Recycled Fiber Technology

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INTRODUCTION

The main technological functions for recycled fiber systems are to remove contaminants from fibrous material, disperse hot melts (stickies) and reduce/release ink particles, increase fiber brightness and develop fiber strength properties.

All traditional recycled fiber systems have all, or at least most, of the following generally described subprocesses:

* Repulping to slush paper and board into a pumpable slurry and at the same time release fibrous material from contaminants including ink. Surface chemistry is also used for more effective operation. Repulping is carried out as a continuous or batch process at low (3-5%) consistency or at high (12-16%) consistency.
* Screening under pressurized conditions by using drilled holes at 2-3.5% consistency and slots at 0.5-1.5% consistency to remove released contaminants.
* Purpose of flotation is (by using surface chemistry) to induce ink particles to become attached to air bubbles either under atmospheric or pressurized conditions and to reject the resulting scum from the system. Typical operation consistency is around 1%.
* Washing and pressing are used to wash out ink/ash out from the pulp, to increase consistency for other subprocesses or to change process water and to seperate water circulation of different groups of subprocesses. Filtrate is led partly countercurrent for washing and partly to water treatment. Fiber consistency increases from below 1% to above 30%.
* Dispersion is used to reduce ink particle size, disperse hot melts and release remaining ink from fibers by applying energy. Both refiner type and kneader type dispersion systems are used. Consistency is aroud 30% and temperature under or above 100^0 C depending on pressure conditions.
* A disperser can also be utilized to admix bleaching chemicals, or seprate chemical mixers can be used. The other key process units are reaction towers and discharge units to operate at low, medium or high consistencies.

  Typical bleaching agents are peroxide and hydrosulphite.
* Refining has not been accepted subprocess in recycled fiber lines in the past, but recent refining results show the potential to improve fiber bonding ability. Post/ trim refining consistency is from 3% to 5%.
* Quality monitoring has mainly been based on naked eye or measured as the number of web breaks in papermaking. All quality control measurements are made in laboratory conditions and therefore have not been in real time.

Sunds Defibrator's approach to recycled fiber treatment is based on fiber processing solutions involving Chemical Pulping, Mechanical Pulping and Stock Preparation Systems.

Figure-1 shows the other Sunds Defibrator pulp preparation technologies that can be applied for recycled fiber treatment.

Figure-1

	Chemical Pulping	Mechanical Pulping	Stock Preparation	Recycled Fiber
1. Pulping			X	X
2. Screening	X	X	X	X
3. Flotation				X
4. Washing	X	X		X
5. Pressing	X	X		
6. Dispersion				X
7. Refining		X	X	
8. Bleaching	X	X		X
9. Quality Control	X	X		

Sunds Defibrator Valkeakoski Oy, FINLAND

SUNDS DEFIBRATOR SUBPROCESSES FOR RECYCLED FIBER

The Sunds Defibrator recycled fiber product family includes equipment for all these subprocesses.

1. REPULPING

1.1 Low consistency (3-5%) batch (type LCPA)

(average values)

size	5...80 m^3
motor size	75...630 kW
production	10...300 T/D

1.2 Low consistency (3-5%) continuous (type LCPA)

size	5...80 m^3
motor size	75...630 kW
production	20...500 T/D

1.3 High consistency (10-15%) batch (type HCPA)

size	10...50 m^3
motor size	200...800 kW
production	50...450 T/D

1.4 The pulpers can be fitted with such auxiliaries as raggers, tail cutters, junk towers, detrashers, etc.

Pulper performance is tested in more than 800 mill installations worldwide.

Figure-2. High Consistency Pulpers (HCPA)

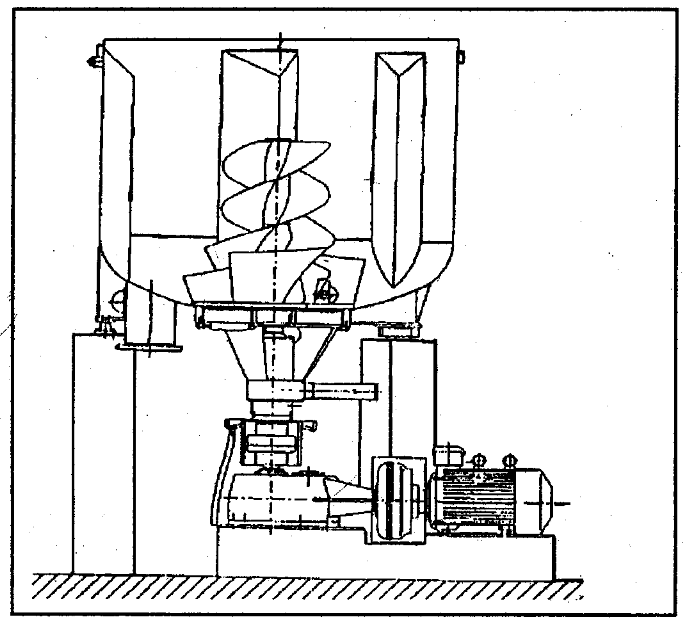


Figure-3 presents a comparison between two different types of the most typical pulpers: drum pulper, with deflaker pump, and vertical batch pulper, with detrasher.

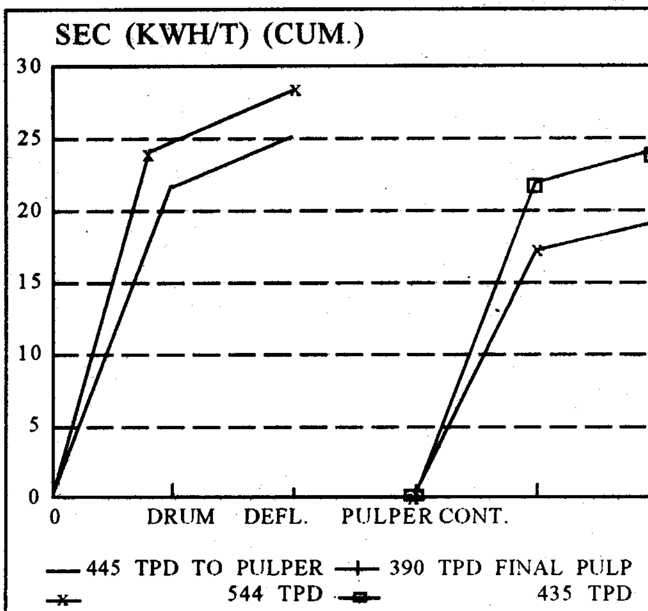


Figure-3

2. SCREENING

2.1 Separation process

The screening process requires that the fiber network in the pulp is broken up in order to allow separation of individual particles. Energy intensity is an important parameter required to overcome the strength of the fiber network in the pulp suspension.

Figure-4 shows the energy requirement to break up the fiber network to fluidize the pulp for three recycled fiber pulps, with a kraft pulp as reference. The upper curve represents a Scandinavian soft-

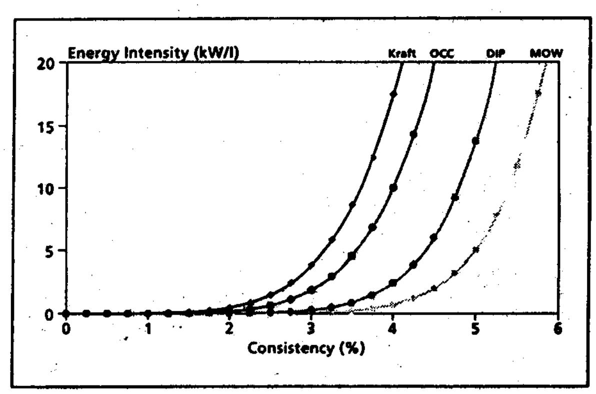


Figure-4

wood kraft pulp. The OCC, DIP and the MOW pulps should be regarded as examples of these types of RCF. The quality of RCF pulps can vary considerably from time to time and from mill to mill.

