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Fluff Pulp Comparison

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by

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Chris W. Hutchings

Introduction

The objective of this thesis is to examine the effects of the variables associated with the defibering of dry lap pulp by means of a laboratory Hammermill. Two separate pulps will be utilized, a Southern Kraft and a Chemithermomechanical (CTMP) pulp.

The absorption core of most diapers is composed of Kraft pulp, 15% of diapers in Europe currently utilize CTMP.[2] A recent movement has been a push for using a less expensive CTMP pulp for the core of many absorbent products. Although brightness levels are not as high, a higher capacity under load is expected due to the stiffness of the CTMP fiber. Consumer preference leans toward the Kraft pulp, due to its sanitary white appearance.[3] The objective of this thesis research project is to determine the optimum conditions to defiber the two pulp samples. This will be accomplished by determining which conditions promote the highest absorption conditions with the fewest nits and lowest energy consumption.

The Kamas Hammermill is a laboratory version of a full scale Hammermill used in the industry for fluff pulp production. Pulp sheets are introduced into the defibering chamber at a constant rate and defiberated by a spinning rotor with hinged beater bars. A vacuum system then pulls the defiberated pulp into a collection zone, where it can be removed for analysis and testing. During defiberation, the Hammermill records the energy consumed by the increase in power needed to keep the rotor at a constant speed. A screen below the rotor controls the residence time of the pulp in the defiberation chamber.

The manipulated variables of the Hammermill will include a range of screen sizes of 8 mm, 12 mm, and 17 mm. The rotor speed will also be varied over a range of 65%, 75%, and 85%. The percentage is based on a maximum of 5000 revolutions per minute. The amount of energy used for each run will be recorded and converted into units of kWh per ton. Trial work suggest the Hammermill closely reproduces industry mills for production and energy consumption, only on a microscale.[1]

The percentage of nits for each defiberation will be determined by the Johnson Nit count. The Johnson Nit count uses air pressure and vacuum to separate fibers, fines, and nits. A nit is a fiber bundle that was not completely defiberated. A 14 mesh screen will be used to contain the nits, a 30 mesh screen for the fibers, and remaining will be the fines. A 3.00 gram sample was used for the percent fiberization analysis.

Following the defibering of the pulps, absorption tests will be run of the samples to determine absorption capacity and speed. The Vertical Wicking test will measure the speed of absorption, while the Absorption test will measure capacity and capacity under load.

The use of a Kamas Hammermill in the laboratory can be helpful in determining design parameters for mill scale operation. The chief means in the fluff pulp industry today for defiberating pulp is by a Hammermill. By analyzing the operating variables associated with defibering pulp, optimum performance can be achieved. Analysis of the effects of screen size, energy consumption, and absorbent properties will allow the performance of fluff pulp to be enhanced.

Procedures

A flow diagram of this research project is contained in the Appendix. I will start by defiberating the pulps at the various rotor speed and screen sizes, 65%, 75%, 85%, and 8 mm, 12 mm, and 17 mm respectively. Samples will be feed into the Hammermill at a constant rate, with a sample size of 50 mm wide. The amount of energy consumed at each setting will be recorded for analysis.

The percent defiberization will be determined by the Johnson Nit count. This test uses air and vacuum to separate the nits, fibers, and fines. The nits are contained by a 14 mesh screen, the fibers by a 30 mesh screen, and the fines will constitute the remainder.

After defiberization of the pulp, absorption tests will be conducted on the various samples. The Absorption tests itself will use a 3.00 gram pad, at a density of 0.06 g/cm^3. The density will be obtained by using a laboratory press and a formation mold to keep the pad at its original 50 cm^2 size. The test will start by saturating the sample with 100 ml of solution. The solution contains 192 grams of salt per 5 gallons. After a 120 second period, the amount of solution not held by the pad, that has drained beneath will be weighed. A 3 kPa load will then be placed on top of the sample. After another 120 second period, the amount of liquid drained will be weighed. The load will then be adjusted to a 5 kPa. After 120 seconds, the amount drained will be weighed. By subtraction, the retention of solution in the pad can be determined at the various loads. A visual representation of the Absorption test is presented in the Appendix.

The Vertical Wicking test utilizes a fluff sample of 1.50 grams, at a density of 0.06 g/cm^3. The sample is 10 cm long and 2.5 cm wide. The sample is placed in a solution, and the time for the solution to rise to electrodes placed in the pad is determined. The lower the Vertical Wicking times, the faster the absorption of the solution into the pad. A visual representation of the Vertical Wicking test is presented in the Appendix.

Statistical analysis of the data will be calculated. A total of three Absorption tests will be run for each condition, and five for the Vertical Wicking. Since a low sample size is used, statistical analysis will be difficult. Due to the timeliness of the research a larger sample size would have been impossible. Standard deviations of all averages will be reported with the results.

Results

The results can be shown best by graphical presentation. Figure 1 represents the energy of fiberization for the three rotor speeds with three different screen sizes. The trend shows an increase in energy consumption as the screen size declines. As the rotor speed increases, the energy also increases. The Kraft pulp also had a higher energy demand at all settings than the CTMP pulp. The energy fiberization data was converted from kWh for the pulp defiberated to kWh per ton of pulp. The figure shows an increase of about 75% for the Kraft pulp.

Figure 2 displays the data from the Johnson Nit count. It clearly shows an increase in nits as the rotor speed is reduced and the screen size increased. At a rotor speed of 85% and with a screen size of 8 mm, the lowest amount of nits was reported. The Kraft had a lesser amount of nits than the CTMP at all equal conditions. As the rotor speed was increased for the CTMP, the nits were reduced and the fines were increased.

The Absorption test data and display of the test is shown in Figures 3-13. Clearly the higher absorption capacities are found with the 85% rotor speed used for difiberation. By comparing the energy consumption and nit count data, the optimum setting appears to be 85% with a 12 mm screen. The CTMP shows a slightly higher capacity under load for nearly all conditions.

The Vertical Wicking data is presented along with a pictorial representation of the test in Figures 14-15. The trial was run on all rotor speeds using the 12 mm screen. The Kraft pulp gave wicking runs nearly three times faster than the CTMP for all rotor speeds. The 65% rotor speed had the fastest Kraft and CTMP wicking times and standard deviations of 27.66 ± 3.0 seconds and 76.53 ± 8.4.

The standard deviation of the results is given with the data in the appendix. Although a small sample size was utilized, the standard deviation gives an estimate of the close proximity of the results.

Discussion

The energy of fiberization of the pulps increased as the screen size decreased. This is due to the residence time of the pulp in the defiberization chamber of the Hammermill. The smaller screen size increase the residence time, therefore the fibers see more mechanical action, which increase energy consumption.

The Kraft pulp showed the highest energy of defiberization due to the higher bonding of fibers in the dry pulp sheets. The Kraft pulping process removes more lignin, making the fibers more flexible, with greater bonding ability. The CTMP shows a lower energy consumption, due to the lower bonding of the fibers.

The Johnson Nit count determines the amount of fibers, fines and nits present in a particular pulp sample. As the rotor speed was increased and screen size decreased the amount of nits also decreased, due to more mechanical action imparted to the pulp. The amount of fines dramatically increased for the 85% rotor speed, possibly due to a stiffer fiber, breaking at the higher rotor speeds, rather than being pulled for the pulp board during defibering.

The amount of fines remained almost constant for the rotor speeds, while the amount of nits decreased with higher rotor speeds. It appears that the more flexible fiber has a greater ability to resist rupture during defiberization in the Hammermill.

The Absorption Test shows the CTMP has a slightly higher capacity at various load levels. The CTMP fibers are stiff compared to the Kraft which is determined by the pulping and bleaching processes. The stiffer fiber has can resist compaction under load, and therefore have a higher retention liquid. As the nit amount in the pulp diminishes, the capacity is increased. This relates to the increase in amount of capillaries and surface area present to retain the liquid within the sample.

The Vertical Wicking data show the 75% rotor speed provides the more effective wicking pulp. The longer Kraft fibers allow a more conducive environment for liquid transfer compared with the CTMP. The decrease in nits gives a decrease in wicking time, for the same reasons as increased absorption capacity discussed above. The 75% rotor speed may have a larger amount of longer fibers which give the slight advantage for wicking.

Conclusion

Comparing the data collected it was determined the optimum defiberization conditions for the Kraft and CTMP pulp is at 85% rotor with a 12 mm screen size. Slightly faster vertical wicking times are realized at a lower rotor speed, but the increased absorption of the pulp counteracts this exchange. The lowest amount of nits and higher absorption capacities with a slight increase in energy support theses conditions for optimization of fluff pulp qualities.

In the comparison of Kraft and CTMP fluff pulp the absorbent qualities of Kraft outperform the CTMP. The vertical wicking time of the Kraft sample was nearly three times faster for every control condition tested. The percentage of nits was also lower at the conditions examined. The CTMP pulp possesses positive qualities that should not be overlooked.

