0.35
6	50	13	63	0.38
7	54	13	67	0.41
8	57	14	71	0.43
9	61	15	76	0.46
10	64	16	80	0.48
Increased fiber content by adding 0.15 lbs. of felt fiber:				
11	64	16	80	0.49
Changed from 250 mesh stainless steel medium to 500 mesh poly:				
12	64	16	80	0.49

TABLE 3

CONTAMINANT PERCENTAGES

Observation	Inlet Solids	Accepts Solids	Rejects Solids
1	0.24	0.24	0.31
2	0.29	0.26	0.34
3	0.30	0.28	0.36
4	0.37	0.31	0.42
5	0.39	0.35	0.44
6	0.47	0.38	0.48
7	0.46	0.41	0.50
8	0.54	0.42	0.52
9	0.55	0.45	0.59
10	0.53	0.48	0.56
11	0.54	0.47	0.65
12	0.49	0.49	0.65

TABLE 4

FLOWRATES IN POUNDS/MINUTE

Observation	Solids In	Solids Accepts	Solids Rejects
1	3.20	2.89	0.409
2	4.11	3.44	0.318
3	4.25	3.72	0.324
4	5.31	4.17	0.382
5	5.53	4.64	0.400
6	6.66	5.06	0.416
7	6.14	5.13	0.417
8	7.21	5.25	0.438
9	7.34	5.63	0.492
10	7.07	6.01	0.467
11	6.76	5.66	0.309
12	6.54	6.34	0.260