The strength of the fiber network is controlled by pulp consistency and fiber length. The energy requirement for fluidization increases rapidly when the consistency of the pulp exceeds 2%. Consequently, pulp consistency plays a most important role in all separation processes.

In a unit operation such as screening, there is a requirement for a minimum level of energy intensity. It is important for the screening process to break up the flocks of fibers and debris into individual components and to allow them to be separated according to their properties. The deflockulation is achieved by turbulence generated by the geometry of the screen plate surface. In this state of deflockulation, with the individual components of the pulp mobilized, the fiber suspension is said to be "fluidized". It is fundamental to the screening process that the individual particles are free to move independently. If not, no selective separation can occur.

The energy intensity in the boundary layer on the screen plate surface should be as close as possible to that required for complete fluidization.

Energy in this context is kinetic energy in the form of turbulence, or more specifically that part of the turbulence spectrum which is small enough to affect individual fibers and particles. Large scale turbulence is only a waste of energy.

2.2 Conditions in a conventional screen vs. an ideal screen

To describe the conditions in conventional screen (see Fig-5) it is convenient to divide the screening zone from feed to reject side of the basket in three parts, with different conditions:

* The upper part, where the consistency is too low to be in balance with the energy input from the rotor, is where most of the pulp is accepted. In this section the pulp is exposed to a higher energy intensity than required by its consistency. The result is excessive turbulence and reduced separation efficiency.

* In the middle part, the feed consistency has increased due to thickening, and the turbulence intensity is high enough to fluidize the pulp, but not so high that excessive mobility is generated. The separation efficiency is high, since the conditions are close to optimal.

* In the lower part of the screening zone, the energy intensity is too low to fluidize the pulp, since the consistency is too high and increasing. Thickening takes place, energy is wasted and only dewatering can occur.

The conditions along the basket vary considerably, and it is evident that a conventional screen is not utilized to its full potential in terms of capacity, separation efficiency and ability to operate at low reject rates.

In an ideal screen, see fig.-6, with no thickening the energy intensity on the screen plate surface can be optimized to match the feed consistency. The accepts consistency is high, in fact the same as the feed and the rejects consistency. The full length of the screening zone is utilized at optimal energy intensity. The operating range is wide, and it is possible to operate at very low reject rates. The

Figure-5

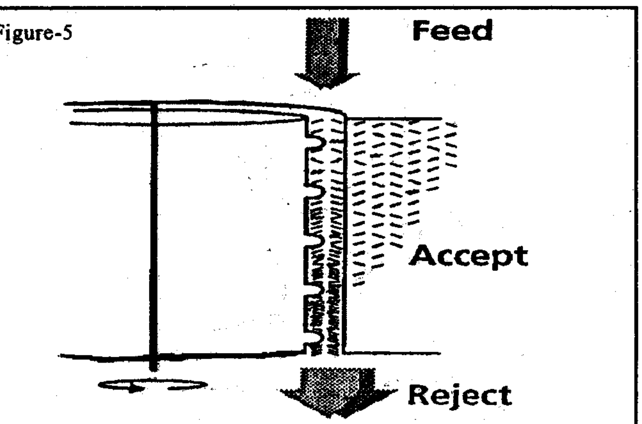
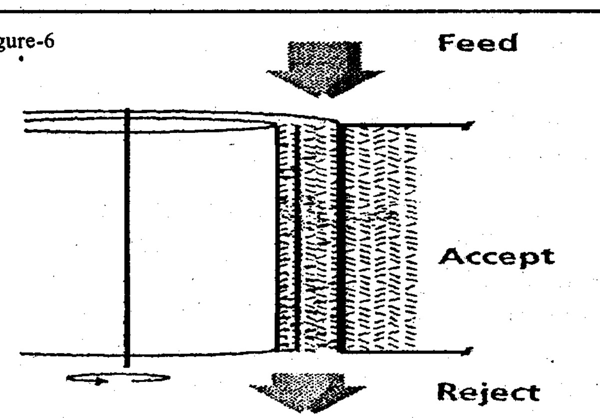


Figure-6



screen will not clog due to thickening, even if the reject valve is closed.

2.3 The Delta Concept - DeltaScreen ®T

By using a much wider foil than in a conventional screen, it is possible to construct a pulp screen that does not cause thickening. The principle is shown in Fig.-7.

During the phase of positive flow through the screen plate (the time between the suction pulses) thickening occurs. This loss of water is offset by filtrate recovered from the accepts side of the screen basket by the long suction pulse generated by the wide foil. The amount of filtrate recovered should idealy be the same as that lost due to the thickening which took place a moment earlier.

The amount of filtrate recovered can be controlled by the intensity and duration of the suction pulse. The practical implication is that the thickening in a widefoil screen can be controlled by the rmp of the rotor.

Development work on the new type T screen focused on three main objectives. The pulp screening process should have:

1. **High separation efficiency**
2. **High accept consistency, for high capacity**
3. **Low mass reject rates, to make it possible to reduce the number of stages in the screening system**

2.4 Liteflo™

The liteflo™ is a special collector for removal of the light weight debris separated from the pulp during its passage up through the rotor the top of the screening zone. The Liteflo™ is an integral part of the top of the screen. It is the extension at the top of the screen.

By adding a small flow of water at the center of the collector a flow .attern is generated which removes the light weight debris from the top of the screen and concentrates the light weight debris at the top of the collector. Besides generating the proper flow pattern in the collector, the flow of water will dilute the fiber suspension in the collector and

Figure-7

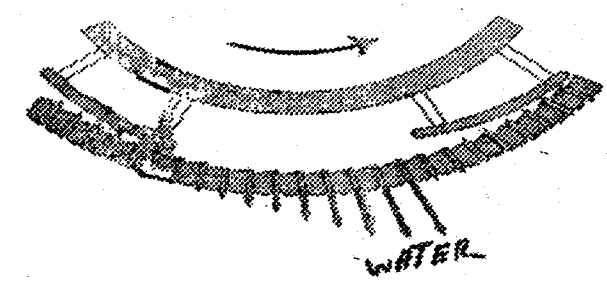


Figure-8

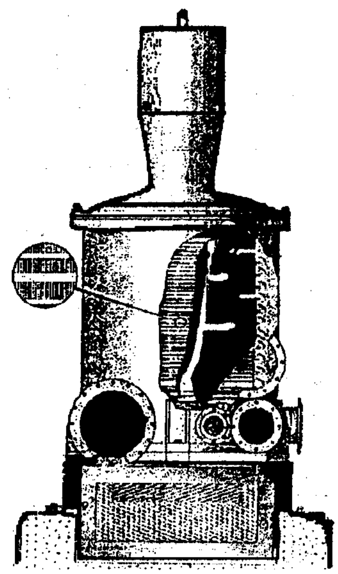
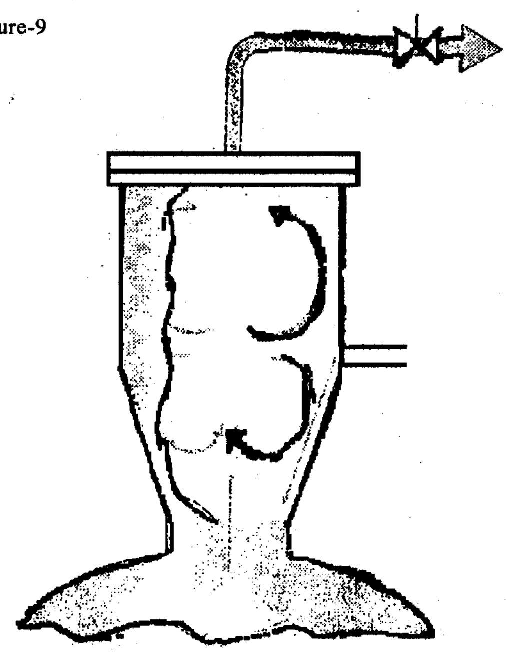