The cost per ton of CTMP is approximately $700, compared to $1000 per ton for Kraft. The energy of fiberization was lower for the CTMP. This is extremely important since it makes the CTMP a more attractive candidate. The Absorption Test of the samples showed the CTMP was able to hold its integrity under load slightly more than the Kraft. This quality and the low cost are the main advantages of the CTMP pulp. Overall, for absorption characteristics the Kraft is the superior fluff.

Further research in this area could include a mixture of both pulps, possibly producing a sandwich of one between another. The wet web integrity of the pulp could be tested, possibly utilizing a tensile tester. Different solutions or liquids could be incorporated to determine differences in absorbing qualities. Liquids such as oil or blood are possible candidates.

References

1. Bolyen, Mark, Lab Hammermill Gives Fast Energy, Quality Data on Pulp Defibration, Pulp & Paper Journal, Oct. 1987, p. 123-125.

2. Nickull, Ole, CTMP Fluff Pulp - A Cost Effective Alternative to Crosslinked Cellulosic Pulp, Presented at the 1994 IDEA Show.

3. Stevens, Anrew, Absorbent Core, Fluff Production, Pulp & Paper Journal, 1990 p. 93-95.

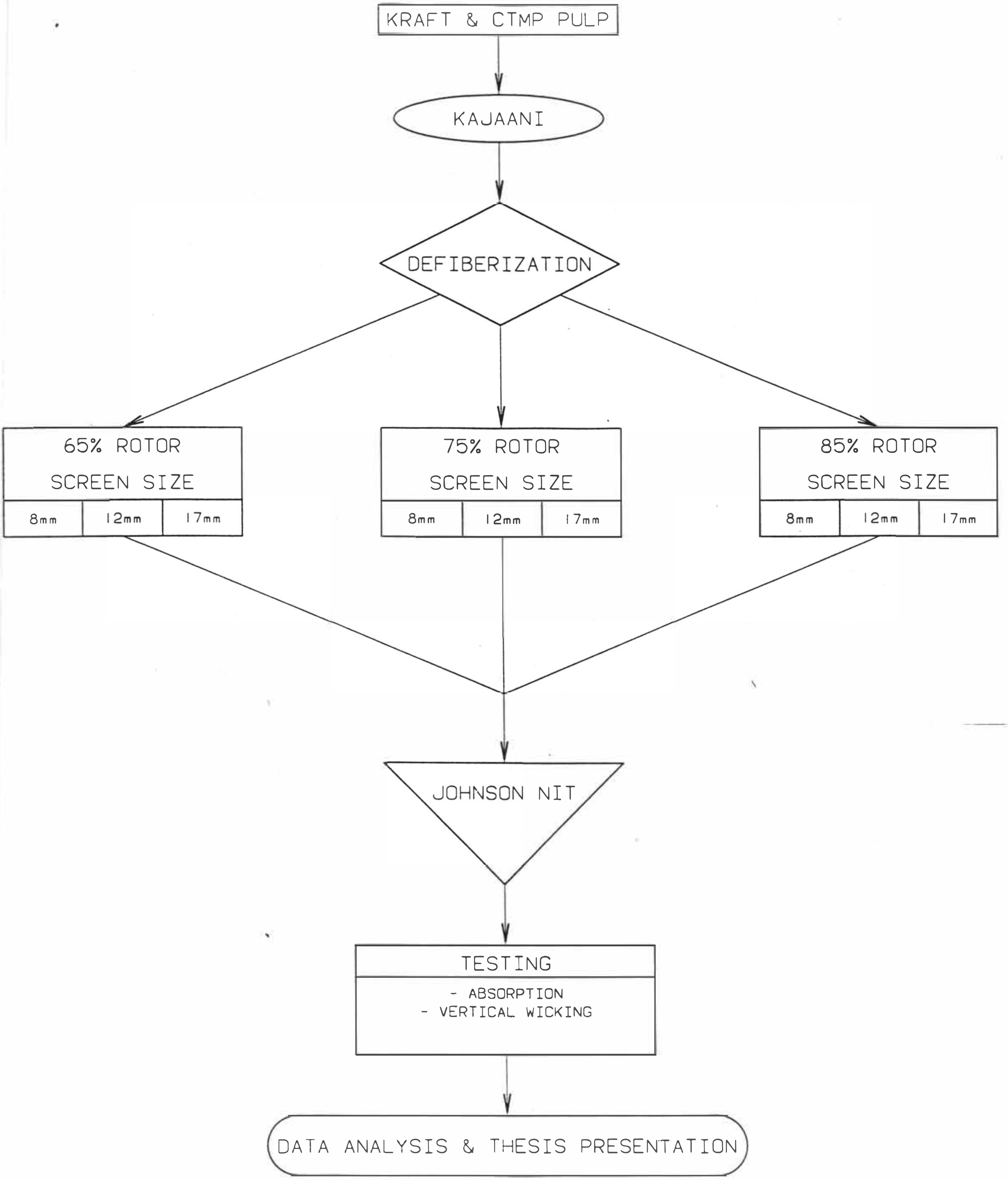

KRAFT & CTMP PULP
KAJAANI
DEFIBERIZATION
65% ROTOR
SCREEN SIZE
8mm
12mm
17mm
75% ROTOR
SCREEN SIZE
8mm
12mm
17mm
85% ROTOR
SCREEN SIZE
8mm
12mm
17mm
JOHNSON NIT
TESTING
- ABSORPTION
- VERTICAL WICKING
DATA ANALYSIS & THESIS PRESENTATION

Figure 1

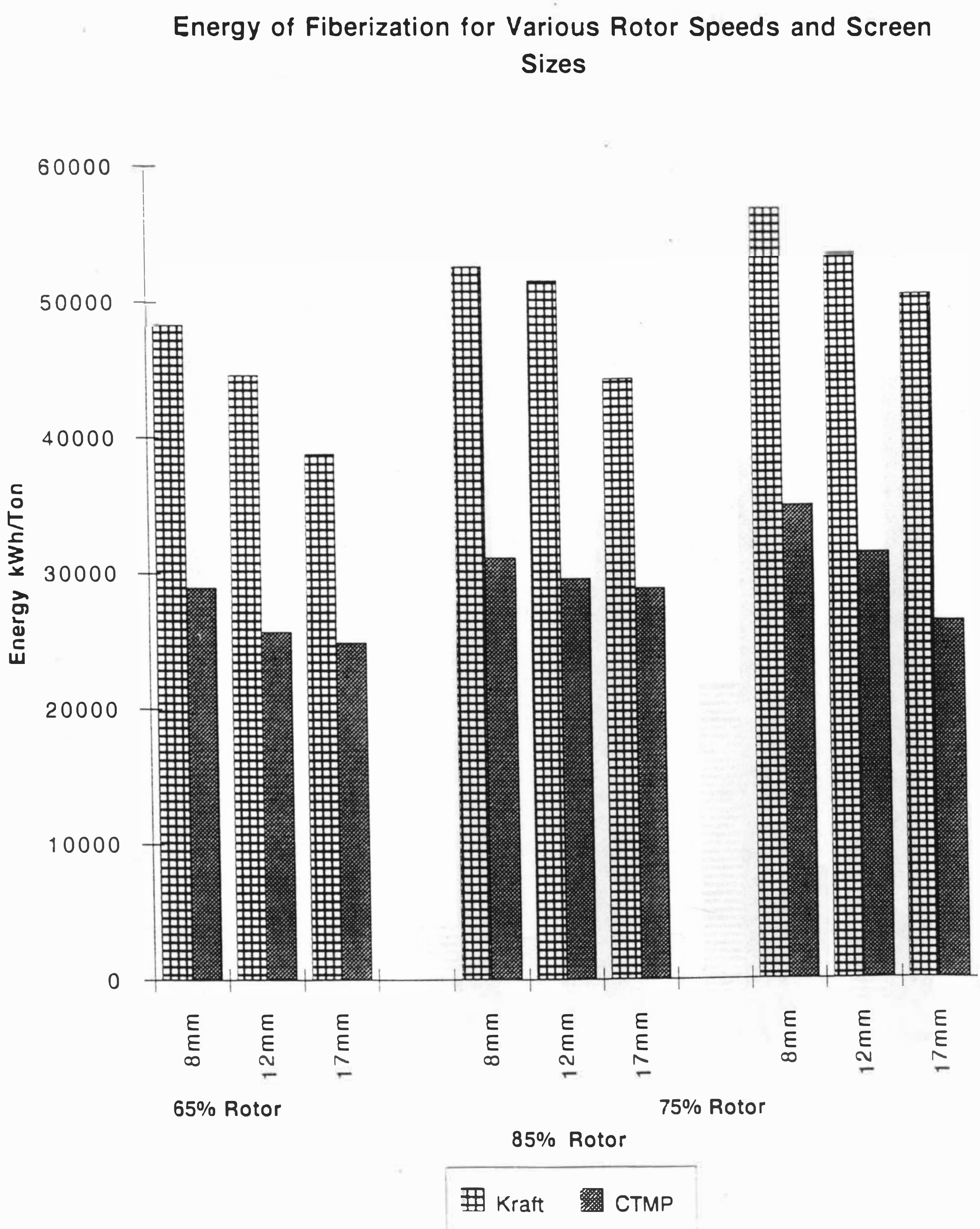

Energy of Fiberization for Various Rotor Speeds and Screen Sizes
60000
50000
40000
30000
20000
10000
0
Energy kWh/Ton
8mm
12mm
17mm
8mm
12mm
17mm
8mm
12mm
17mm
65% Rotor
75% Rotor
85% Rotor
Kraft
CTMP

