

# Medium consistency processing of pulp

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## ABSTRACT

Medium consistency processing of pulp requires considerably less volume to be handled, which ultimately results in substantial energy saving and saving in space. For efficient separation during screening, intense shear forces need to be applied so that the fibres, knots, shives and dirt particles move freely within the system. Device for screening of pulp at 8-15% consistency has already been developed and tried at plant scale. Similarly, cleaning of pulp at consistency of upto 5% is also possible with same cleaning efficiency.

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## KEY WORDS

Medium Consistency Processing, Screening, Cleaning, Pulp suspension, turbulence.

## INTRODUCTION

One of the major drawbacks of the conventional pulp processing system from blow tank to stock-preparation plant, is intermediate dilution and thickening loops. This dilution and thickening is inevitable for transportation and storage of pulp at various stages with the currently adopted technology in the mills.

Studies and experiments have been carried out from time to time to get rid of such troublesome and energy consuming process. Medium consistency (MC) processing of pulp is one obvious solution of this problem. Due to fiber suspension characteristics and rheological variations at different consistencies, the MC processing at once does not appear a very easy process.

Device for screening of pulp at a consistency of 8-15% has already been developed aboard and also tried at plant scale. Such screen has been operated as knotter and primary screen both. Similarly cleaning of pulp at consistency of about 4-5% has also been shown as equally efficient. Previous work shows that screening efficiency as high as that for low consistency pulp can also be achieved in MC screening.

The reduced flow rate through such system substantially results in space and energy savings. Volumetric flow which is about 80-150 m<sup>3</sup>/a.d. ton of pulp in case of low consistency (LC) screening can be reduced to the range of 6-11 m<sup>3</sup>/a.d. ton in case of MC screening.

## PRINCIPLE

For an efficient separation during screening, it is essential that the fibres, knots, shives and dirt particles move freely within the suspension. Conventionally, this is achieved by diluting the pulp to a consistency of about 0.5 to 2%. However, the pulp at MC (8-15%) can also be brought into a turbulent and fluidized stage provided the fiber suspension is exposed to intense shear forces.

## SUSPENSION CHARACTERISTICS

Knowledge of hydrodynamics of fibre suspension is much important before changing over the process from LC to MC. The properties of individual fibres in a fibre water suspension affects the rheological behaviour of the suspension. This rheological behaviour of the suspension is also dependent upon the viscoelastic network which the fibres form. When fibres are exposed to sufficient shear forces a turbulent motion starts re-

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sulting the disruption of fibre net work. Hydrodynamic behaviour of the fibre suspension differs with water at low velocities while at higher velocities "Newtonian" properties are approached. Pressure drop due to frictional losses in case of fibre suspension is less than water. During the flow of suspension through a pipe, fibres and loosely held flocs make a plug in contact with the pipe wall. In the beginning, the suspension moves as a sheared, viscoelastic body in direct contact of the wall. The fibres and loosely held flocs break loose from the plug with an increase in velocity and move into the annulus between wall and plug, where they act like rollers. This annulus flow is laminar. Again the increase in velocity intensifies turbulence and decrease the plug size. The whole suspension becomes turbulent at a velocity where fibre suspension flow characteristics resembles with water flow characteristics. Please refer to Fig. 1 for the suspension flow characteristics at various consistency levels. At this

point no velocity and consistency gradient appears and the suspension behaves as a turbulent liquid. Now the shear field due to mass of fibres will be more than the shear stress required to disrupt the fibre net work completely. The velocity at which full turbulence occurs may be calculated as—

$$W = 1.8C^{1.4}$$

Where—W=Velocity in M/s

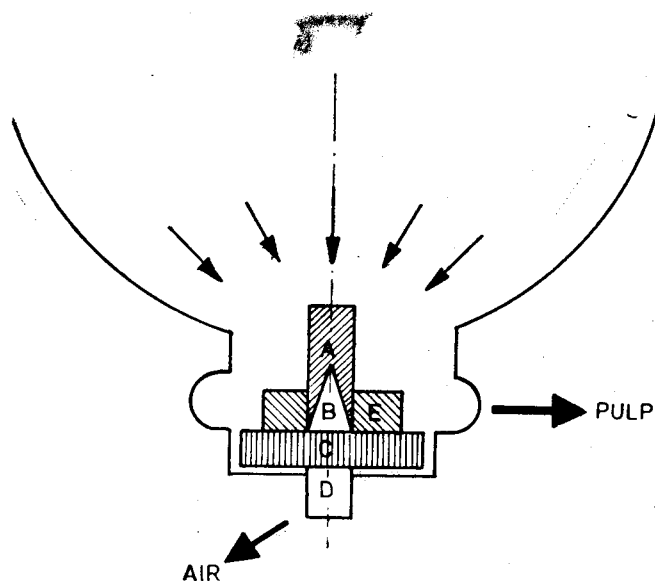
C=Consistency (0—5%).