Figure-9



wash and concentrate the debris, so when the collector is discharged the fiber losses are very small. As the debris will concentrate at center of the top, it is enough to discharge small volume (<10 liter) each time. The suitable time between discharges depends on the amount of removable light weight debris in the stock. It could be anything from 15 minutes to once a shift.

When the Liteflo™ was tested in the reject handling system of an OCC mill, the light weight debris was discharged every hour at a pulp consistency of 0.3% (the consistency of the white water), when the screening was done at > 3.5% consistency.

2.5 Mill evaluations

Examples of the performance of the new screen:

A) DIP

Figure 10 shows the accepts capacity, expressed as T/D/m² screen plate surface area, and the accepts consistencies obtained when screening DIP-stock, using Nimega™ baskets with different slot widths. With a short fiber-stock MOW, it is possible to run higher consistencies, while with longer fiber OCC-stock the maximum consistencies and capacities will be lower than the values shown for DIP.

The screen was tested in a position before the

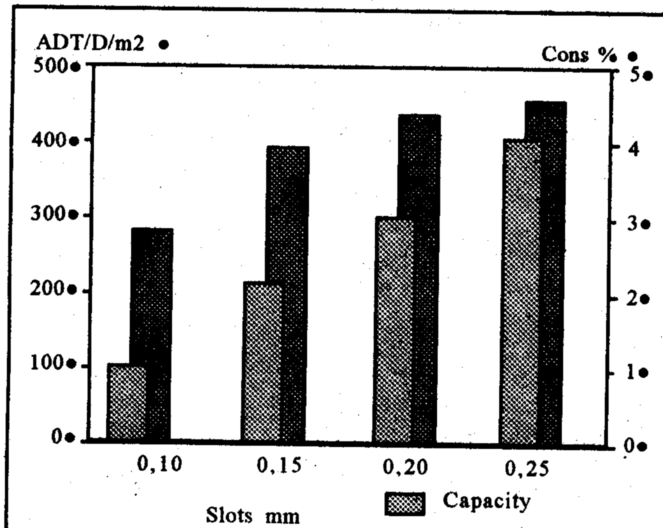


Figure-10

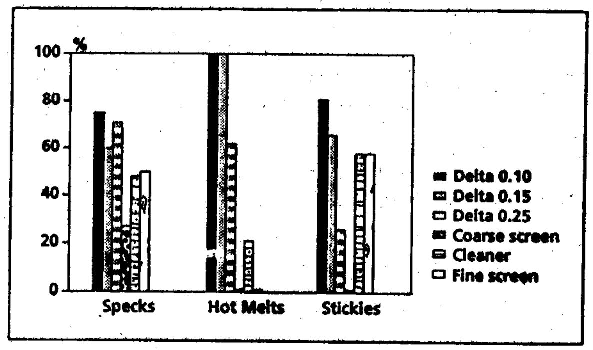


Figure-11

coarse screens in a large modern DIP system. The results are presented in Figure 11, which shows the removal of specks, hot melts and stickies using 0.10, 0.15 and 0.20 mm slots on the new Nimega™ welded bar baskets.

Hot melts were completely removed with HC screening on 0.10 and 0.15 mm slots. With slots 0.15 mm and smaller, the reduction efficiency for stickies was higher with the new HC screen than with the conventional screens and cleaners installed at the mill.

In this DIP system it was possible to operate at an average accept consistency of nearly 5%, at a mass reject rate of < 3% in one stage, while at the same time maintaining high removal efficiency.

B) MOW

The tests on MOW shown in Figure 12 were conducted on a furnish used as a top layer on a

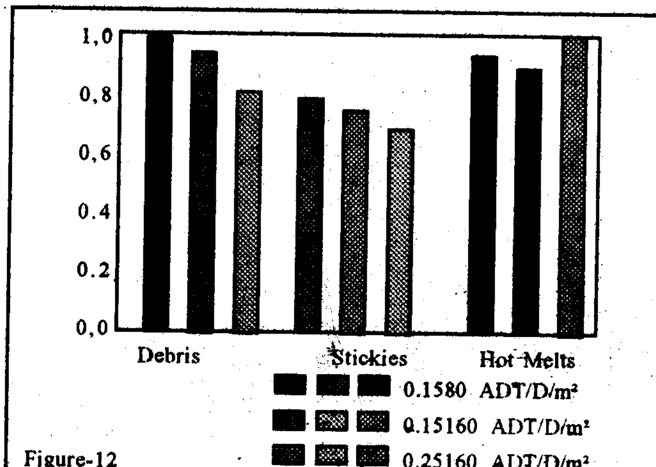


Figure-12

white top linerboard. The DeltaScreen was installed after the refiners ahead of the machine chest and the screen was operated at accepts consistencies around 3.5%. The rejects were used in the base layer on another machine. Two different baskets with 0.15 and 0.20 mm slots were tested and the efficiency was evaluated at two production rates.

An increase in production rate, from 80 to 160 ADT/D/m^2, caused a small reduction in efficiency, while increasing slot width from 0.15 to 0.25 mm reduced the efficiency further.

C) OCC

With OCC the screen was installed early in the system, after two turbo separators and high-density cleaners. Only 0.15 mm slots were evaluated. The production rate was 120 to 175 ADT/D/m^2 at 3 to 4% accepts consistency. Figure-13 shows the reduction of debris stickies and hot melts measured under these conditions. With this stock the reduction of stickies over the screen was very high, and the hot melts were completely removed.

2.6 Screening system investment and operation cost

Sunds Defibrator's system compared to conventional screening system.

Sunds Defibrator has delivered more than 1400 screens worldwide and during the last 10 months over 50 DeltaScreen®T units.

3. FLOTATION

Flotation as a subprocess of Sunds Defibrator's Recycled Fiber Technology is undergoing intensive development.