Figure 2

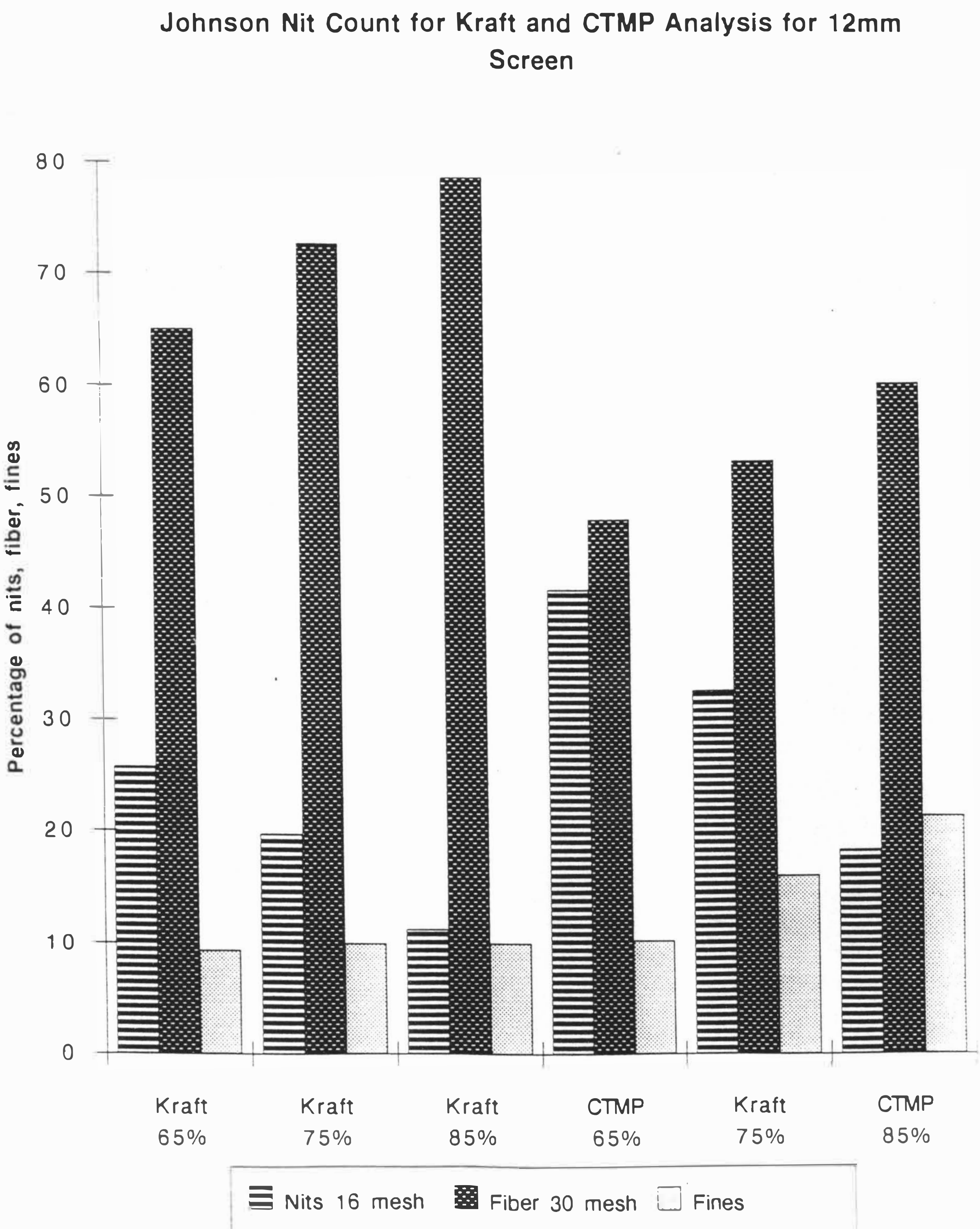
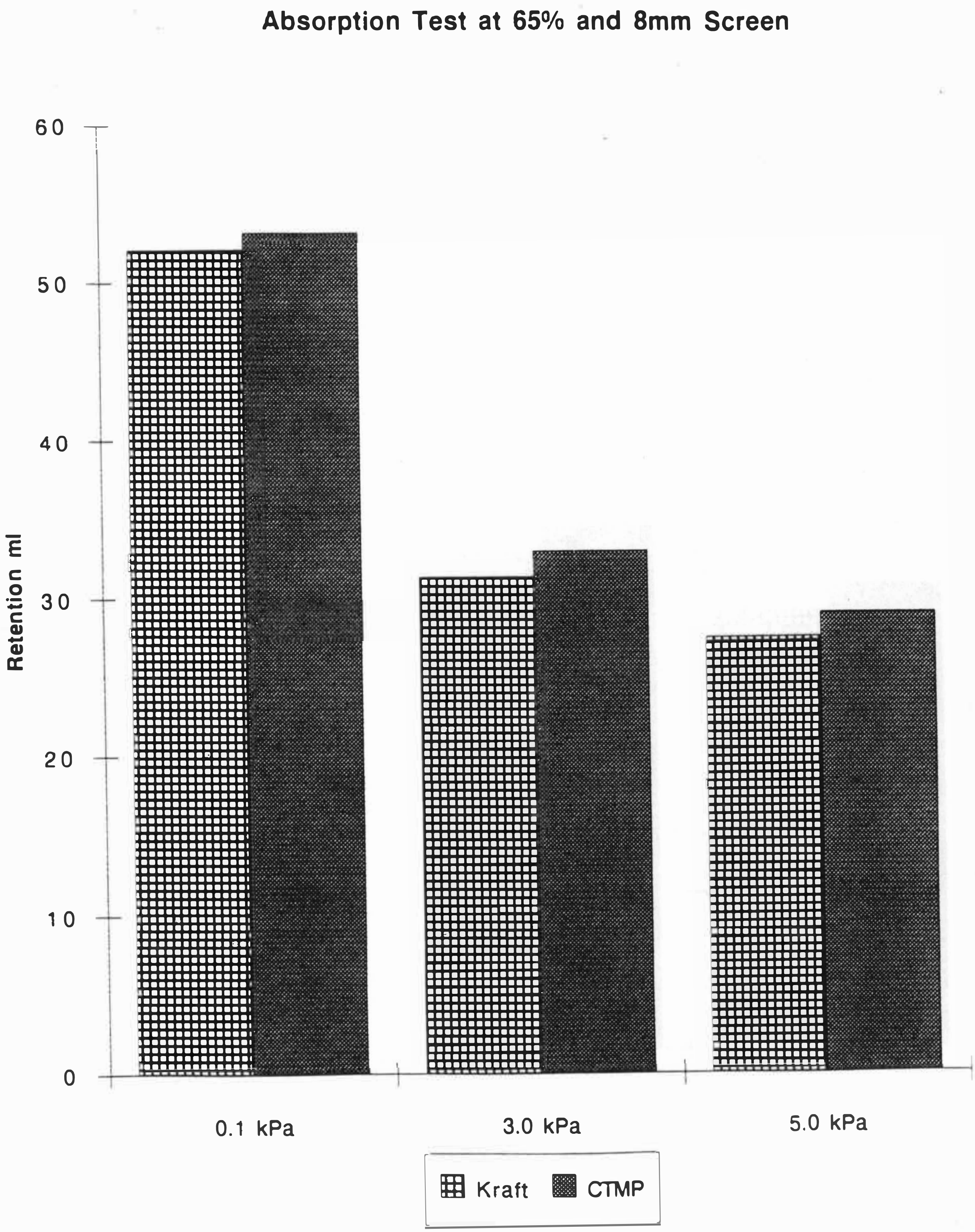

Johnson Nit Count for Kraft and CTMP Analysis for 12mm Screen
Percentage of nits, fiber, fines
80
70
60
50
40
30
20
10
0
Kraft 65%
Kraft 75%
Kraft 85%
CTMP 65%
Kraft 75%
CTMP 85%
Nits 16 mesh
Fiber 30 mesh
Fines

Figure 3



Absorption Test at 65% and 8mm Screen
Retention ml
60
50
40
30
20
10
0
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 4

