THE DEVELOPMENT OF A METHOD TO MEASURE CLARIFIER MUD CONSISTENCY

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Abstract

At present clarifier/filter stations are operated by manual control to obtain the desired mud consistency for the filters. As a first step to automating this process an investigation was carried out into methods of measuring mud consistency between the clarifier and the mud mixer and after the addition of bagacillo in the mixer. The difficulties of applying instruments are described and the results of some measuring methods are presented. A successful method using a venturi has been developed and an instrument to measure consistency inside the mud mixer is described.

Introduction

The need to present mud of optimum consistency to the rotary drum filters is well known but very little is done to measure this consistency during normal plant operation. The adjustment of mud flow and bagacillo addition is dependent upon the observation and judgement of the operator. His decisions are based on the behaviour (mobility) of the mud pouring out of the mud pumps and the mud mixer and the behaviour and texture of the mud layer on the filter drum. The operation of the filter station can be seen to vary from one shift to another as different operators control the plant in different ways. There can also be quite wide variations in the primary mud consistency over a time span of a few minutes. These fluctuations together with fairly long lag times between an adjustment and the appearance of its effect on the filter drum make the operation of a filter station something of an art.

Flow properties

The flow properties of all materials are defined by the relationship between shearing stress (force) and rate of shear (flow). Newtonian liquids are liquids where the shearing stress is directly proportional to the rate of shear. For non-Newtonian liquids the shearing stress is not directly proportional. These non-Newtonian liquids can be placed in one of five general groups to correspond to curves shown in Figure 1.

Nix (1973) showed that primary mud has a shear stress which must be overcome before flow occurs and belongs to the Bingham plastic fluid family.

Consistency

There are various definitions of consistency which cover a wide range of substances, largely as a result of the usage made of the measurement. Substances which undergo continuous deformation when subjected to a shear stress exhibit fluid behaviour. The resistance to this deformation offered by a substance is measured as consistency. The consistency of Newtonian fluids is usually called viscosity. The consistency of non-Newtonian fluids is a function of the applied shear rate and is frequently called apparent viscosity. Although consistency is a real property of non-Newtonian fluids its measurement is usually relative to arbitrary standards. Most consistency measuring devices deduce a value of consistency from measurements of other fluid properties. The relationship of consistency to percent solids has caused the term consistency to acquire the meaning of solids content and caused its true scientific definition to be disregarded in some industries.

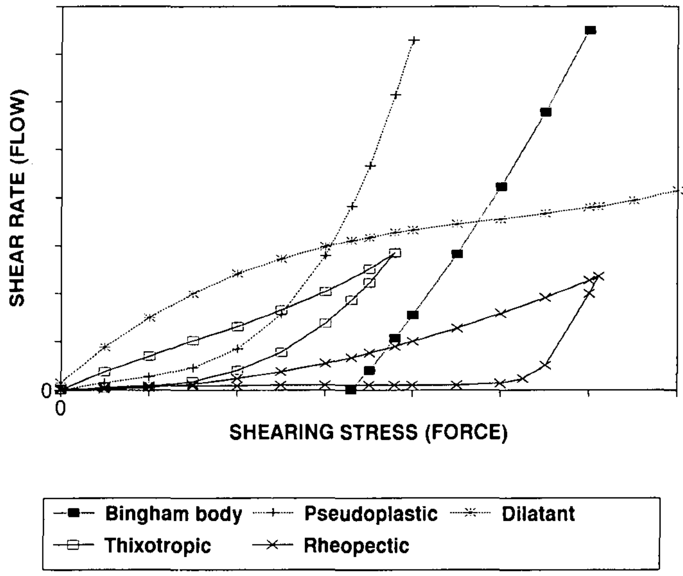

FIGURE 1 Behaviour of non-Newtonian liquids.

Consistency measuring devices

Instruments used for measuring consistency are divided into the following categories:

- Apparent viscosity, both mechanical and hydraulic types.
- Drainage rate.
- Electrical resonance.
- Optical methods.