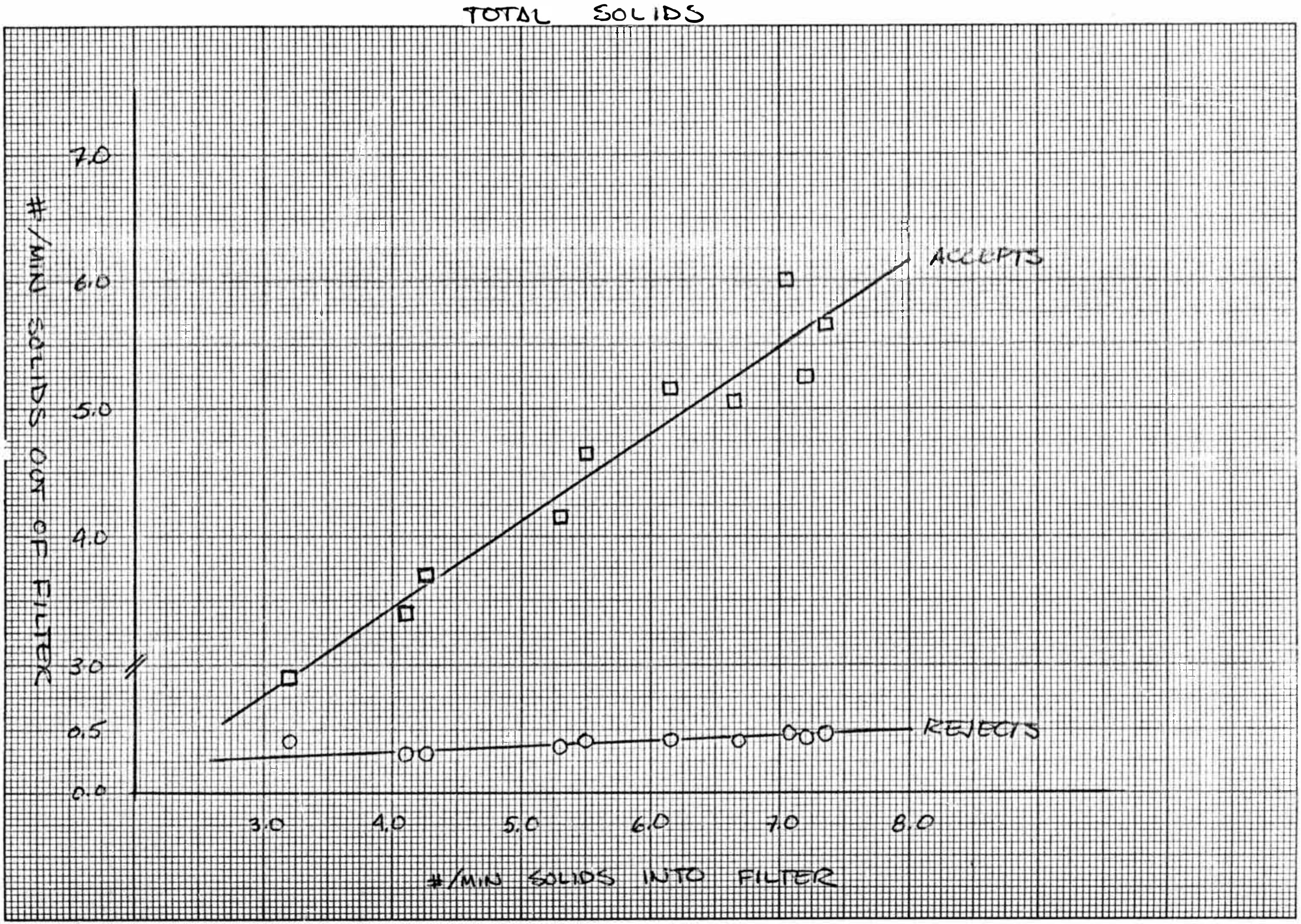

TOTAL SOLIDS
#/MIN SOLIDS OUT OF FILTER
7.0
6.0
5.0
4.0
3.0
0.5
0.0
3.0
4.0
5.0
6.0
7.0
8.0
#/MIN SOLIDS INTO FILTER
ACCEPTS
REJECTS

Figure 4

TABLE 5

CONTAMINANT PERCENTAGES

Observation	Inlet Ash	Accepts Ash	Rejects Ash
1	77.86	74.45	65.83
2	78.41	80.23	68.54
3	79.56	80.14	66.51
4	78.10	78.89	68.28
5	77.14	78.15	67.65
6	77.68	77.79	66.33
7	72.92	78.11	71.02
8	76.98	77.61	67.31
9	77.96	78.94	70.13
10	77.27	78.12	68.96
11	77.44	77.76	60.86
12	77.20	(77.50)	64.41

TABLE 6

FLOWRATES IN POUNDS/MINUTE

Observation	Filler In	Filler Accepts	Filler Rejects
1	3.14	2.89	0.338
2	4.06	3.48	0.274
3	4.26	3.75	0.271
4	5.21	4.13	0.328
5	5.37	4.57	0.340
6	6.51	5.95	0.347
7	5.63	5.04	0.373
8	6.98	5.13	0.371
9	7.20	5.59	0.434
10	6.87	5.90	0.405
11	6.58	5.53	0.237
12	6.35	(6.18)	0.211