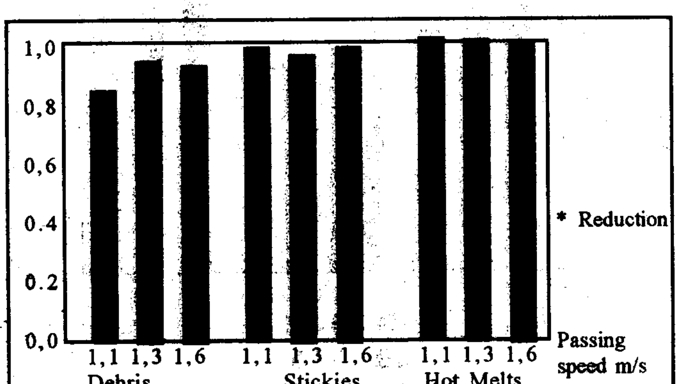


Figure-13

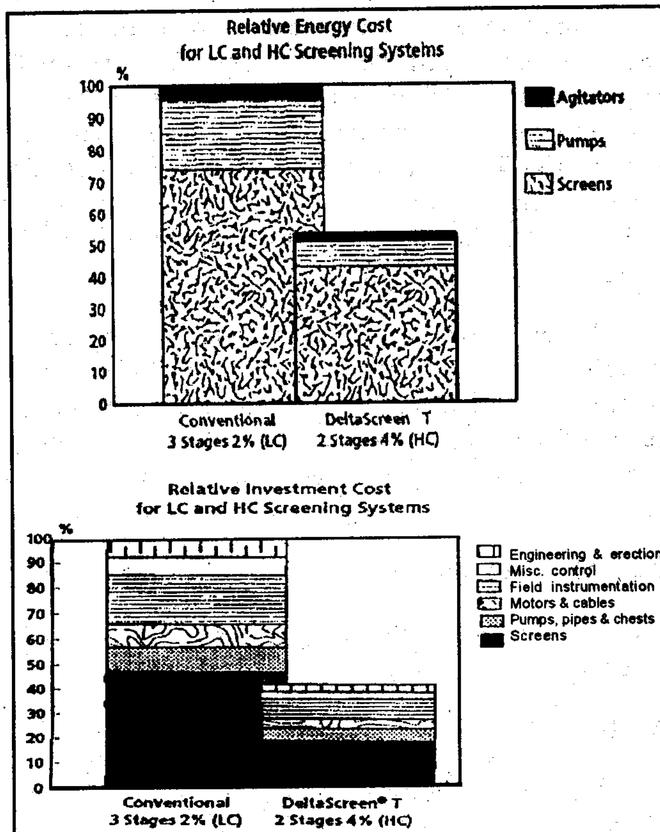


Figure-14

Today, we are in the final stage of testing a new flotation concept in over pilot plant to finalize it for market introduction.

4. WASHING

PreRoll™

The PreRoll™ is a newly developed dewatering and washing equipment, see Figure-15.

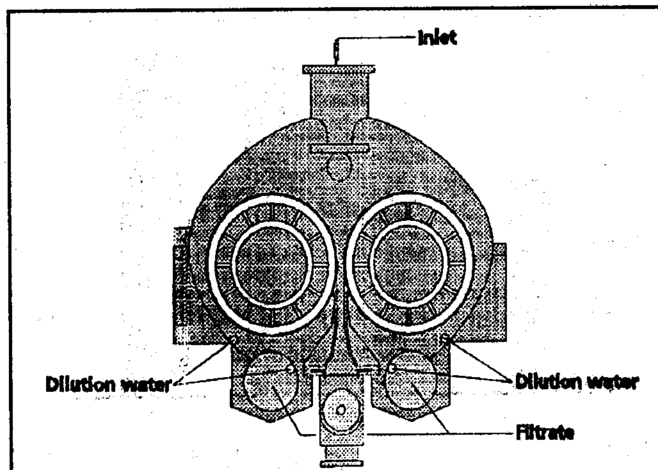


Figure-15

The main field of application is to use it as a pre-dewatering press, that is, for thickening of pulp with a feed consistency of 1-4% to discharge consistency of 8-10%, and then dewater it further on a roll press.

5. DISPERSION

In Sunds Defibrator RCF process the contaminants are removed very efficiently.

Because of increasing recycling, paper and board manufacturers are forced to utilize decreasing furnish quality for their products.

At the smae time, the market is demanding continuously higher end product qualities.

Sunds Defibrator's tools to meet these requirements are:

* **improved ink particle size reduction**
* **efficient ink release from fibers**
* **optimum hot melt dispersion**
* **pulp homogenization**
* **controlled development of fiber properties**

The Sunds Defibrator dispersion subprocesses is the combination of (Figure 16):

* **Dewatering with Roll Press**
* **Preheating with high intensity Hi-Preheater including the Fluffer**
* **Dispersion with conical DCA-disperser**

5.1 Dewatering requires adjustable washing effect, controlled thickening and easy operation.

Figure 16

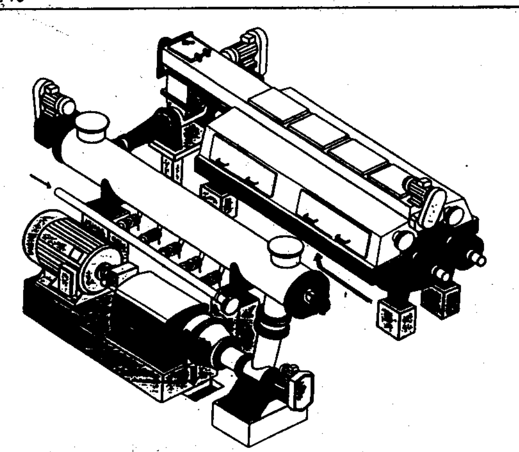


Figure-16

The roll press is based on the proven Twin-Roll concept. (Figure-17). A great number of units are currently operating in a wide range of washing and dewatering application worldwide. The Twin-Roll presses are also known for their compact design which means smaller space requirement and savings in building and installation costs.

5.2 Preheating is needed to adjust pulp and ink/sticky temperature to be suitable for efficient dispersion. This means that by good mixing and fluffing the steam consumption and equipment size are minimized.

Figure 18 shows the arrangement of the feed/plug screw, Fluffer and the Hi-Preheater.

5.3 Disperser, figure 19

The heart of dispersion is the new conical DCA-disperser, which has been developed and en-

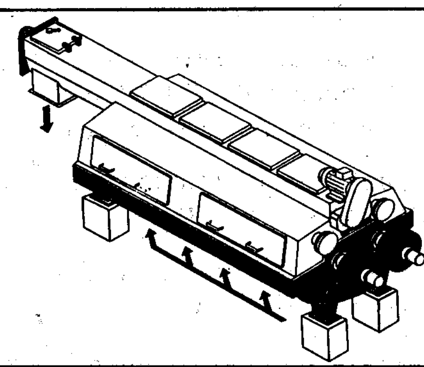


Figure-17

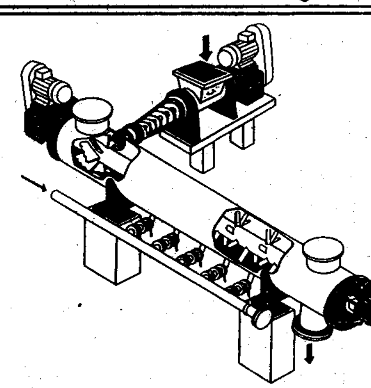


Figure-18

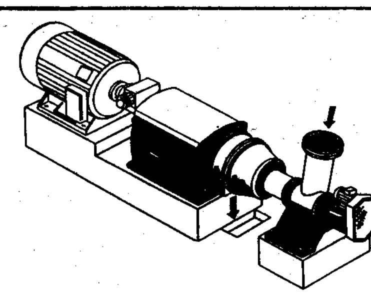


Figure-19

gineered from the proven Conflo® refiner, known for its gentle fiber treatment.

