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Improving the Performance of the Finckh Screen

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IMPROVING THE PERFORMANCE OF
THE FINCKH SCREEN

by

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ABSTRACT

As dewatering of the stock occurs around the screen basket of a Finckh pressurized, inward flow pulp screen, from 0 to 360 degrees, stock mass flow through the outer screen annulus decreases. Some sections of the screen basket hence handle more stock than other sections.

Stock velocity is dependent on mass flow through an area. Stock velocity is critical to fiber orintation, which is in turn critical to screening.

A volute, much like a tapered manifold header, would decrease the area available for stock flow. This will maintain stock velocity around the full circumference of the screen basket.

A volute was designed and installed in the Finckh screen. It did not alter seperation efficiency at .7% consistemcy. The volute significantly reduced screen variability.

The volute was tried with 1.2% consistency stock. The volute structually failed by expansion, because of Bernouli forces.

ACKNOWLEDGEMENTS

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INTRODUCTION

Stock consistency must be maintained below 1% for reliable operation of the Finckh pressurized pulp screen. An increase in consistency is desirable because of the high energy cost associated with fiber dewatering. This paper is the culmination of a research project which was intended to increase stock screening consistency to 1.2 - 1.5%.

THE FINCKH SCREEN

The Finckh (figure 1) is a pressurized pulp cleaning device. The screen is divided into two annular chambers, the accepts being the inner, by a metallic screen basket. Two foils rotate in the accept chamber. They provide outward and inward pressure pulses against the screen basket. These pulses are propagated through venturi shaped slots in the screen basket to the feedstock. The pressure pulses help to avoid plugging or blinding of the screen basket.

The pulses also aid the removal of rejects. Rejects flow by gravity down the outer face of the basket to a rejects trough and are expelled.

HYPOTHESIS

It is hypothesized that a change in the shape of the outer chamber, from an annulus to a volute, would maintain higher radial and tangential stock velocities throughout the outer chamber. A volute would prevent the mass flow velocity loss caused by decreasing flow volume within a fixed volume casing.

PREVIOUS WORK

A literature search turned up several articles on fiber dynamics and pressure screening. The majority of research done on pulp screens is proprietary.

Van den Akker found that the long axis of a fiber tends to line up with fluid gradients after a certain threshold velocity has been attained in the fluid. (1)

Cowan found strong strong evidence for the existance of a fiber mat screening zone on the feedside of the basket. It is felt that this mat, and not the basket, is the point of selective fiber separation. (2)

Clark-Pounder suggests that this screening zone is made of two lamella, one of the screened fibers and the other of unscreened.

Discussion minutes from the January, 1970 C.P.P.A. meeting in Montreal show Cowan and Clarke-Pounder in disagreement over the existance of lamella. (2)

Gullichsen and Harkonen have found that stock (up to 15%) will behave as a Newtonian fluid when in high shear conditions. They further found that consistency is not a factor in handling pulps, once turbulence has been established. (3)

Martin and Mats have identified the factors which influence screening. They are:

- Freeness
- Contaminates in feedstock
- Proportion of large fibers (greater than R 14)
- Accepts flow (gpm)
- Rejects flow (gpm)
- Inlet consistency
- Dilution water flow (gpm)
- Hole or slot size

It should be noted that stock temperature, hence viscosity, was not a factor in the Martin and Mats study. (4)

At a given fiber length, freer stocks allow individual fibers more freedom to rotate (yaw, pitch and roll) hence allowing individual fibers to navigate through a screen basket with less difficulty than fibers in a slow stock. Increasing feedstock contaminates increases screen efficiency. This is due to the nature of the efficiency calculation, which is presented below.

Decreasing reject flow rate or increasing accept flow rate often induces screen blinding. Blinding is the condition when fibers lay flat across the screen basket openings. This is not the same as plugging, which occurs when fibers bind together inside the basket openings.