A suspension at 10% consistency requires velocities upto 40—50 M/s for complete turbulence. As it is very much difficult to get such exceptionally high velocities, disruption is created by providing shear between the surfaces in relative motion. Required shear stress can be calculated as—

$$Td = K.C^{\alpha}$$

where K and  $\alpha$  are constants depending upon pulp & C is the consistency.

### CENTRIFUGAL STOCK PUMPING UNIT AT MEDIUM CONSISTENCY.



- A → TURBULENCE GENERATOR
- B → AIR SEPARATOR
- C → FIBRE SEPARATOR
- D → AIR DISCHARGER
- E → PUMP

### PROCESS

To process the pulp at MC (8-15%) at screens it is very much desired to bring the suspension in turbulent motion for efficient separation of acceptable fibres from the debris. For this the specially designed screens are used. In this type of screens, a rotor inside the cylindrical screen basket is provided to yield tangential suspension flow and axial reject flow at the face of the screen. The feeding point is in the bottom of such screens and rotor is extended into the reject chamber. It is shaped to provide a higher discharge pressure than feed and to maintain the complete reject fluidization upto the reject valve. The accept flows through the screen into the annular accept chamber and is discharged at an equal or slightly higher pressure than feed. The pressure drop over the screen is thus equal to or lower than the head generated by the rotor.

A specially designed device can be put in the line to provide sufficient shear stresses at the vessel wall for disruptions. It can be calculated as follows :

$$Td = 2 \frac{Md}{\pi D^2 L}$$

Where Td = Disruptive shear stresses, N/m<sup>2</sup>

Md = Torque at network disruption point (Nm)

D = Diameter of vessel (m)

L = Length of vessel (m)

However the basic mechanism governing to response to shear forces at low consistency also apply to the medium consistency range.

#### EFFICIENCY OF SCREENING :

The screening efficiency is evaluated by measuring the separation as a function of material rejected.

$$E = \frac{E_c}{(R_w + E_c (1 - R_w))} \quad - \quad 1$$

or

$$E = (E_r - R_w) / (E_r (1 - R_w)) \quad - \quad 2$$

From which it follows—

$$E = \frac{E_c}{E_r} \quad - \quad 3$$

$$\text{and } E = 1 - \frac{C_a}{C_R} \quad - \quad 4$$

Wheres E = Efficiency

E<sub>r</sub> = Shive removal efficiency

E<sub>c</sub> = Cleanliness efficiency

R<sub>w</sub> = Reject ratio by weight

C<sub>a</sub> = Concentration of debris in accept flow

C<sub>R</sub> = Concentration of debris in reject flow

E = 1 represents 100% efficient screening, which in turn means that the reject flow consists of only debris and no good fibres.

#### ADVANTAGES

1. It requires low volume to be pumped and less equipment size. The reduced volume results in energy savings to the tune of 20 kwh/ton of pulp for each eliminated dilution thickening loop.
2. No need of thickeners.
3. Lower space and energy requirement.
4. Less water requirement and less effluent.
5. Though maintaining a turbulent state at higher consistencies requires more energy input but it is compensated by the beating effects of fibres.

6. Specific surface of the fibre increases and specific volume decreases.

Such equipments for MC screening are available from Kamyr Inc., Bird Escher Wyss, Mitsubishi International Corpn. Sunds Defibrator, Voith Modern Inc. etc.

#### STOCK CLEANING AT MEDIUM CY (5%).

Designs have been developed over the years by manufacturers and researchers to have equally efficient cleaning at higher consistencies. Conventionally this operation is carried out at consistencies between 0.6—1.2% which requires lot of dilution and thickening at later stage.

The main factors which affect the centrifugal force are mass, tangential velocity and radius of the cyclone.

Conventional designs of cyclones have been modified basically to develop the centrifugal force required for cleaning of pulp at higher consistencies. The available designs of cyclones can run efficiently upto a consistency of about 5%.

#### ADVANTAGES :

1. Low Power consumption due to low volume to be handled.
2. Saving in space due to smaller size of equipment.
3. Low dilution water consumption.
4. Minimal fibre losses.
5. Saving in initial capital investment.