In addition to excellent dispersion performance based on the large processing area of the conical shape, the new unit offers the flexibility of being able to apply its refining effect to improve strength properties.

5.4 Mill results

Dispersion efficiency is usually described as a function of energy consumption and measured as reduction of ink particles, stickies, hot melts or freeness.

As known, good reduction values can be achieved if the process before the dispersion is ineffective and/or furnish is very dirty.

To make comparisons all process parameters have to be taken into account.

The following curves show some post dispersing results made with 70 ONP/300 MG DIP ahead of paper machine to improve quality.

Figure-20: Speck reduction (>50 μm) vs. SEC (kWh/t) dispersed with **DCA.**

Figure-21: Hot melt reduction (>150 μm) vs. SEC (kWh/t) with DCA.

Figure-22: Tensile strength improvement (%) vs. SEC (kWh/t) with DCA.

One of the main advantages of DCA is the superior fiber strength improvement.

Sunds Defibrator dispersion for ONP/OMG, white grades and OCC may be atmospheric or pressurized (90-115°C). The capacity range is 100-750T/D.

Another important source of in-house synergy originates from the refiner segment operations of Sunds Defibrator. This ensures effective development of dispersion fillings and segments for various applications.

6 BLEACHING

Sunds Defibrator's first bleaching application for recycled fiber is the two-stage bleaching system for an MOW line including pressurized peroxide (PO) and hydrosulphite stages.

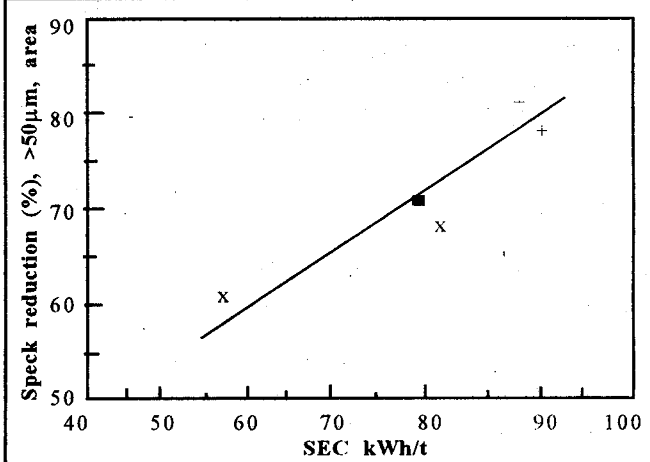


Figure-20

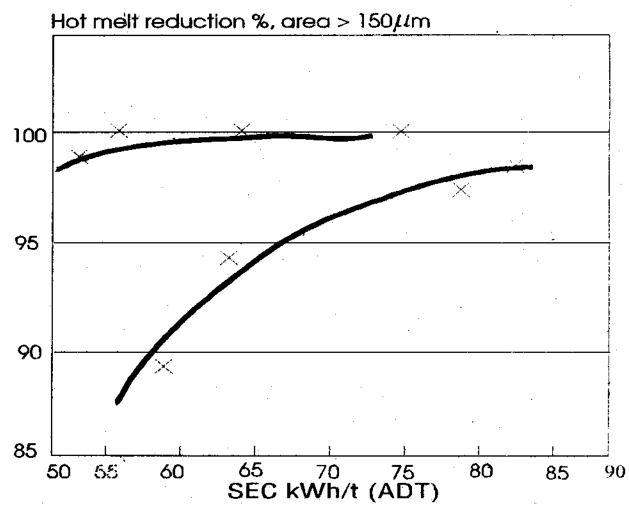


Figure-21

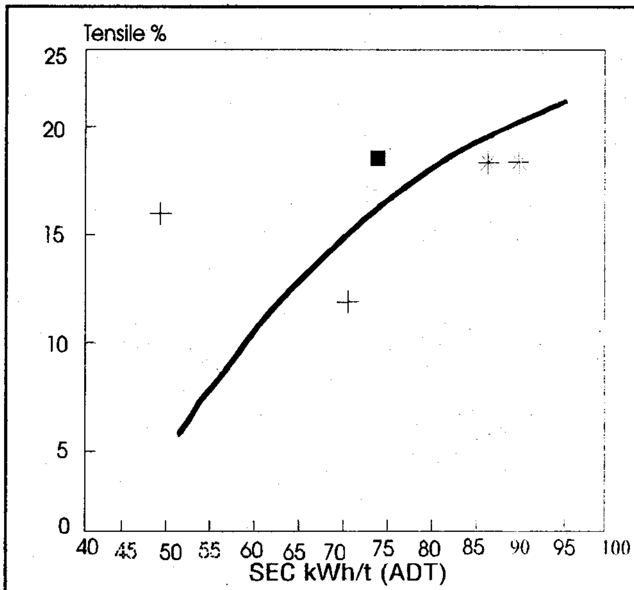


Figure-22

The key process units include variety of existing chemical mixers, reactor towers and discharging units all applicable in low, medium and high consistencies. The bleaching agents cover peroxide, oxygen, ozone, dithionite and FAS applications.

6.1 Equipment

1. T - Mixer

Sund Defibrator's T-Mixer, a new family of high shear mixers, features a totally new design for mixing chemicals into pulp suspensions. The T-Mixer combines the best possible efficiency with low energy consumption and a low pressure drop. Compact and easy to maintain, the new T-Mixer represents a breakthrough in mixing efficiency and cost-effectiveness.

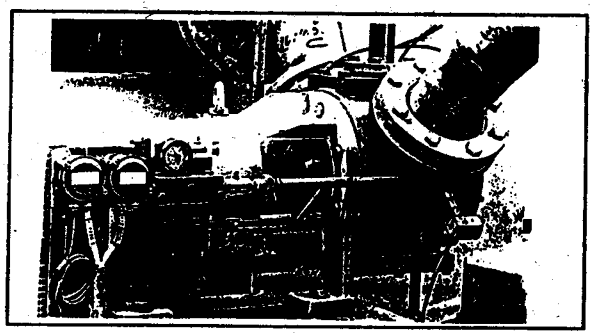


Figure-23

2. Rotomixer™

Sund Defibrator's Rotomixer™ is specially designed to mix chemicals with pulp at high consistencies of 20 to 45%.