McCabe and Smith have derived several screen efficiency equations. Pressurized screen efficiency can be modeled with the following:

$$E = \frac{(X_f - X_b)(X_d - X_f)X_d(1 - X_b)}{(X_d - X_b)^2 (1 - X_f)X_f} \qquad (1)$$

Where: E= efficiency

X_f= consistency of feed

X_d= consistency of rejects

X_b= consistency of accepts

The equation is based on the amount of oversized fiber accepted and rejected in relation to the amount of oversized fiber in feedstock.

A second equation is often used with paper stock:

$$E = (100)\left[\frac{Se - Sa}{Sr - Sa}\right]\left[\frac{Sr}{Se}\right] \qquad (2)$$

Where: Se= mass of long fibers in feed

Sa= mass of long fibers in accepts

Sr= mass of long fibers in rejects

A long fiber is defined as that which will be retained on an R14 screen of a Bauer classifier. (4)

PROCEDURE

Two trial runs at .7% consistency were made, one with the volute and one without. Two trials were then made at 1.2% consistency. Again, one trial with the volute and one without.

FURNISH

The furnish was 75% hardwood bleached Kraft and 25% of 60% deflaked news. Stock temperature was kept at 100 F. The stock was slushed in a hydrapulper at 3.0% consistency at 150 F and then diluted. Final freeness was 500 CSF.

Formaldehyde was added to the furnish to prevent spoilage. The same stock was used for all the screen runs.

CONTROL RUNS

The screen inlet was connected to a pump. The pump drew stock from a storage chest in the Western Michigan University secondary fiber pilot research plant. Both accepted and rejected stock were returned to the same chest, to provide a constant head on the pump.

Stock flow was measured with a five gallon bucket and a stopwatch. A sample was drawn from each stock flow for Bauer classification.

VOLUTE

The volute was made of linoleum flooring. The following equation was used to design the volute: (6)

$$A_v = A_{thr} \frac{\theta}{360}$$

Where:
A_v = Volute area
A_{thr} = Throat area

This is the equation for a centrifical pump casing. In actual construction, the volute will be truncated so that its area never reaches 3.6 in^2. This allows for the recycle of unscreened, unrejected stock into the lower half of the inlet flow. Stock will be cycled around the screen until it is accepted or rejected for being oversized.

A reject trough formed the lower support of the volute. Fibers that enter the trough will be unconditionally rejected. The trough will not be present between the reject port and the inlet port, so that unrejected stock in this area will only recycle.

The volute was fitted into place with a wax babbit. Styrene foam was dispensed from an aerosol can to form the permanent support for the volute. After twenty four hours of foam curing, the wax was removed.

TRIAL RUNS

The screen was run with the volute at .7% and 1.2% consistency. Data was gathered in the same method as the control run data was gatthered.

DATA

Inlet flow was kept at fifty seven gallons per minute. Accept and reject flows were kept at half the input. Dilution water was not measured, and can be assumed insignificant because mass balences around the screen closed. The pressure drop across the screen was kept at three pounds per square inch.

The following data was collected by running five Bauer classifications for each trial. The classification data was used to determine efficiency according to equation 1. Both equations 1 and 2 gave similar results. Bauer classifications were run according to TAPPI standards.

Table 1: Low consistency control and test data.

RUN	EFFICIENCY WITH VOLUTE	EFFICIENCY WITHOUT VOLUTE
1	38.5%	48.2%
2	40.0%	42.7%
3	45.5%	51.4%
4	43.2%	41.7%
5	42.4%	41.5%
MEAN	41.9%	45.1%
STAND. DEV.	2.74	4.46

Statistical analysis on the data did not prove a significant difference between screen efficiency with and without the volute at .7% consistency. The standard deviations at low consistency were significantly different, indicating that the screen operated more uniformly with the volute. All data analyses were performed over a 95% confidence interval.

At 1.2% consistency, the control run had relatively low efficiencies of about 22%. The trial run (volute in place) proceeded smoothly for about five minutes. The volute then collapsed inward, against the screen basket. A new volute was made and installed. It also collapsed.

The foam cells behind the volute(s) burst in expansion, indicating low pressure in the outer screen annulus.

Insufficient time was available to collect enough data for statisical analysis before the volutes failed. The incomplete data that was gathered indicated that the volute was allowing stock to be screened at 1.2% with better (higher) efficiency than could be had without the volute.