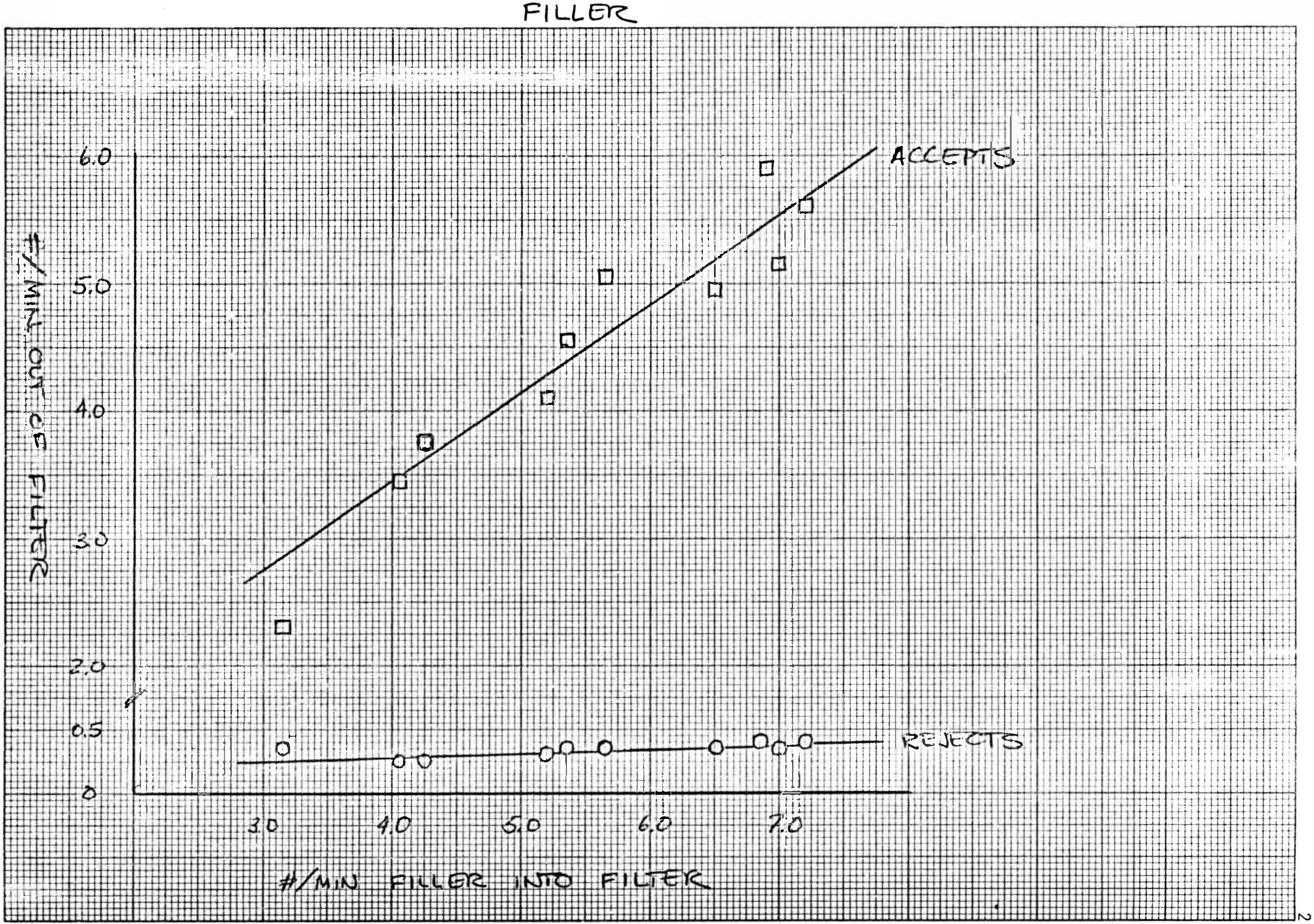

FILLER
ACCEPTS
REJECTS
#/MIN OUT OF FILTER
#/MIN FILLER INTO FILTER
6.0
5.0
4.0
3.0
2.0
0.5
0
3.0
4.0
5.0
6.0
7.0

Figure 5

DISCUSSION OF RESULTS

Experiment 1: Effect of Filler Loading

The total suspended solids data from the first experiment is explainable by using the filter cake buildup theory in conjunction with the fact that the contaminants are being continuously removed from the unit via the blowoff stream. The Klondyke filler clay and Hydrocarb 30 are of similar particle size, the clay being a water washed fine particle size and the carbonate sized at 90% less than four microns. By design, the fillers should pass through the screen and into the accepts, while the fibers (whether felt or cellulose) shuld be retained and be removed through the blowoff. By inspection, the graph of rejects solids suggests that the majority of the filler in the inlet is being found in the accepts, while only a small portion ends up in the rejects.

The slope of the accepts line should, by theory, be unity, but is only 0.67, and the slope of the rejects line should be zero, but is found to be 0.029. These phenomenon can be explained if one assumes the filler is directly responsible for the total solids curve behavior. As filler loading increases, the fibrous material that is retained on the screen acts to reduce the effective open area of the medium, thereby causing some of the filler to become entrapped and carried away in the blowoff, which reduces the filler in the accepts and increases it in the rejects.