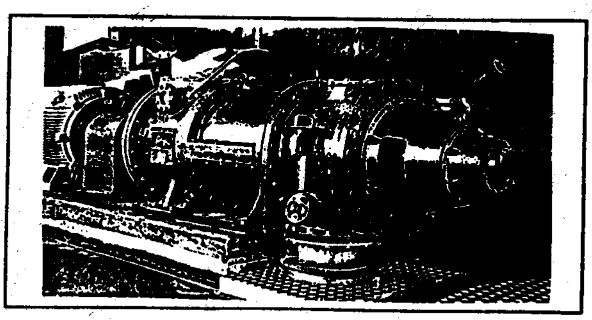


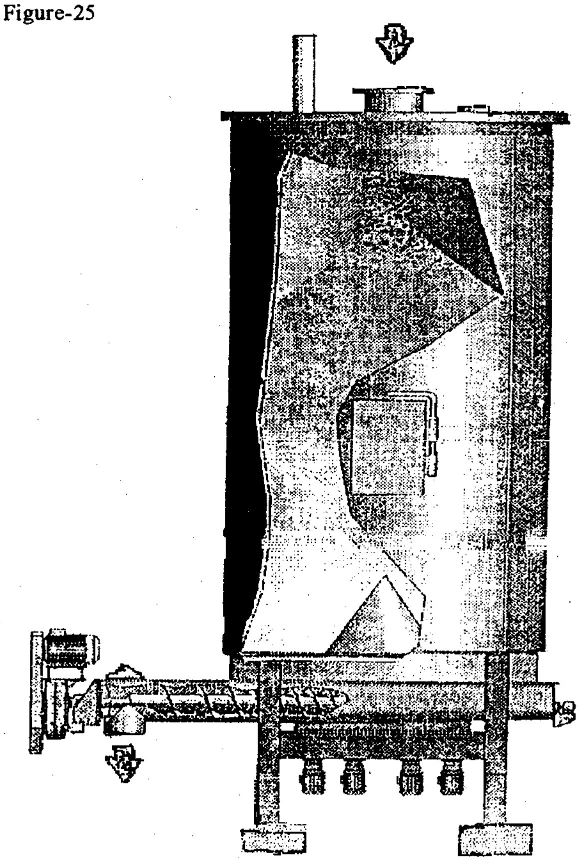
Figure-24

3. HC Tower

Sund Defibrator's HC Tower can handle pulp in the same consistency range as the Rotomixer™.

The tower design and discharge system ensure the smooth and uniform pulp flow necessary for correct bleaching.

Figure-25



6.2 Results

(PO) Bleaching

A PO stage can basically be described as a standard peroxide stage run at a high temperature (around 100°C) and pressurized with oxygen. By running the PO stage at 100°C it is possible to reduce the bleaching time, that is, the size of the bleaching tower. The high temperature is also necessary for activation and utilization of oxygen. The reasons for pressurization is to be able to apply oxygen and to suppress an uncontrolled peroxide decomposition at the high temperatures.

To evaluate the potential of using PO stage as the base in a bleaching sequence for MOW, a number of laboratory trials and a pilot trial were carried out.

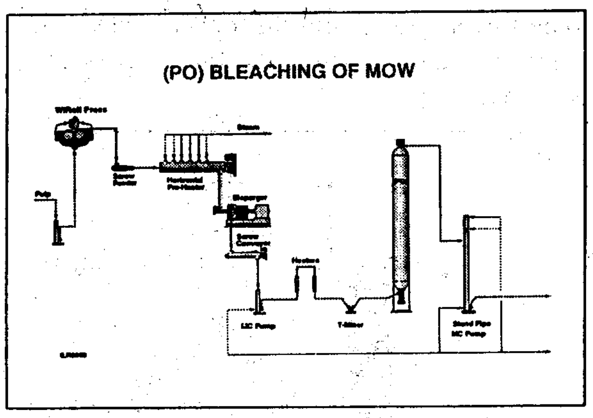


Figure-26

Test-1 The pulp used was MOW 2 with an initial brightness of 67.8% ISO, which can be considered as "normal". The pulp had a relatively high content of mechanical pulp fiber: 15%. The OCC content was about 1%.

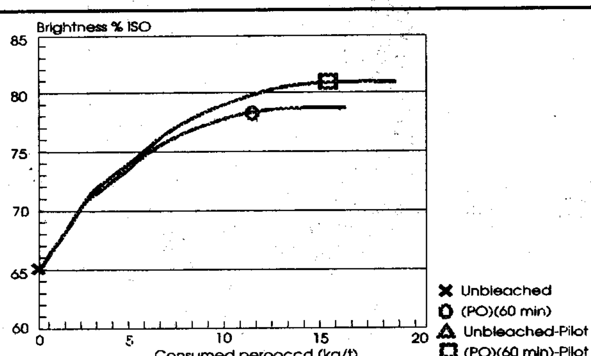


Figure-27

Test-2 The pulp was MOW 1 with an intial brightness of 74.6 which is relatively high. The color content was about 10% which is quite "normal". The wood content and OCC content was low, probably close to zero.

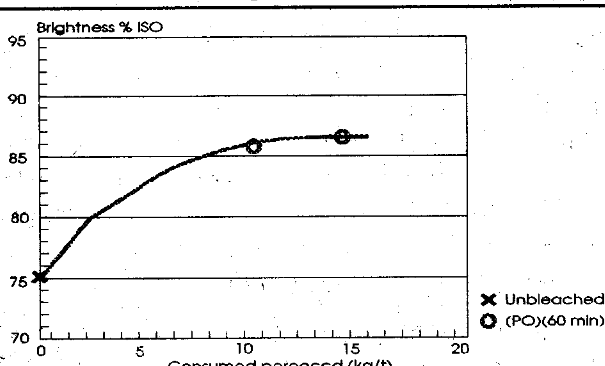


Figure-28

Test-3 The bleaching time was evaluated on MOW 3, which had an initial brightness of 63.3% and b* value of 8.4. The high b* value indicates the relatively high color content: about 20%. The OCC content was about 0.5% and the mechanical pulp fiber content was 5%, which can be considered "normal".

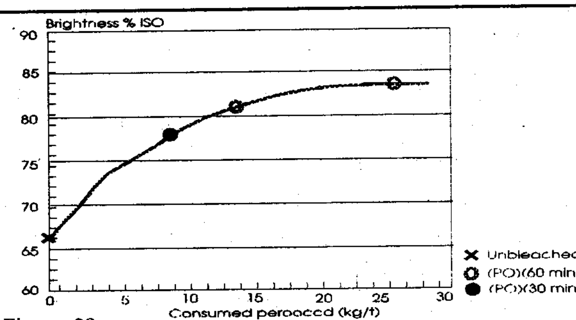


Figure-29

Test-4 The raw material for this study was MOW 4. With an initial brightness of 64.0% ISO, an OCC content of 2% and color content around 20%, this pulp really can be considered as a good example of a MOW of rather poor quality. ("worst case").

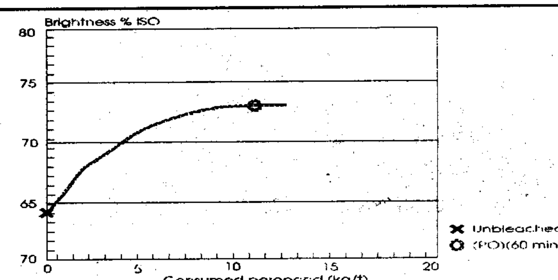


Figure-30

Test-5 An important feature of the PO stage is the excellent "removal" of the brown color of fibers originated from OCC and similar furnishes. An effort to quantify this has been done by running a standard speck count with a Contron Dot Counter on handsheets after bleaching MOW 2 with 1% OCC in a PO stage. The result of this is shown in Fig.-17.

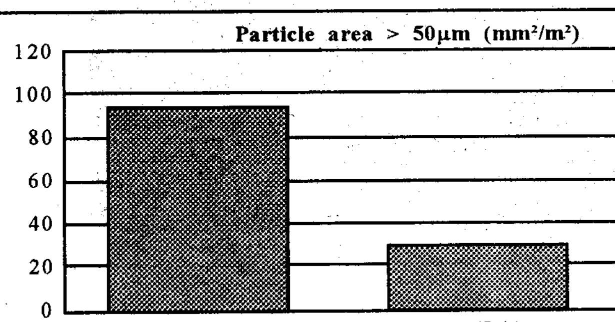


Figure-31

7 REFINING

Today there are several reasons for refining secondary fibers. The old maxim "Once refined, fibers should not be refined anymore" must be reconsidered.