Problems of the measurement of the consistency of primary mud

The consistency of primary mud is not a common measurement in the sugar industry despite the availability of commercial consistency meters. Mud is fed from the clarifiers to the mixer by gravity flow through pipes that are generally over-sized to handle worst case mud thickness. The flow of conditioned mud to the rotary drum filters is also by gravity and pipes do not run full. Two parameters of mud, % mud solids and % bagacillo, need to be measured for optimum control of the rotary drum filters. To measure the mud solids, the primary mud into the mud mixer must be measured before the addition of bagacillo. Another device must be used in the mud mixer which is more sensitive to bagacillo rather than mud to give an indication of the bagacillo concentration.

Devices made at the SMRI

Two different devices for measuring mud consistency are described. The first uses the venturi for measurements on primary mud. The second uses a probe installed in the side of the mud mixer for measuring the consistency of mud fed to the rotary drum filters.

Venturi

This device uses the principle that at a constant applied pressure the velocity of a fluid, at a constant temperature, through a restriction is a function of consistency. The differential pressure in a venturi can be used as a measure of the velocity and hence the consistency of the primary mud if the line pressure is kept constant. At the start of this project it was assumed that side stream sampling would not be possible with primary mud because of pipe blockages. Being faced with no alternative it was shown that with careful design of intake and screen configurations side stream sampling is possible.

Tests run at the SMRI

The dimensions of the venturi used for these tests, based on the Herschel design (Miller, 1983) are shown in Figure 2. Figure 3 shows the flow diagram of the laboratory setup at the SMRI. The primary mud was heated to various temperatures and allowed to flow into the header tank, where a constant head height was maintained, through the venturi into the discharge tank and pumped back into the storage tank. The 8 mm screen was inserted in the header tank to prevent any pieces of baked mud from the heater coil fouling the throat of the venturi.

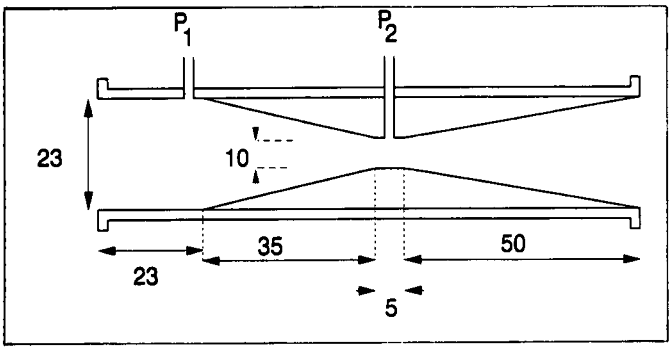

FIGURE 2 Venturi dimensions.

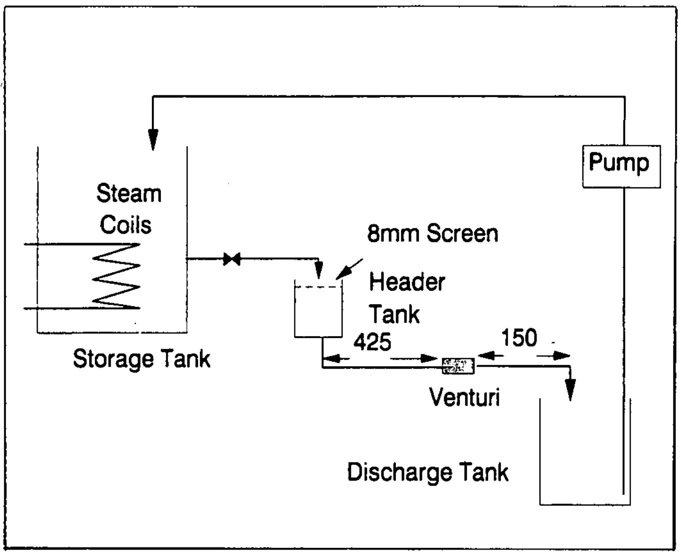

FIGURE 3 Flow diagram: experimental setup at the SMRI.

Laboratory results

The primary mud used for these tests was from the Sezela mill and was diluted with water to obtain various consistencies, with the temperature being maintained at 80°C. The results of the relationship of suspended solids versus differential pressure in the venturi are presented in Figure 4. The "fitted curves" in all graphs were obtained by means of a polynomial best-fit to the data (to a maximum of the third power). It can be seen from these results between the range of 2,5% to 6,5% suspended solids that the output is nonlinear. Since there is more interest in a repeatable output for control purposes than in a precise measurement of mud consistency, this result is quite acceptable.