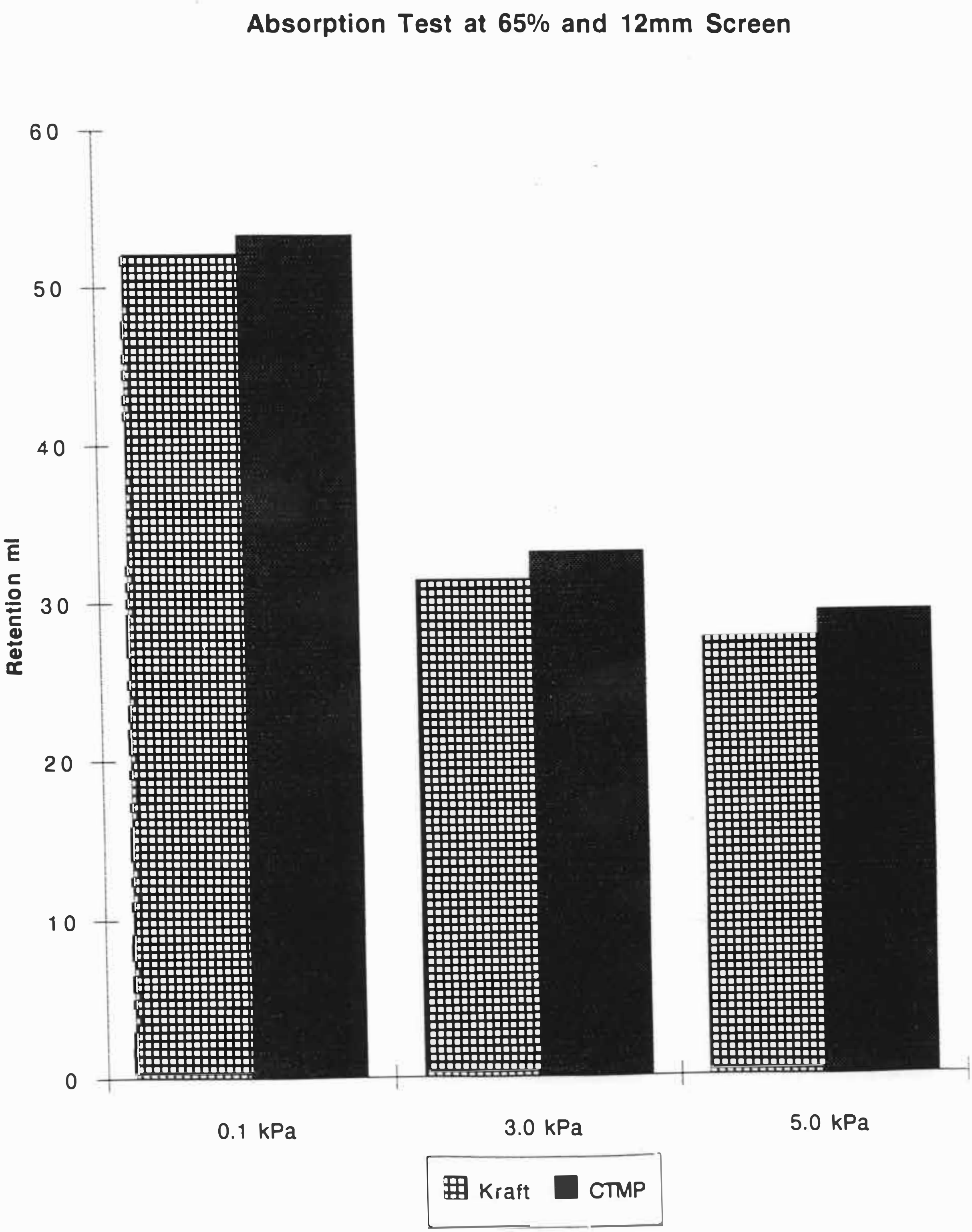

Absorption Test at 65% and 12mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 5

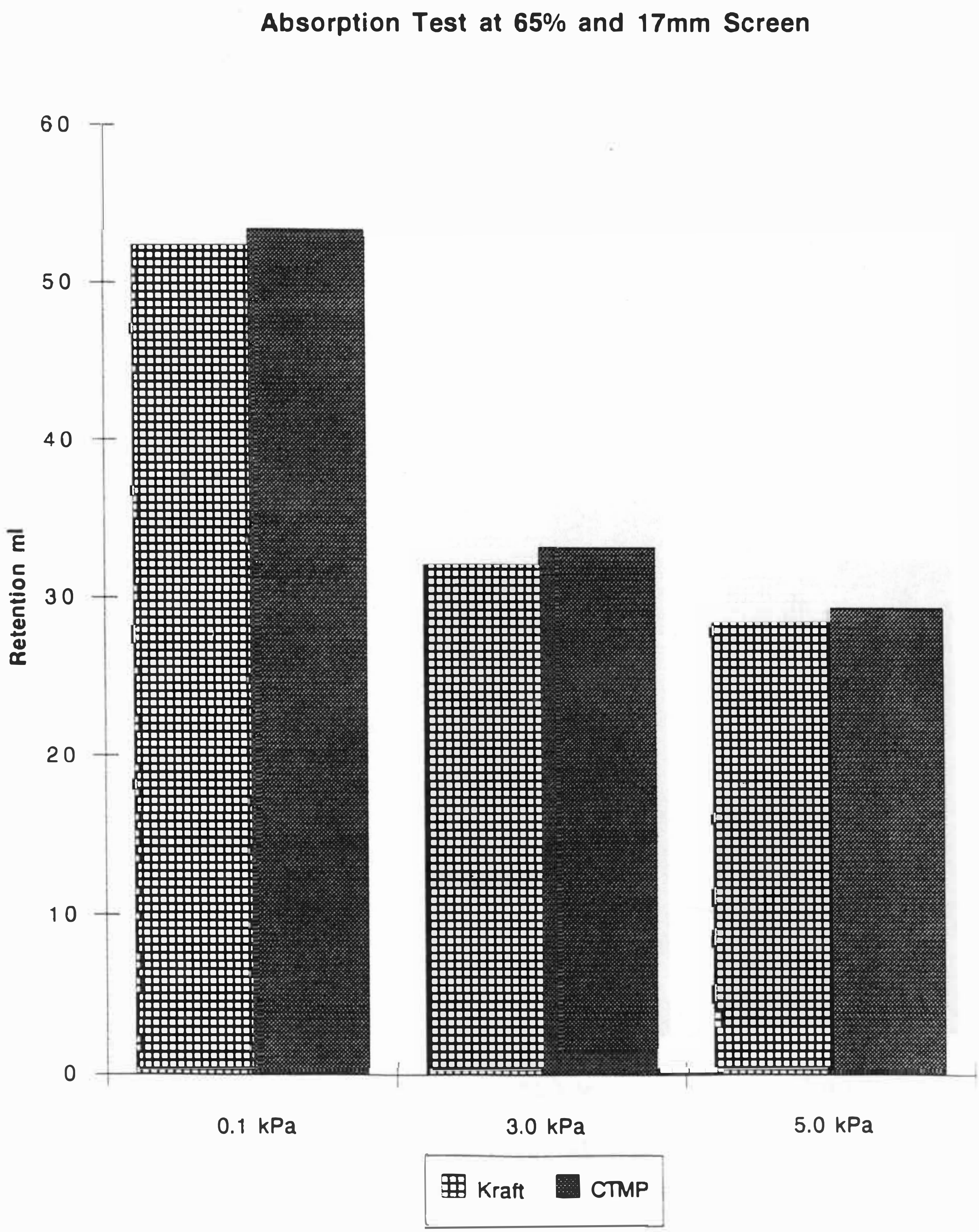
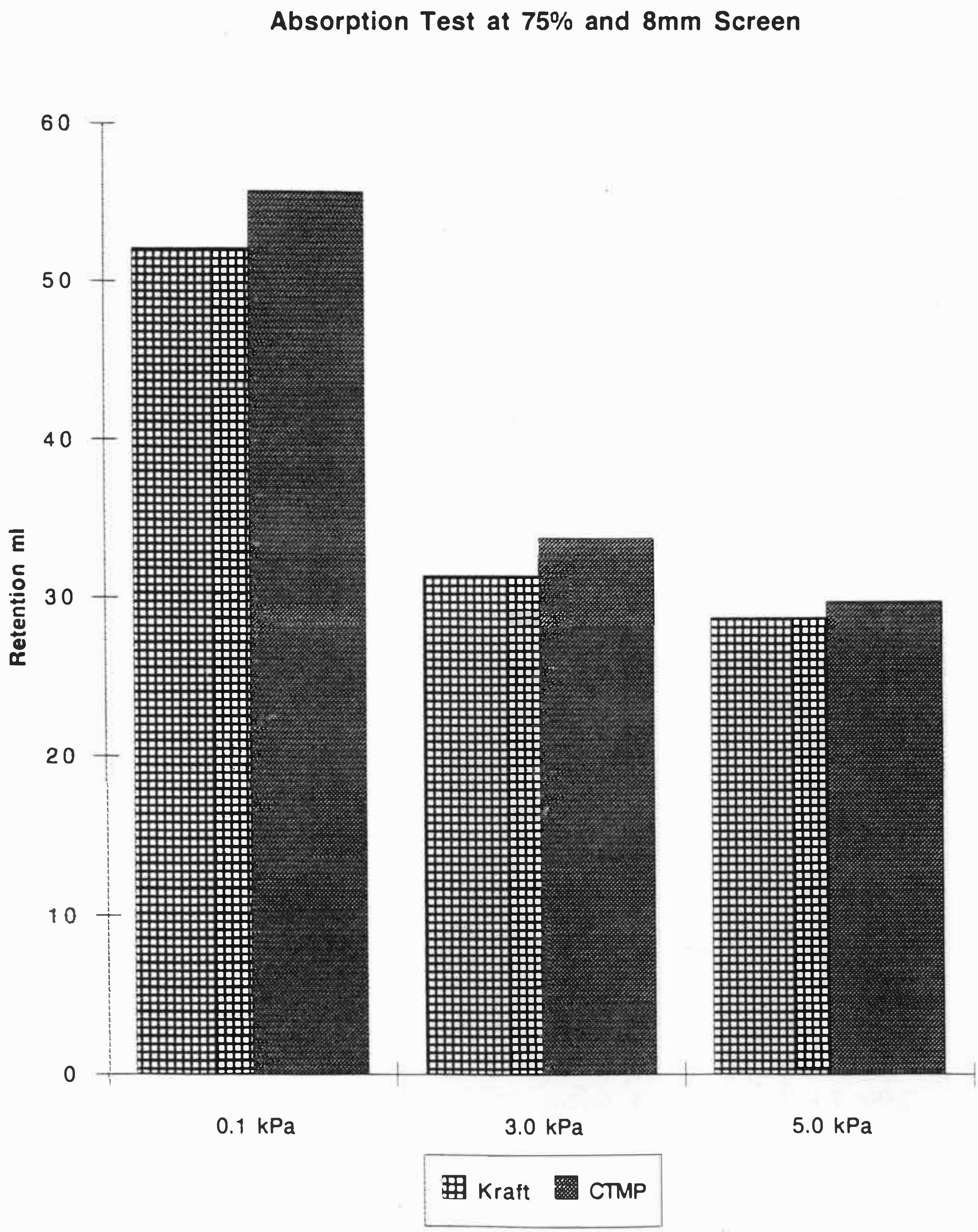