Why refine recycled fibers?

Because once refined fiber has been processed to developed a good bonding ability. After having been through the papermaking process once, this inherent bonding ability has been reduced and fibers which were well developed are no longer in their best condition for the reuse in papermaking:

* Severe drying and pressing forces have created irreversible changes
* Recycled fiber treatment process has cleaned but not necessarily developed the fiber.

It is not desirable to:

* shorten the fibers
* weaken the fibers
* increase the dewatering resistance
* reduce the bulk

It is desirable to regenerate the swelling and the bonding ability of fibers.

The Conflo® concept was developed to perform gentle and fiber-saving refining. In other words, to develop the bonding ability of fibers with a minimum increase in drainage resistance and a minimum decrease of fiber length. The other targets, such as low energy consumption and easy maintenance, are also met.

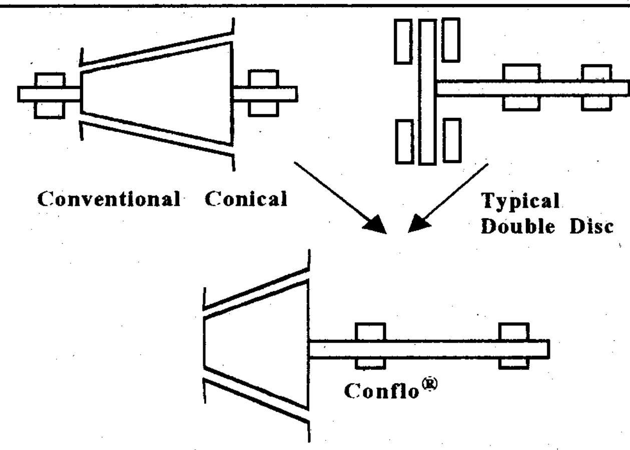


Figure-32

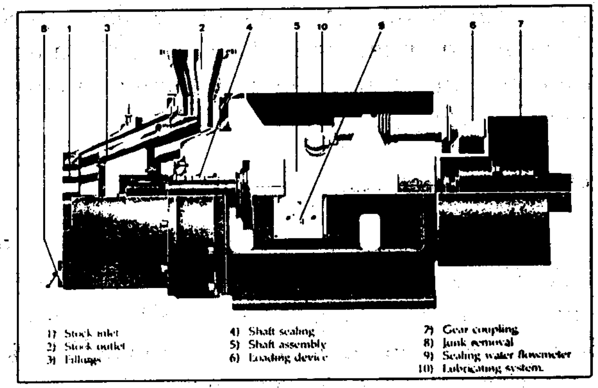


Figure-33

Since being introduced in 1983, more than 1,000 Conflo® units have been delivered for various fibers and for various paper and paperboard grades. Increasingly, deliveries are intended for secondary fiber applications (Figure 34).

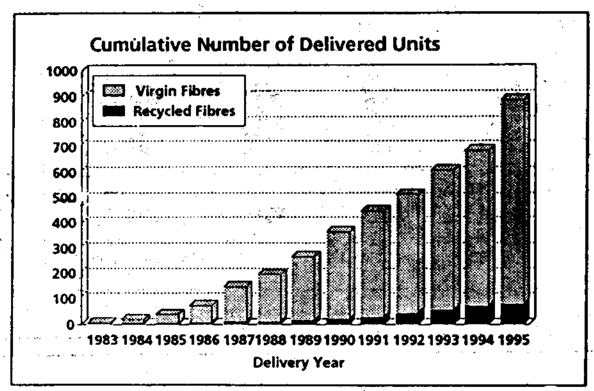


Figure-34

7.1 Results from mill installations

1. White ledger

Figure 35 shows mill results with white kraft waste (white ledger). The results indicate that a net

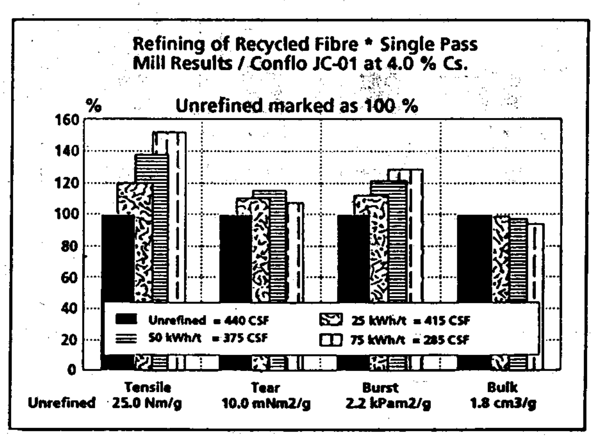


Figure-35

refining energy of about 50 kWh/t gives the highest tear strength and an increase of almost 40% in tensile strength without too great a reduction in either beating degree or bulk.

2. OCC

The other example shows the development of strong AOCC (American OCC). Figures 36 and 37 show that the bonding ability of the fibers can be greatly improved without reducing fiber length, bulk, tear or drainage resistance too much.

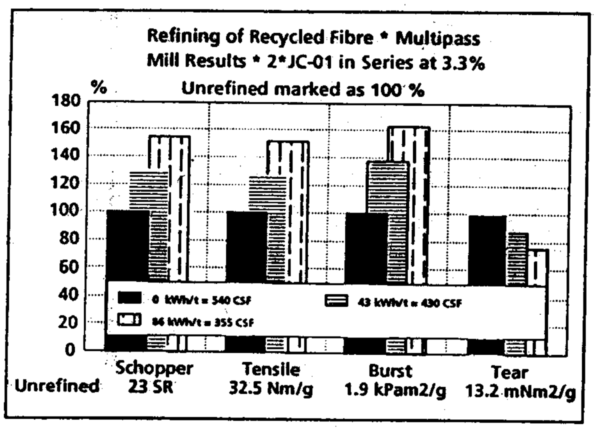


Figure-36

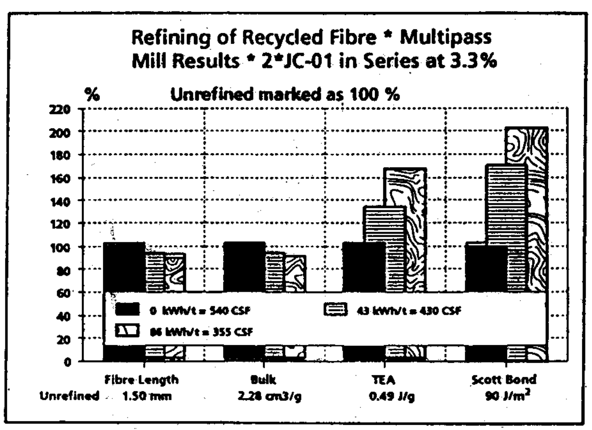


Figure-37

3. DIP

The third mill trial example shows the development of deinked pulp (Figure-38).