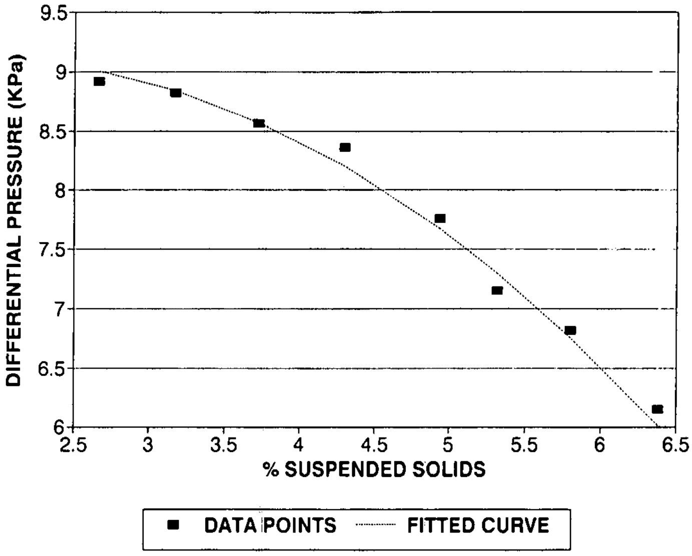

FIGURE 4 Differential pressure versus consistency.

To determine the effect of temperature on consistency the mud at 4% suspended solids was heated and the results are presented in Figure 5. In a filter station the primary mud temperature under normal operating conditions is about 90°C at the mud mixer. A variation of 10°C would cause an output error of less than 10%.

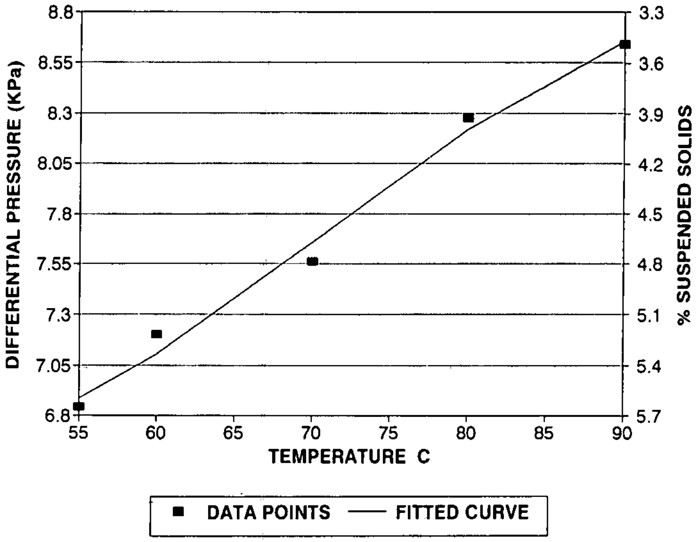

FIGURE 5 Differential pressure versus temperature.

Test carried out on primary mud at the Mount Edgecombe mill

The venturi device was installed approximately two metres from the mud mixer. A flow diagram of this experimental setup is shown in Figure 6.

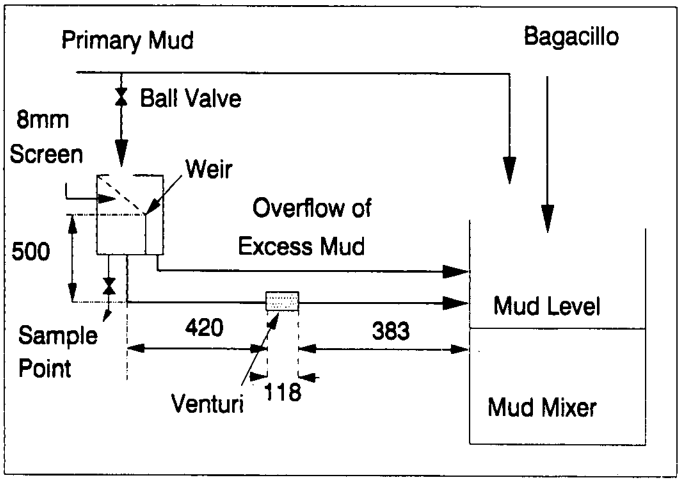

FIGURE 6 Flow diagram: experimental setup at the Mount Edgcombe mill.