DISCUSSION

The volute did not affect screen efficiency at low consistency. It did affect screen variability. It is theorized that a moving micro blind circulates around the screen basket. (4). This micro blind causes screen variability.

A micro blind is caused by eddy currents within the outer annulus. When an eddy current is flowing in the reverse direction to stock mass flow, fibers slow down and tend to lay over the screen basket openings.

The volute may disrupt the formation of these eddy currents, hence eliminating the source of screen variability.

The volute failed in expansion at high stock consistency. This was not expected, but can be attributed to the Bernouli Principle.

CONCLUSIONS

No statistical difference in screen efficiency can be proven at .7% stock consistency, when a volute is added to the outer annulus of a Finckh pressurized pulp screen.

The variations in screen efficiency are reduced when a volute is added to the outer annulus of the Finckh pressurized pulp screen.

RECOMMENDATIONS

The experiment should be repeated with a machined or cast volute that will not be damaged by Bernouli forces. These Bernouli forces should also be studied to learn whether they retard fiber motion through the screen basket.

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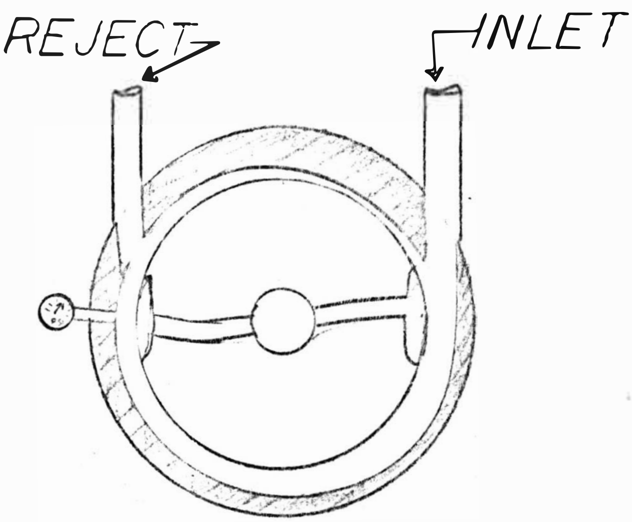

fig 1

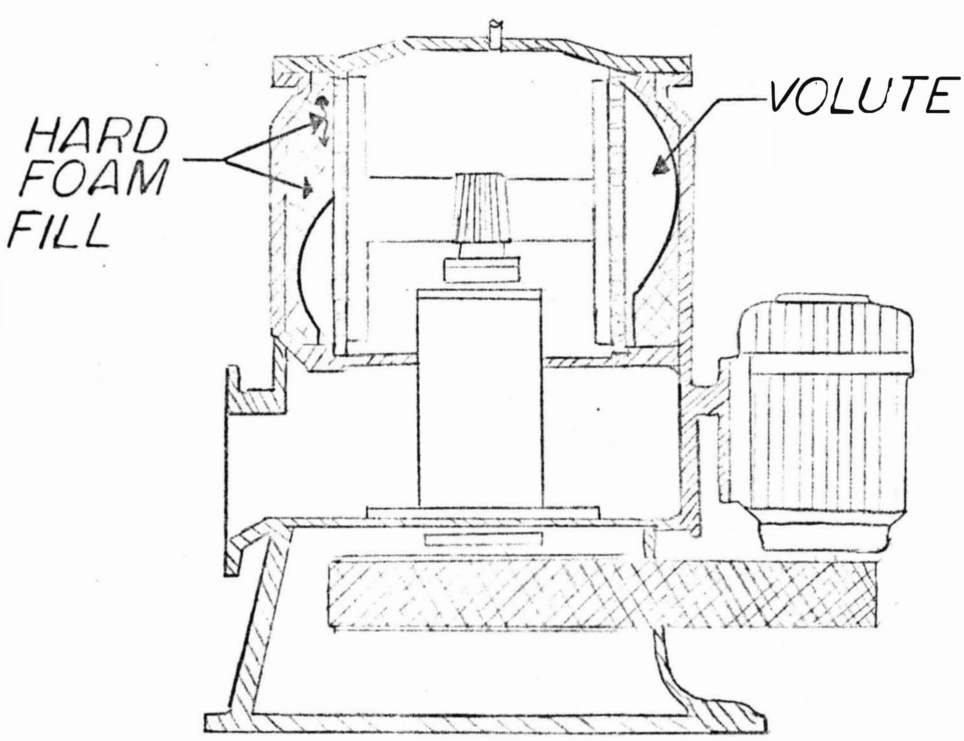

fig 2.