Absorption Test at 65% and 17mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 6



Absorption Test at 75% and 8mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 7

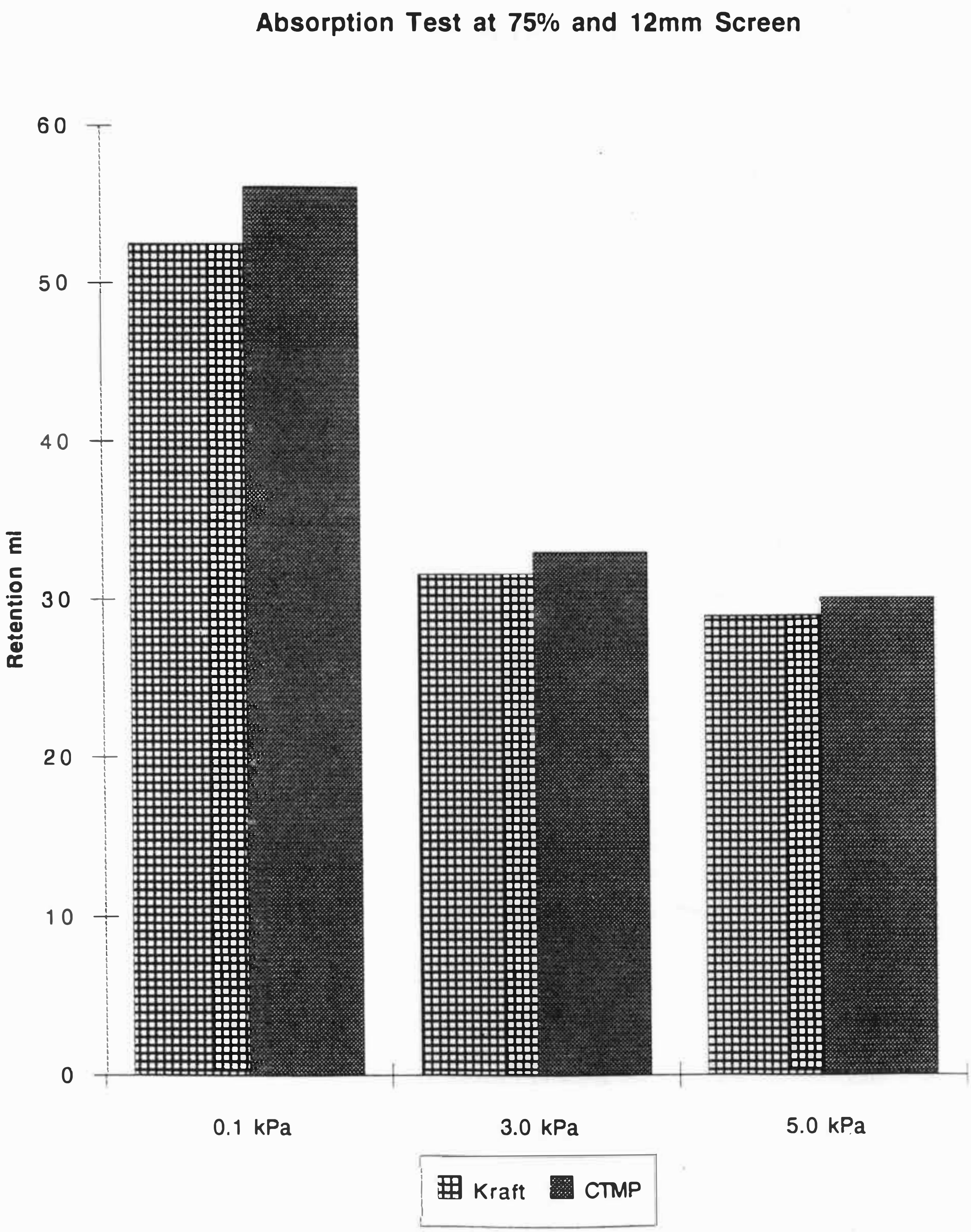
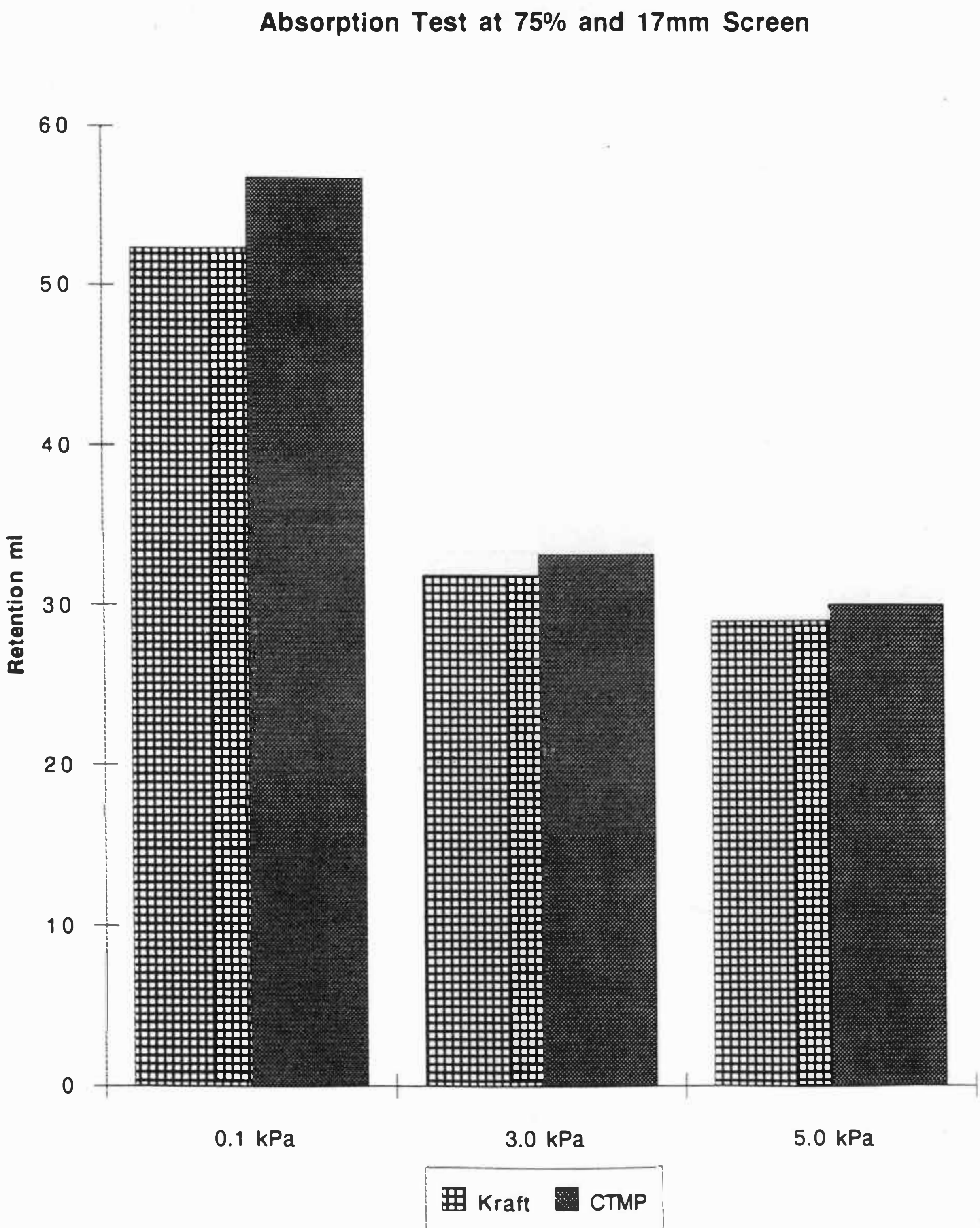
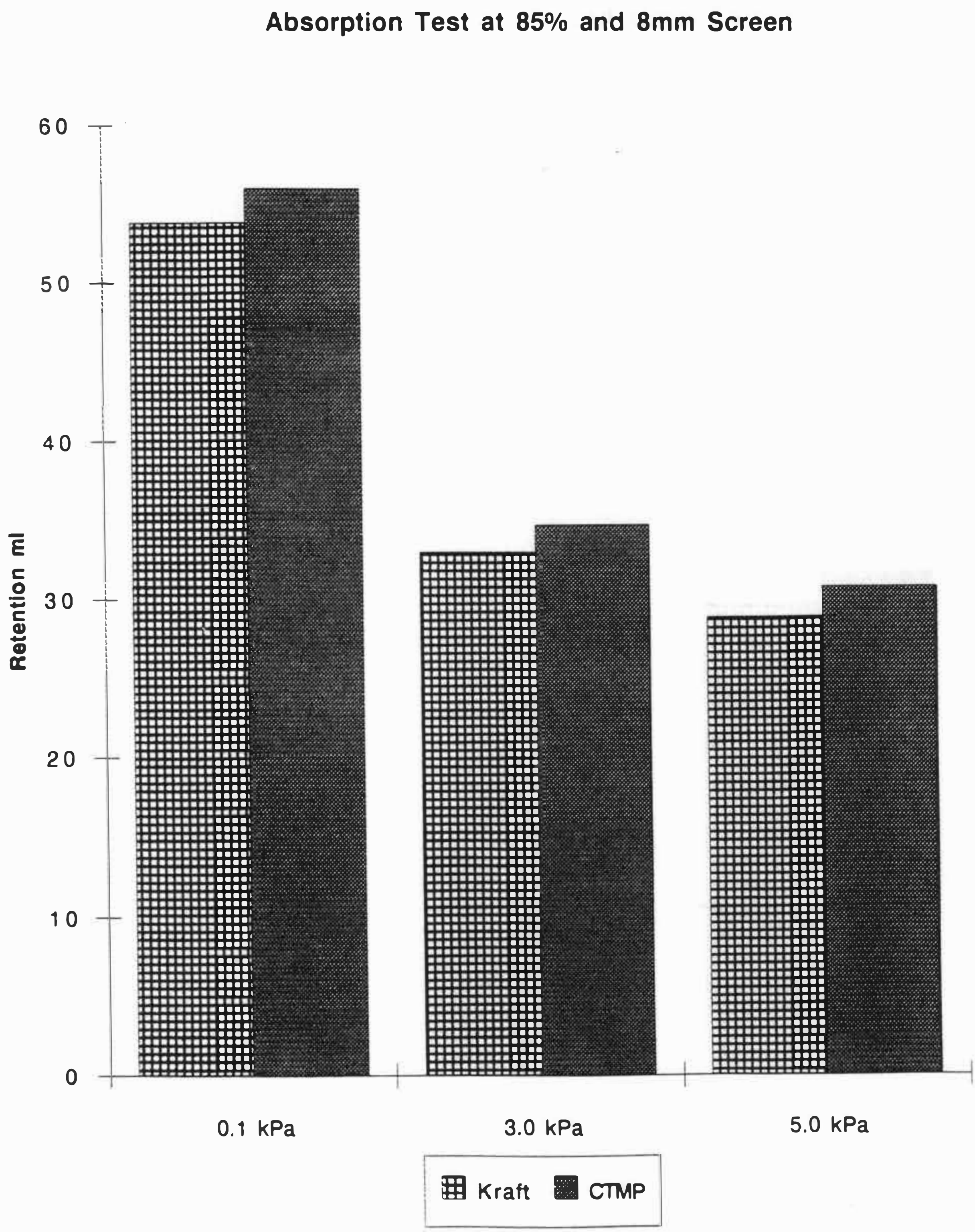