This hypothesis can be further tested by studying the graph of filler flow rate in versus filler flow rates out in both accepts and rejects. The accepts curve has a slope of 0.72, closer yet to the expected unity, and the rejects slope is 0.030. The extreme similarity between the two figures strongly suggest that a majority of the filler fraction in the sample of presswater is being passed into the accepts and the fiber fraction is being rejected, with some small portion of the filler entrapped in the entagled fibers.

The eleventh run of the experiment further illustrates the separations ability of the unit. The inlet solids percentage figure did not change appreciably with the introduction of additional felt fibers, as should be expected in light of the small total increase in percent solids, and the accepts did not change because no increase in filler was made. The rejects percent solids, however, increased significantly from 0.56% to 0.65%, showing approximately the same increase as was made in the felt fiber amount. Additional visual observation of the concentrated felt and cellulose fiber contaminant in the rejects samples back up the numerical data. A 325 mesh Tyler screen placed under the accepts showed very little material retained, but the rejects showed a dramatic difference in the amount of fibers present.

Experiment 2: Optimum Screen Size

Replacement of the 250 mesh stainless steel screen with a 500 mesh polypropylene fabric caused an increase in reject ash, indicating that more filler was entrained in the blowoff, but lack of change in the accepts ash shows that no additional fiber was removed from the accepts side of the filter. Further reduction in mesh size to a 20 micron fabric caused immediate plugging of the screen and was rejected as a possible medium.

From this data, it can be concluded that 250 mesh screen is of sufficient size to effectively remove the felt and cellulose fibers from press water.

RECOMMENDATIONS

Further study of the CycloSpray's separations capabilities could be made using fiber loading as the independant variable, again using total suspended solids and ash determinations for efficiency evaluation. The filter's application to presswater can be deemed a success if and only if all objectionable fibers, such as the felt hairs, are removed from the accepts. If the synthetic fibers could be dyed, or tagged in some manner so as to be distinguishable from the cellulose fibers, their presence in the accepts would be easily discernable, thereby giving a qualititative evaluation of the separation.

More extensive tests on screen size should be made, as only three sizes were examined in this thesis. The minimum of 250 mesh is due to the fact that if a larger mesh is used, shower plugging is a distinct possibility if fresh water is not used for the shower source. This does not mean that a sufficient separation could not be achieved with a larger fabric, but the sample concentration would change due to the fresh shower water introduced. Smaller screen sizes than 250 mesh, but larger than 20 micron, should also be considered, although work done by Union Camp suggests that any size less than 85 microns was enough to remove any detrimental material from presswater.

CONCLUSIONS

The Ronnigen-Petter CycloSpray filter effectively removes synthetic felt fibers from simulated press section water containing filler clay and carbonate. A 250 mesh stainless steel filter medium is adequate to accomplish the separation.

Economic advantage to the mill is evident in that cost of materials recycled for a 100 gpm operation, based on 350 operating days per year and a 0.40% solids level, is $128,000 per year (see Figure 6).