A side stream sample was taken from the primary mud pipe feeding the mud mixer and was fed into the venturi header tank. This tank was designed to maintain a constant mud level with a self cleaning screen to prevent solid pieces of mud greater than 8 mm from flowing through the venturi.

Mill results

The venturi device was installed at Mount Edgcombe for two months. During this time samples were collected randomly and analysed for suspended solids. The results are presented in Figure 7.

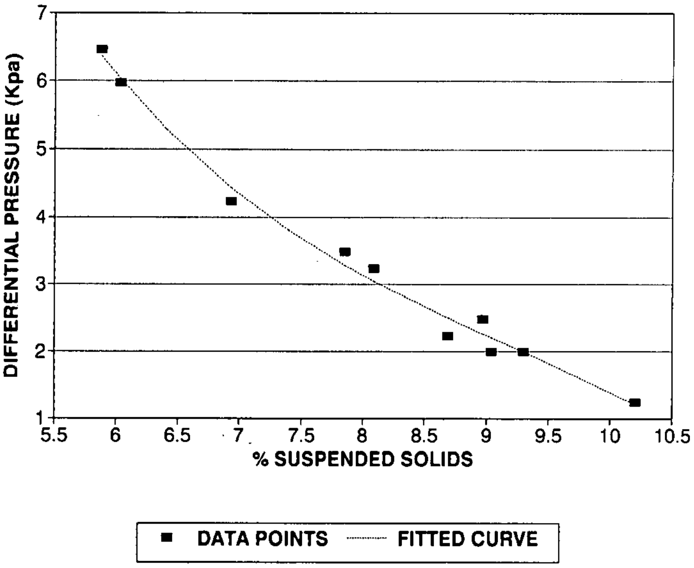

FIGURE 7 Differential pressure versus consistency.

For the duration of this experiment the samples collected varied from 6% to 10% suspended solids of which bagacillo accounted for 1-2%. A typical output from the venturi installed at Mount Edgecombe mill is given in Figure 8. Values of suspended solids implied from the differential pressure are also shown. The cycling observed in the mud solids reading was not due to any control intervention.

Drag measuring instrument

This instrument is installed in the side of a mud mixer. Its operating principle is relatively simple. The mud in the

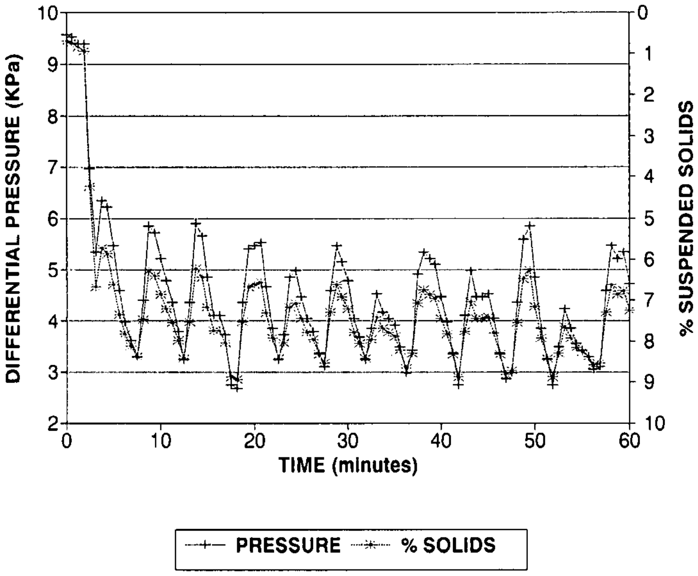

FIGURE 8 Typical results from the venturi installed at the Mount Edgecombe mill.