Absorption Test at 75% and 12mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 8



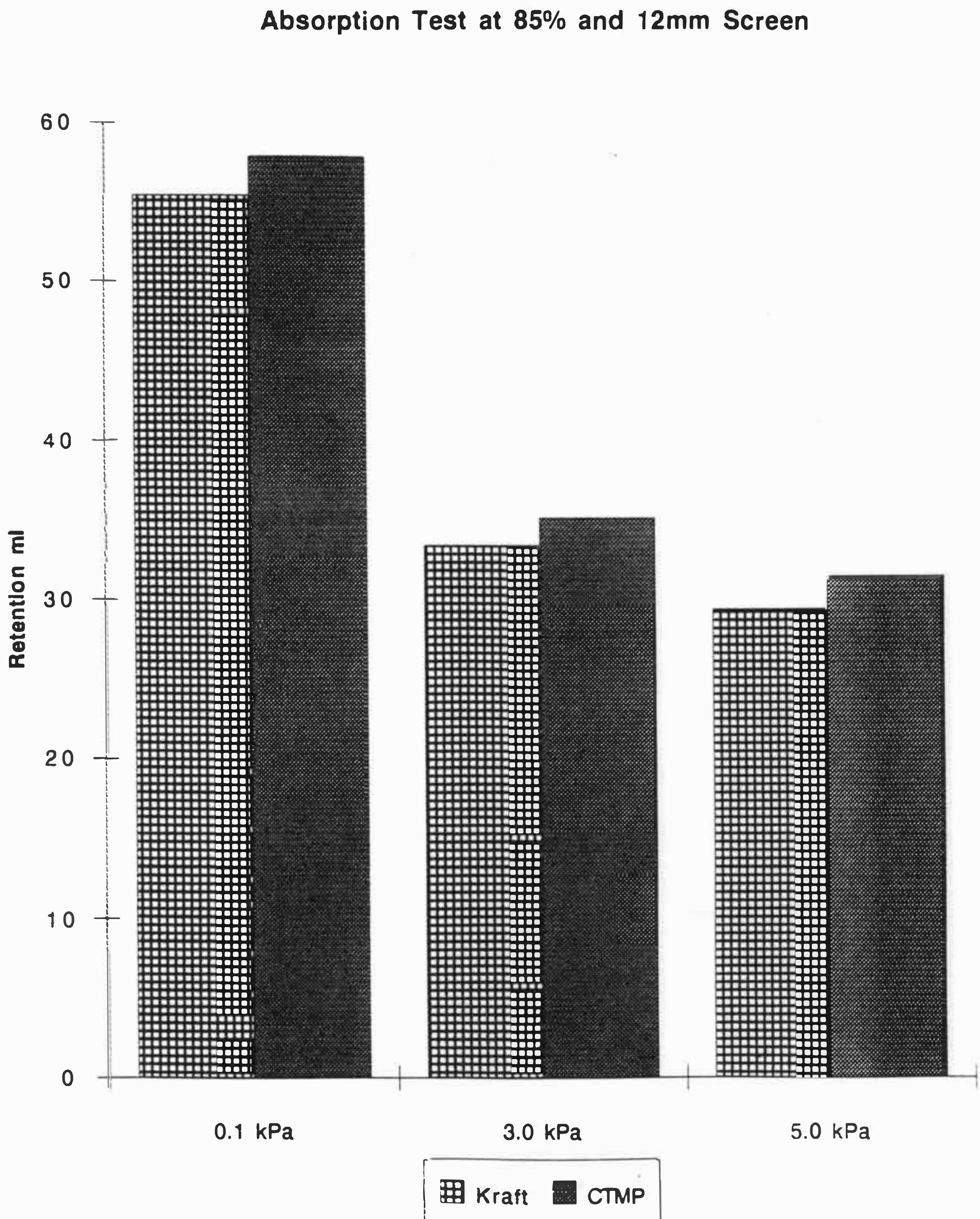
Absorption Test at 75% and 17mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 9



Absorption Test at 85% and 8mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 10



Absorption Test at 85% and 12mm Screen
Retention ml
60
50
40
30
20
10
0
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 11