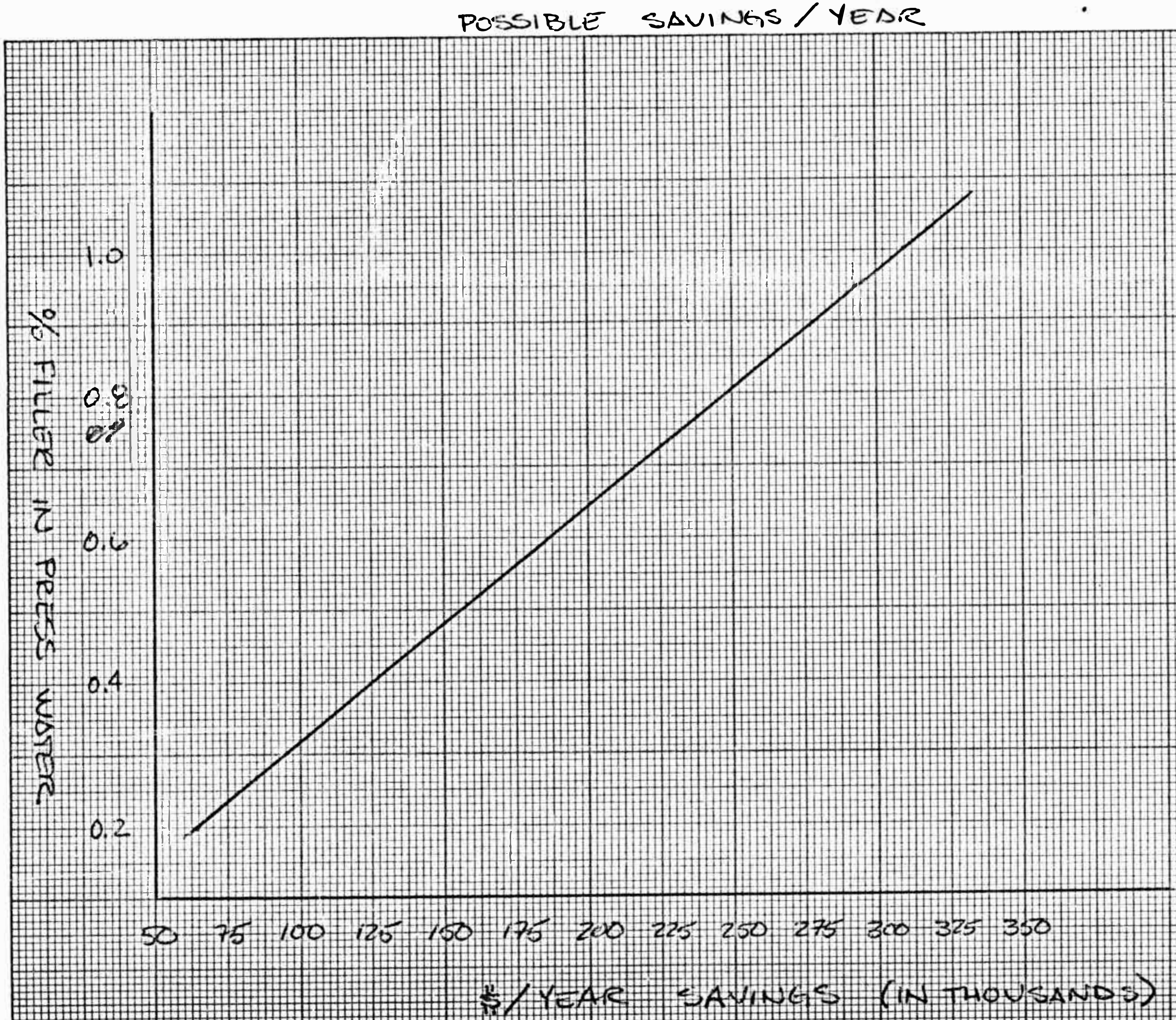

POSSIBLE SAVINGS / YEAR
% FILLER IN PRESS WATER
1.0
0.8
0.6
0.4
0.2
50
75
100
125
150
175
200
225
250
275
300
325
350
$/YEAR SAVINGS (IN THOUSANDS)