Cleaners for centricleaning of 4-5% consistency stock are available from almost all reputed centricleaner manufacturers viz. Celleco Inc., Bird Escher Wyss, etc.

#### CENTRIFUGAL STOCK PUMPING AT MEDIUM CONSISTENCY :

As discussed earlier, medium consistency (8-15%) fiber suspensions acquire fluid properties when exposed to proper shear forces. Standard centrifugal pumps are known to be capable of pumping the fiber suspensions of upto 7% consistency. Higher consistency suspension creates problem, although sufficient shear forces are available in the impeller area. The limitation may be due to feed and the flow in the inlet throat.

From time to time several modifications and experiments were carried out to develop a centrifugal pump for pumping medium consistency pulp stock. Earlier it was decided to incorporate both the tower discharger and thick stock pumping into one unit with a flat bottom tower and installation of a pump vertically at the centre of the tower with a modified impeller in order to eliminate bridging effect and to maintain the turbulent zone around the pump inlet. Recirculation line was also provided and then it was possible to pump a pulp stock of 12% consistency against a considerable pressure if the amount of air is kept low. But afterwards accumulation of excessive air occurred in the pump and the pump stopped developing pressure. Then it was inferred that entrained air and not the higher consistency causes the pumping problem with centrifugal pump. No such problem was experienced with a conventional positive displacement pump with modified impeller as it is insensitive to air.

This has proved that pressure developed by the centrifugal pump depends upon the relative air content.

After lot of efforts, a modified centrifugal pump was developed by some research engineers abroad which consist of a discharger modified to incorporate air separation and combined with a centrifugal stock pump. This enabled them to pump pulp stock of 12% consistency at a desired pressure with proper air separation. The pressure difference between pulp inlet and the air discharging cavity determined the degree of separation.

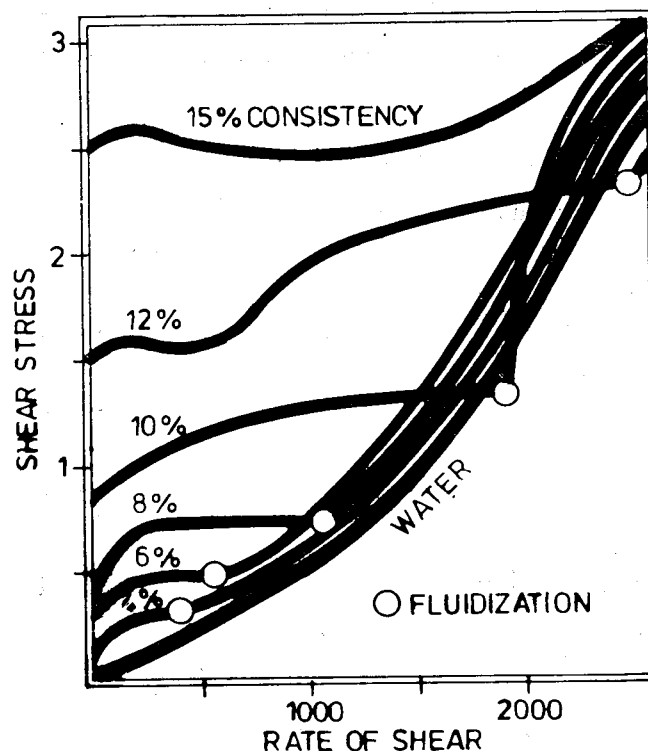
Hence it is possible with the centrifugal pump to discharge the medium consistency pulp stock by integrating the air separator and the pump into one single shaft device as shown in the Figure No. 2.

MC centrifugal pumps are available from several reputed pump manufacturers abroad e.g. Kamyr Inc., Metex Corporation, Finland, Ahlstrom Machinery Inc. etc. It is understood that such pumps will be soon manufactured in India by Grasim Industries. Ltd.

#### CONCLUSIONS :

- 1 It is possible to have centrifugal pumping of medium consistency (8–15%) pulp stock provided proper air separation is done during pumping.

## Fluidization



- 2 Medium consistency (MC) processing results in considerable space saving and also energy saving to the extent of 15–25 kwh/ton of pulp for every dilution-thickening loop eliminated.
- 3 Equally efficient screening system of pulp at MC has been developed and also tried at plant scale.
- 4 Cleaning of pulp at consistencies upto 5% is also possible with design modifications of the cleaner. Such configurations are already available.

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