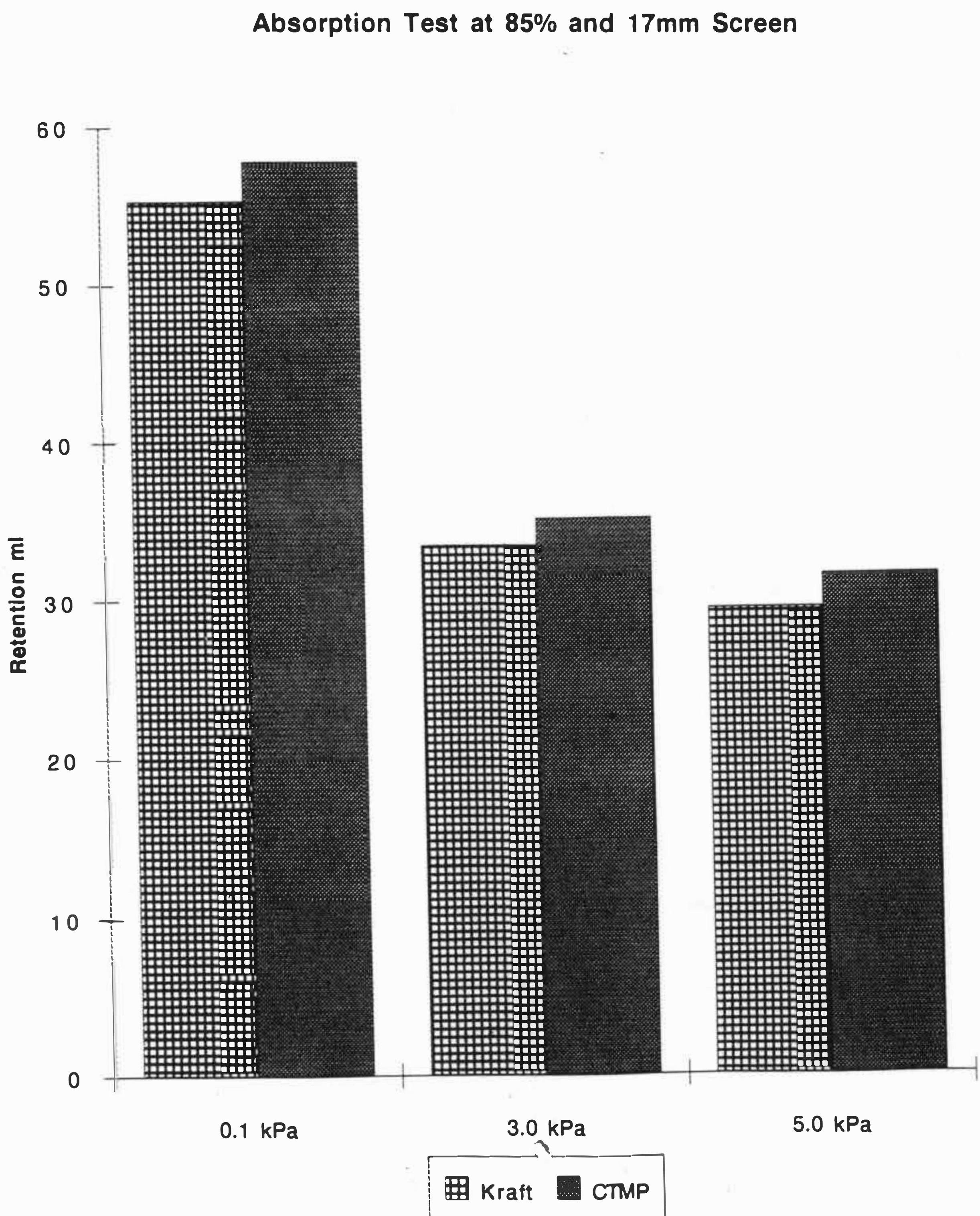

Absorption Test at 85% and 17mm Screen
60
50
40
30
20
10
0
Retention ml
0.1 kPa
3.0 kPa
5.0 kPa
Kraft
CTMP