FINCKH SCREEN

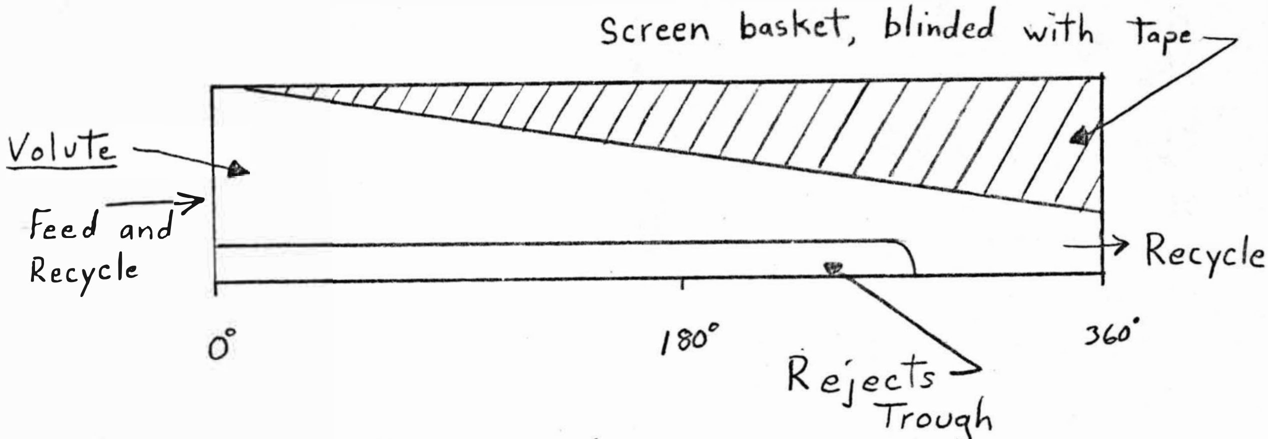
Screen basket, blinded with Tape
Volute
Feed and
Recycle
Recycle
0°
180°
360°
Rejects
Trough

fig 3

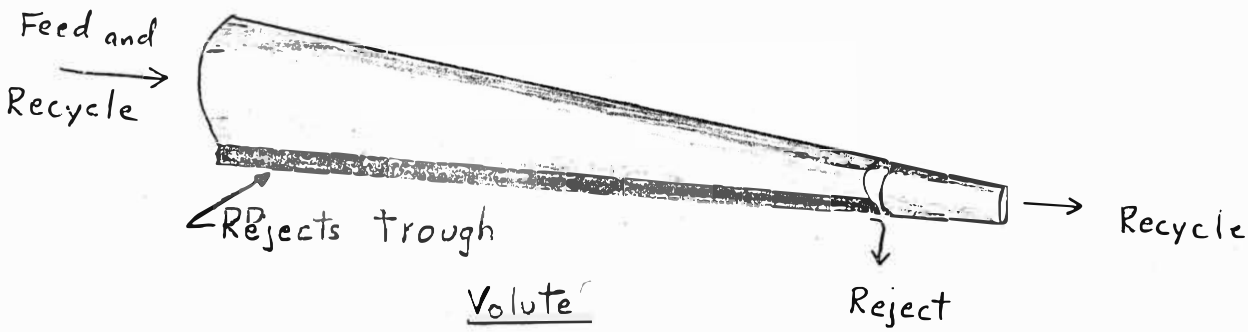
Feed and
Recycle
Recycle
Rejects trough
Reject
Volute

fig 4