Figure 6

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APPENDIX A

```
          ***** MULTIPLE LINEAR REGRESSION *****

SAMPLE SIZE   10
DEPENDENT VARIABLE: FIL#A
INDEPENDENT VARIABLES:  FIL#I

COEFFICIENT OF DETERMINATION  0.91982
MULTIPLE CORR COEFF.   0.95907

ESTIMATED CONSTANT TERM  0.70081258

ANALYSIS OF VARIANCE
FOR THE REGRESSION
SOURCE OF VARIATION   DF      S. SQ.       M.S.          F         PROB
     REGRESSION        1    8.29082     8.29082      91.77       0.0000
     RESIDUALS         8   0.722710    .903387E-01
     TOTAL             9    9.01353

      REGRESSION       S. E. OF   F-VALUE                     CORR.COEF.
VAR.  COEFFICIENT     REG. COEF.  DF (1,    8)  PROB          WITH FIL#A
FIL#I   0.6921877       .7225E-01   91.77       0.0000         0.9591
```

```
          ***** MULTIPLE LINEAR REGRESSION *****

SAMPLE SIZE   10
DEPENDENT VARIABLE: FIL#R
INDEPENDENT VARIABLES:  FIL#I

COEFFICIENT OF DETERMINATION  0.59211
MULTIPLE CORR COEFF.   0.76949

ESTIMATED CONSTANT TERM  0.19077062

ANALYSIS OF VARIANCE
FOR THE REGRESSION
SOURCE OF VARIATION   DF      S. SQ.       M.S.          F         PROB
     REGRESSION        1   0.140578E-01 .140578E-01 11.61        0.0093
     RESIDUALS         8   0.968388E-02 .121048E-02
     TOTAL             9   0.237417E-01

      REGRESSION       S. E. OF   F-VALUE                     CORR.COEF.
VAR.  COEFFICIENT     REG. COEF.  DF (1,    8)  PROB          WITH FIL#R
FIL#I   0.2850256E-01   .8364E-02   11.61       0.0093         0.7695
```

APPENDIX B

```
           ***** MULTIPLE LINEAR REGRESSION *****

SAMPLE SIZE   10
DEPENDENT VARIABLE: SOL#A
INDEPENDENT VARIABLES:  SOL#I

COEFFICIENT OF DETERMINATION  0.94224
MULTIPLE CORR COEFF.   0.97069

ESTIMATED CONSTANT TERM  0.75584716

ANALYSIS OF VARIANCE
FOR THE REGRESSION
SOURCE OF VARIATION   DF      S. SQ.       M.S.            F        PROB
     REGRESSION        1    8.65921     8.65921      130.5       0.0000
     RESIDUALS         8   0.530862     .663577E-01
     TOTAL             9    9.19007

      REGRESSION        S. E. OF    F-VALUE                    CORR.COEF.
VAR.  COEFFICIENT      REG. COEF.   DF (1,    8)  PROB         WITH SOL#A
SOL#I   0.6752500        .5911E-01   130.5       0.0000         0.9707
```

```
           ***** MULTIPLE LINEAR REGRESSION *****

SAMPLE SIZE   10
DEPENDENT VARIABLE: SOL#R
INDEPENDENT VARIABLES:  SOL#I

COEFFICIENT OF DETERMINATION  0.58077
MULTIPLE CORR COEFF.   0.76208

ESTIMATED CONSTANT TERM  0.24143866

ANALYSIS OF VARIANCE
FOR THE REGRESSION
SOURCE OF VARIATION   DF     S. SQ.        M.S.            F        PROB
     REGRESSION        1   0.159774E-01 .159774E-01 11.08        0.0104
     RESIDUALS         8   0.115332E-01 .144164E-02
     TOTAL             9   0.275105E-01

      REGRESSION        S. E. OF    F-VALUE                    CORR.COEF.
VAR.  COEFFICIENT      REG. COEF.   DF (1,    8)  PROB         WITH SOL#R
SOL#I   0.2900537E-01   .8713E-02   11.08       0.0104          0.7621
```

APPENDIX C

LINEAR REGRESSION ANALYSIS

x	y	slope	y-intercept	corr. coef.
Inlet Solids %	Accepts Solids %	0.718	0.061	0.971
Inlet Solids %	Rejects Solids %	0.827	0.110	0.983
Inlet Solids #/Min.	Rejects Solids #/Min.	0.675	0.756	0.971
Inlet Solids #/Min.	Rejects Solids #/Min.	0.046	0.133	0.963
Inlet Ash %	Accepts Ash %	0.221	61.2	0.237
Inlet Ash %	Rejects Ash %	-0.591	113.8	-0.612
Inlet Filler #/Min.	Accepts Filler #/Min.	0.724	0.645	0.948
Inlet Filler #/Min.	Rejects Filler #/Min.	0.029	0.190	0.770