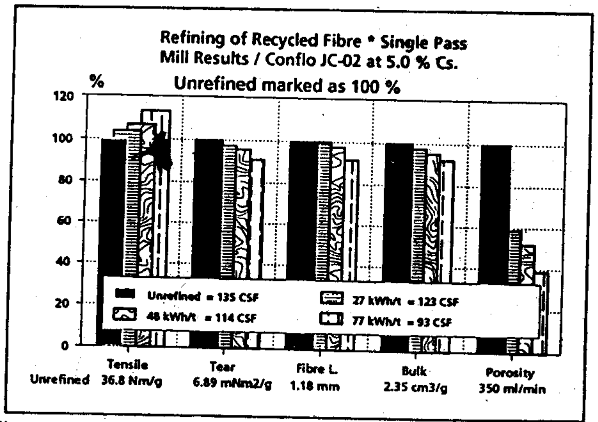
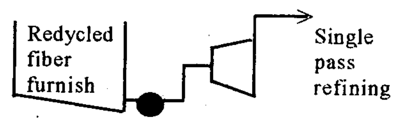


Figure-38

Typical Conflo® applications for RCF.



Typical applications and obtained benefits

* Mixed waste for Fluting
  * better strength and stiffness
  * less starch
* OCC and kraft waste for Board
  * better strength
* DIP for Printing papers
  * better printability and less chemical pulp
* DIP for Tissue papers
  * better strength, less dust and web breaks

Figure-39

Tensile strength is improved more than 10% without significant loss in the fiber length, tear or bulk. It should be noted that a clear porosity reduction improves the printability of the paper as the pinholes are reduced. The other important fact is that refining reduces stiffness of coarse fibers which also improves printability.

CONCLUSION

Moderate low-consistency refining should be used to complete recycled fiber treatment.

Favourable fiber upgrading in low-consistency refining is obtained at moderate energy consumption by using Conflo® refiners.

As in refining of virgin fibers, the refining conditions for recycled fibers must also be selected correctly to avoid over-refining and other problems.

Refining improves the natural bonding ability of recycled fibers, which in turn reduces the need for chemical bonding agents.

Improved bonding ability allows papermakers to use increasing amounts of recycled fibers in furnish.

8. PQM™ Dirt Counter: Image analysis technology for on-line dirt control

The new PQM™ (Pulp Quality Monitor) Dirt Counter is a further development resulting from more than twenty years experience of pulp analysis based on optical measuring methods. These analyzers have been used for monitoring of fiber quality and shive content.

In 1988, Sunds Defibrator developed an analyzer (PQM 1000) based on image analysis. This technology opened a new dimension to pulp analysis, making a more precise and complete analysis of the pulp possible.

Sunds Defibrators RCF program needed a fully automated dirt counting system. The existing test methods were slow to react and time consuming and the results included a risk related to the differences in the testing personnel's routines. The methods were not designed for on-line process quality monitoring. The PQM™ Dirt Counter is a tool fast enough for on-line control, sensitive enough to analyze samples from different steps in the deinking process and to analyze different raw materials.

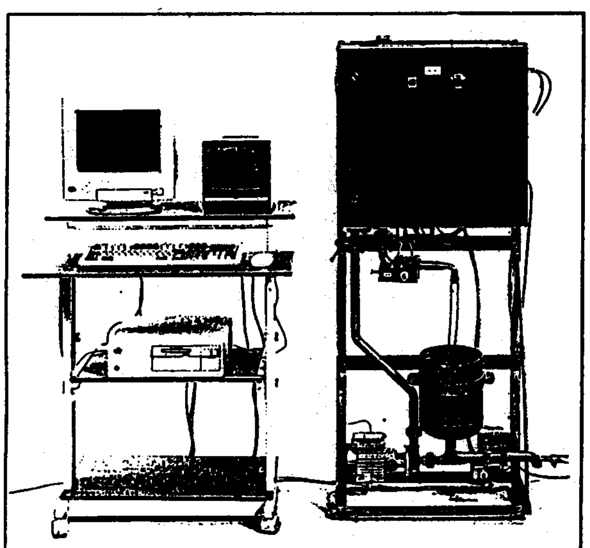


Figure-40

The PQM™ Dirt Counter unit consists of a sampling device connected to the stock line, a measurement cabinet that contains camera, flash light system and a micro controller. A presentation system is located in the control room. An optional data server or communication computer can be located anywhere convenient.

Stock line pulp is diluted to approximately 1% consistency in the sampler and continuously pumped through the analyzer, viewed through a glass window and illuminated by reflected light. A camera with a high-resolution lens system is located in front of the window.

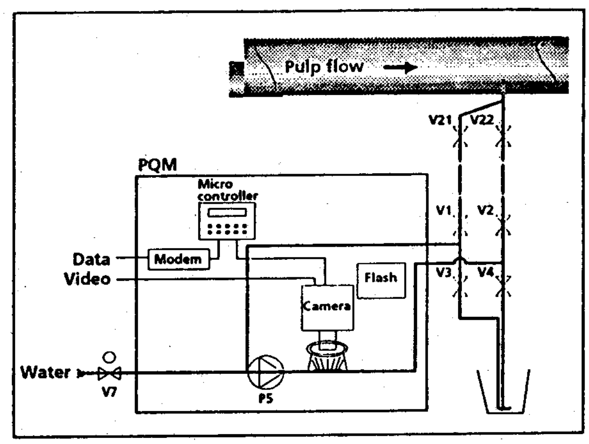


Figure-41

Dirt particles are identified as objects with a difference in reflection compared with the pulp background.

The area of each individual dirt particle is measured and an equivalent diameter is calulated. Video monitor is connected to the camera.

A PQM Dirt Counter unit can be used both for laboratory and on-line analysis. Sequence control is performed by a micro controller. This unit handles the analysis, the startup, the shut-down and the cleaning sequences.

APPLICATIONS AND RESULTS

The PQM Dirt counter is designed for analysis in various applications, such as control of operation offlotation cells, dispersion units, screening/cleaning

DIP System Analysis

Stage	No of dirt/m²	Dirt area mm²/m	TAPPI dirt area
After pulper	328996	5737	3311
After dispersion	395291	1570	161.5
reduction		73%	95%
After flotation	72065	480	91.6
reduction		69%	43%
Total reduction		92%	97%

Figure-42

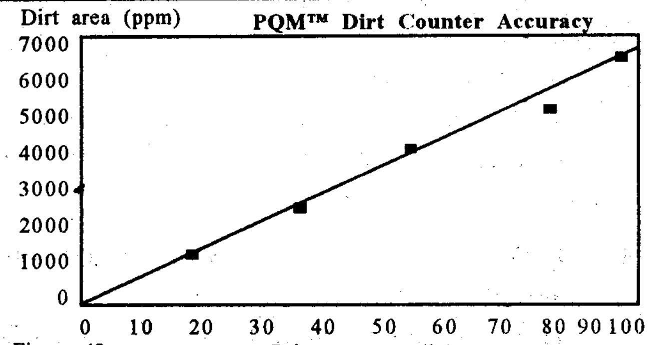


Figure-43

systems and overall deinking efficiency in the process. The PQM handles samples with brightness variations from incoming paper to deinked paper.

Different kinds of evaluations have been performed both in laboratory and mill trials.

The trials below (Figure-42) were performed on office waste grade.

The dirt content is reduced in each step although the number is increasing in the dispersion step. This is because the very large dirt particles are dispersed into several smaller particles.

Another trial was made where six pulp samples were prepared in the laboratory. The material was a mixture of printed and unprinted paper. The six samples contained 0, 20, 40, 60, 80 and 100% printed paper. As shown the response from the PQM Dirt Counter is very linear correlation with the amount of printed paper.