Figure 12

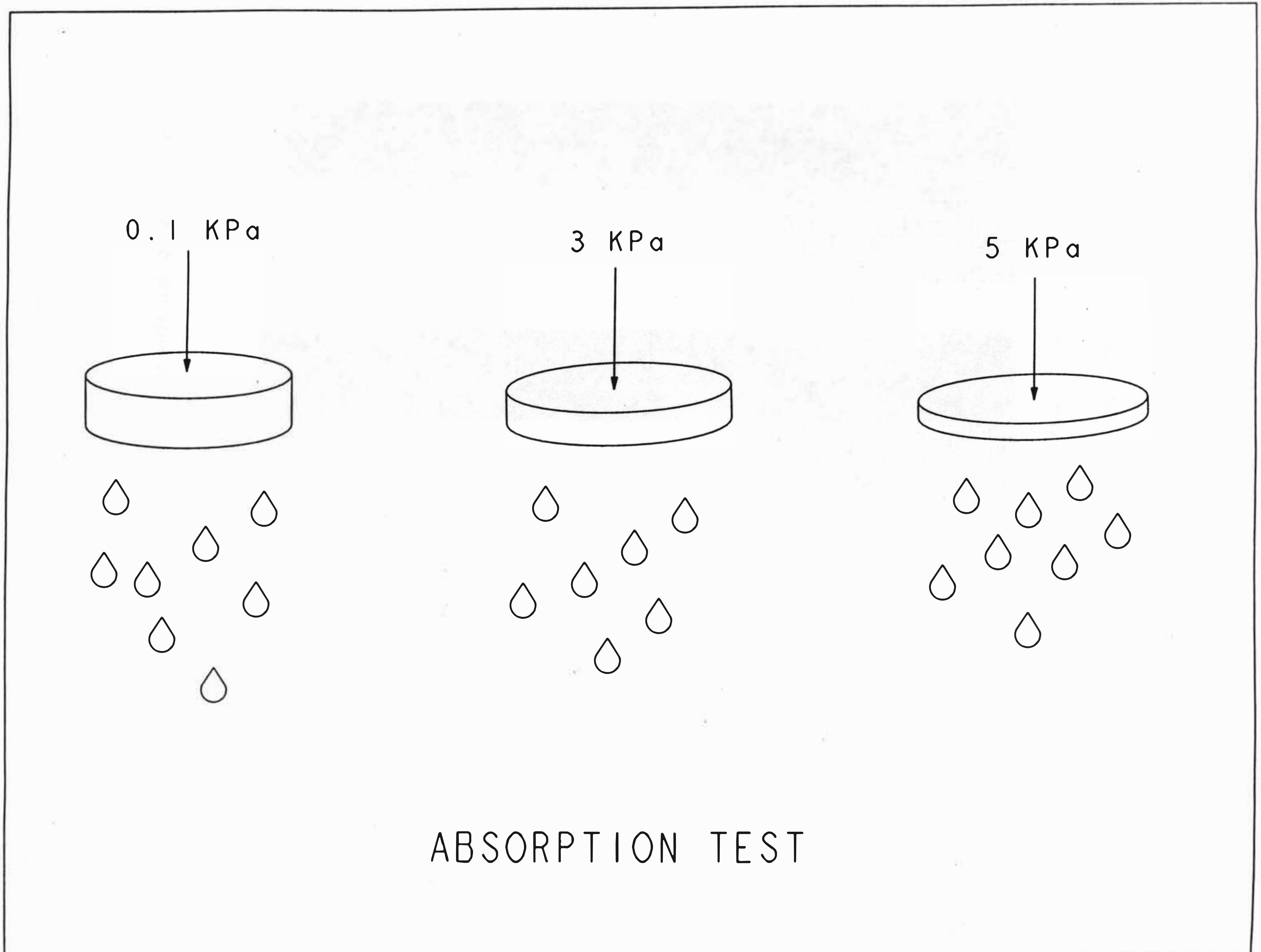


Figure 13

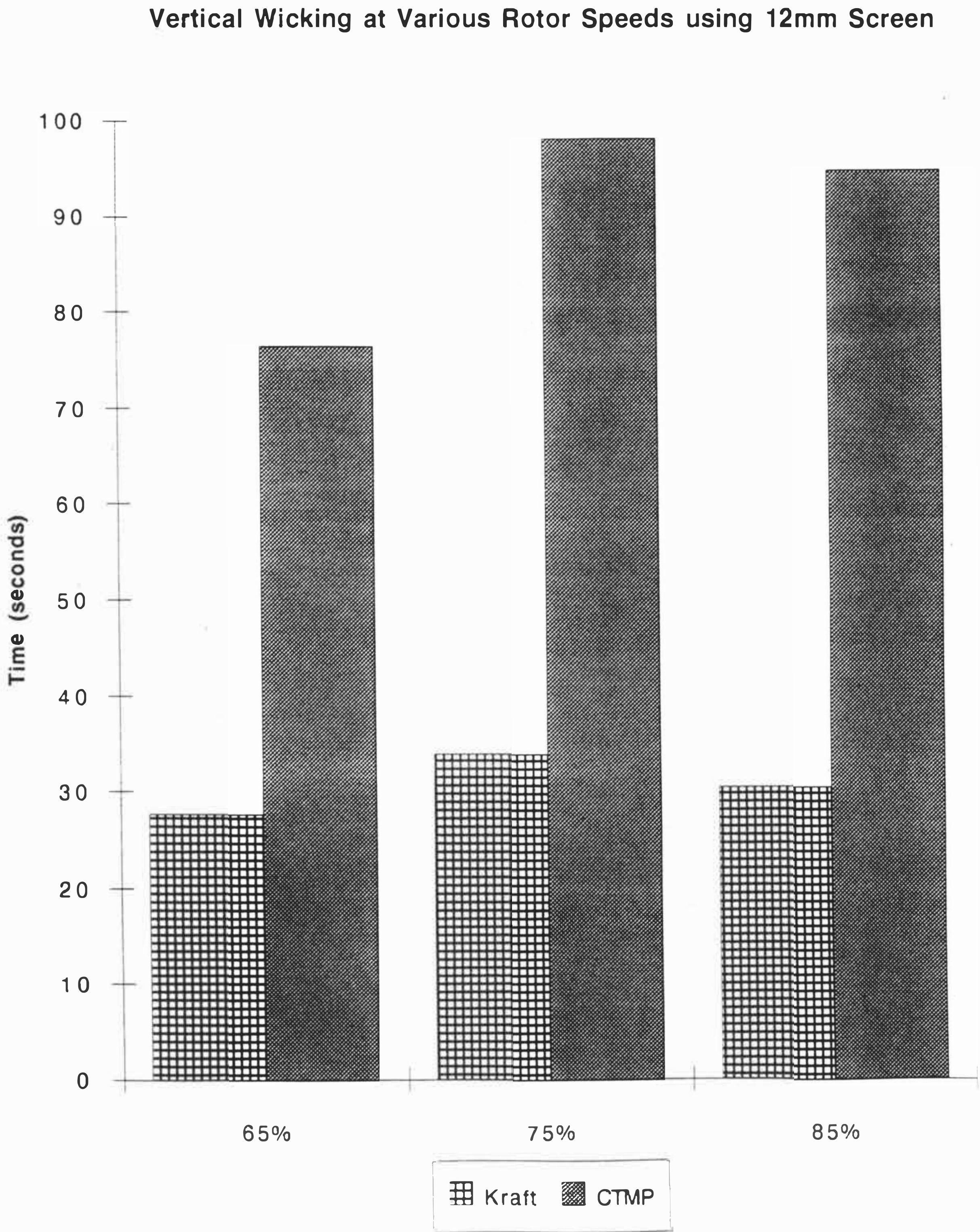
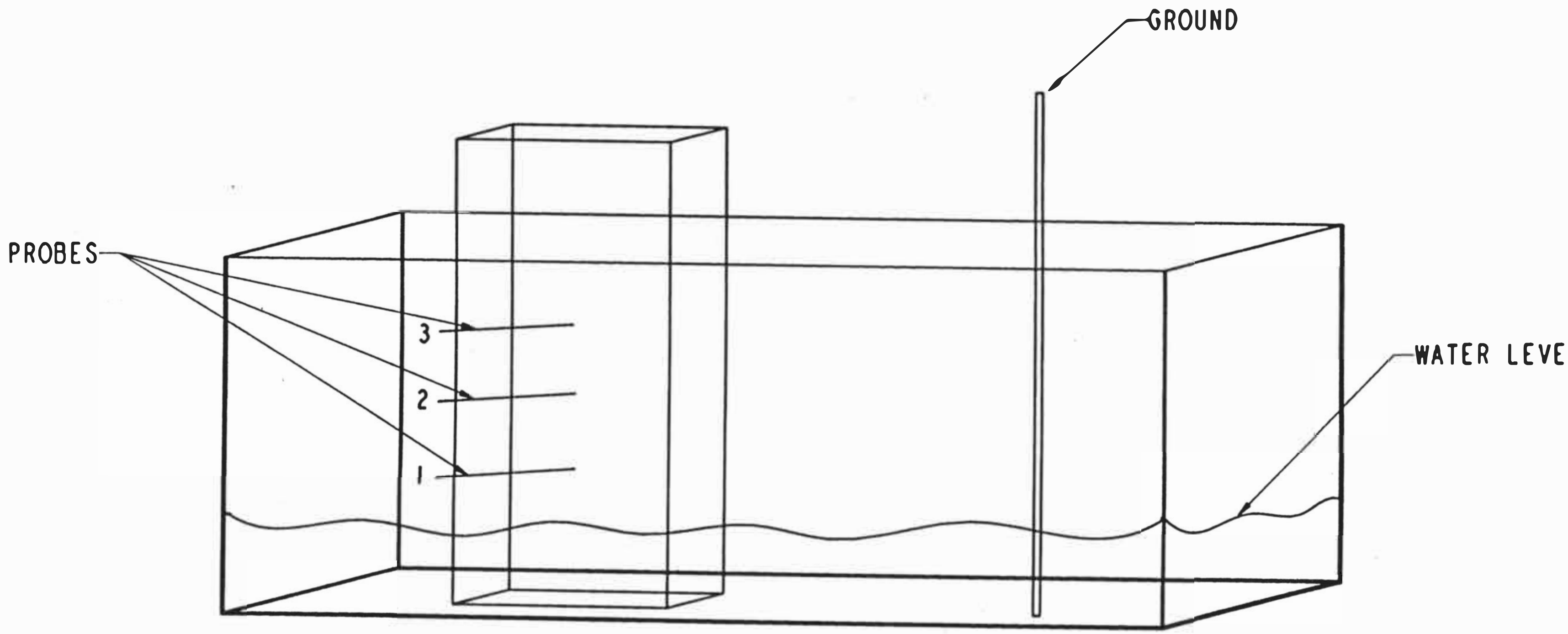

Vertical Wicking at Various Rotor Speeds using 12mm Screen
Time (seconds)
100
90
80
70
60
50
40
30
20
10
0
65%
75%
85%
Kraft
CTMP

Figure 14



VERTICAL WICKING

Energy

Energy of Fiberization	kWh/TON		Standard Dev.	
	Kraft 65%	CTMP 65%	Kraft	CTMP
8mm	48289	28921	1987	1208
12mm	44605	25707	1425	987
17mm	38815	24895	1384	989
	Kraft 75%	CTMP 75%		
8mm	52602	31182	2354	754
12mm	51589	29617	2258	689
17mm	44397	28902	1874	652
	Kraft 85%	CTMP 85%		
8mm	56821	34917	2475	873
12mm	53476	31431	2100	802
17mm	50505	26409	1984	605

Nits 16 mesh Fiber 30 mesh Fines remain

Kraft 65%	Kraft 75%	Kraft 85%	CTMP 65%	Kraft 75%	CTMP 85%
25.7	19.7	11.3	41.7	32.7	18.3
65	72.7	78.7	48	53.3	60.3
9.3	10	10	10.3	16	21.3

Vertical Wick.	12mm Screen		Standard Dev.	
	Kraft	CTMP	Kraft	CTMP
65%	27.66	76.53	3	8.4
75%	33.91	98.31	3.2	12.4
85%	30.42	94.99	3.1	11.9

Absorption				
65 Percent	Retention ml	Retention ml		
8mm			Standard Dev.	
	Kraft	CTMP	Kraft	CTMP
0.1 kPa	52.05	53.1	2.41	2.54
3.0 kPa	31.32	32.98	1.85	1.23
5.0 kPa	27.48	29.01	0.89	0.75
12mm				
	Kraft	CTMP		
0.1 kPa	52.11	53.31	2.12	2.14
3.0 kPa	31.44	33.15	1.54	1.44
5.0 kPa	27.64	29.25	0.89	0.98
17mm				
	Kraft	CTMP		
0.1 kPa	52.37	53.4	2.13	2.8
3.0 kPa	32.17	33.24	1.02	1.65
5.0 kPa	28.55	29.4	0.87	0.55
75 Percent				
8mm				
	Kraft	CTMP		
0.1 kPa	52.11	55.72	1.98	1.54
3.0 kPa	31.44	33.83	1.22	1.5
5.0 kPa	28.8	29.81	0.56	0.99
12mm				
	Kraft	CTMP		
0.1 kPa	52.49	56.11	2.11	1.63
3.0 kPa	31.62	33.01	2.01	1.32
5.0 kPa	29.02	30.1	1.02	1.01
	Kraft	CTMP		
0.1 kPa	52.35	56.75	1.54	2.01
3.0 kPa	31.9	33.2	1.21	1.87
5.0 kPa	29.08	30.05	0.88	1.11
85 Percent				
8mm				
	Kraft	CTMP		
0.1 kPa	53.84	55.99	2.54	2.68
3.0 kPa	33.01	34.72	1.54	2.07
5.0 kPa	28.89	30.75	1.19	1.03
12mm				
	Kraft	CTMP		
0.1 kPa	55.41	57.82	2.98	2.45
3.0 kPa	33.4	35.1	1.41	1.11
5.0 kPa	29.39	31.42	0.57	0.69
17mm				
	Kraft	CTMP		
0.1 kPa	55.29	57.8	2.65	2.45
3.0 kPa	33.45	35.15	1.97	2.27
5.0 kPa	29.45	31.52	1.31	1.59