APPENDIX D

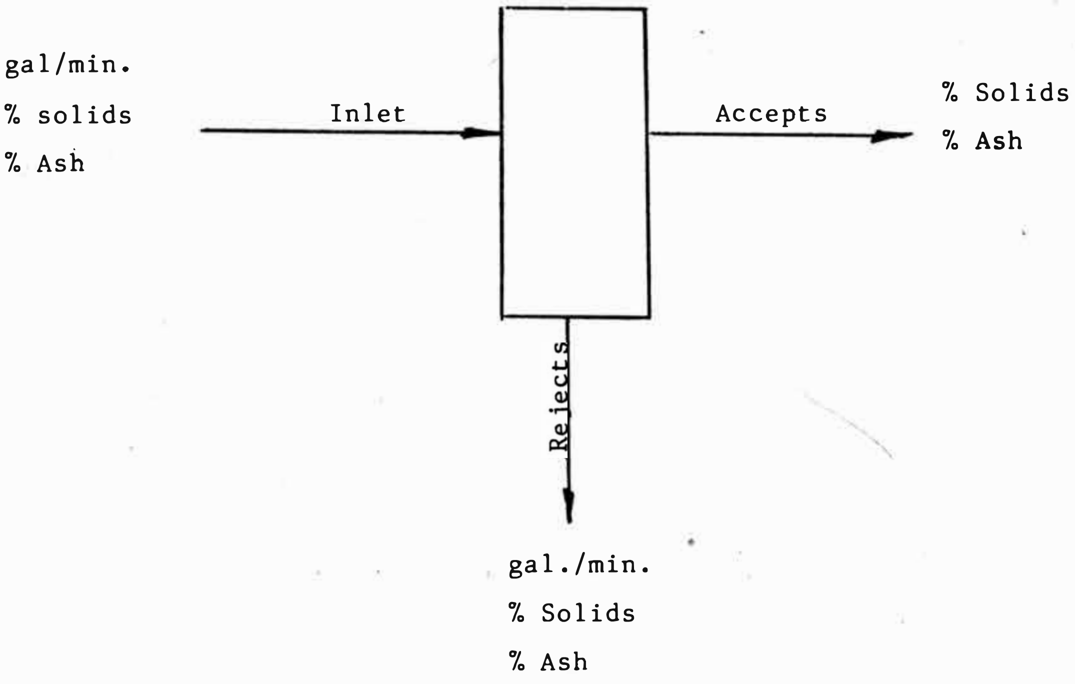
SAMPLE CALCULATION

Mass Balance Equations:

$$\frac{160.0\text{ gal.}}{\text{min.}} * \frac{8.34\#}{\text{gal.}} * \frac{0.24\#\text{ solids}}{100.0\#} = 3.20\ \#/\text{min. solids in}$$

$$\frac{3.20\#\text{ solids}}{\text{min.}} * \frac{77.86\#\text{ ash}}{100.0\#} * \frac{1.258\#\text{ filler}}{\#\text{ ash}} = 3.14\#/\text{min. filler in}$$

MEASURED TEST PARAMETERS



APPENDIX E

TEST CONDITION FLOWRATES IN GALLONS/MINUTE

Observation	Inlet	Accepts	Rejects
1	160.0	144.2	15.8
2	170.0	158.8	11.2
3	170.0	159.2	10.8
4	172.0	161.1	10.9
5	170.0	159.1	10.9
6	170.0	159.6	10.4
7	160.0	150.0	10.0
8	160.0	149.9	10.1
9	160.0	150.0	10.0
10	160.0	150.0	10.0
11	150.0	144.3	5.7
12	160.0	155.2	4.8