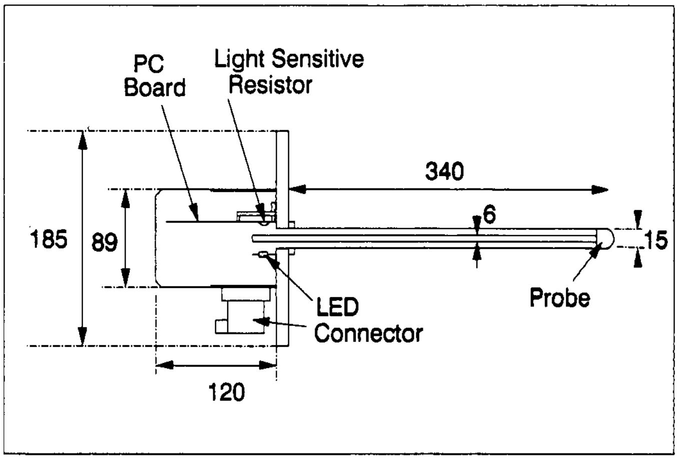

FIGURE 9 Drag measuring device.

mud mixer is stirred by paddles at a constant speed, imparting a force on the probe inserted into the mud. The measurement of this force should be proportional to the consistency. Figure 9 shows an outline of this instrument.

On applying a force at the end of the probe this force is transmitted by the movement of a pointer. This movement is measured by the shadow of the pointer on two light sensitive resistors, from a light source, connected in a Wheatstone-bridge circuit.

Results

To check the linearity of this instrument various forces were applied to the end of the probe. The results of this calibration test are given in Figure 10. This instrument is still in the development stage and has not been tested in a sugar mill. The results of consistency versus output of this device have not yet been determined.

Discussion

Venturi

From the results shown in Figure 5 it can be seen that a temperature change between 80°C and 90°C of primary mud

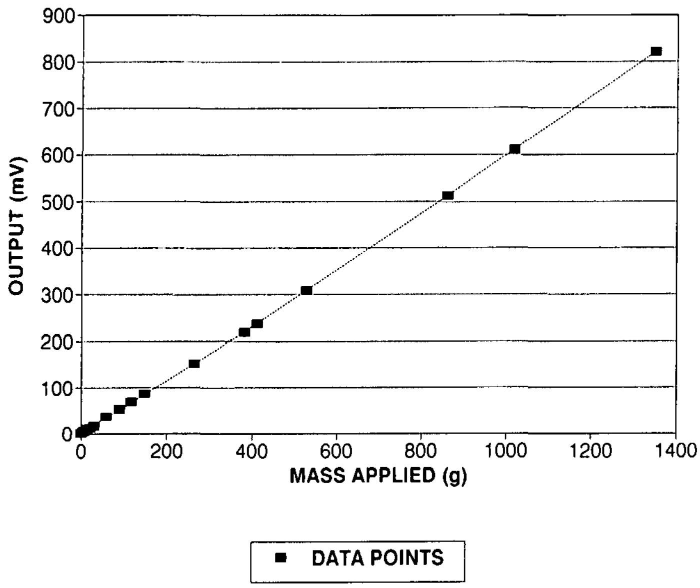

FIGURE 10 Calibration points.

causes an output error of less than 5%. It has also been shown that the venturi can measure the consistency of primary mud between the ranges of 2,5% to 10%. Work done by Lionnet (1984) shows that this range should be acceptable for normal operating conditions of a filter station. Figure 8 also gives an idea of the response of the venturi output to variations in suspended solids in primary mud and will possibly help the operator to achieve a better filter efficiency.

For the period that the venturi was installed at Mount Edgecombe a small build up of scale was noticed. This was in the pipe between the header tank and the venturi and in the pipe to the mud mixer. The dimensions of the venturi used were chosen for doing experimental work only. A larger venturi should be chosen to use a greater volume of primary mud which would eliminate the possibility of blockages in the venturi and reduce the significance of scale accumulations.

Drag measuring instrument

From preliminary work carried out it has been noticed that a probe inserted into a mixer is more sensitive to varying quantities of bagacillo than to mud solids. Further work on this unit should hopefully prove its application to measure % bagacillo solids in a mud mixer.

Conclusions

Venturi

The work carried out in measuring consistency in a filter station has been done with the object of obtaining a repeatable output rather than an extremely accurate one. The venturi device has been shown to fulfil this requirement of measuring suspended solids successfully. The effect of small changes of bagacillo in primary mud on the output still has to be investigated. During normal operating conditions the primary mud temperature variation will not cause a significant output error from the venturi and its effect can be ignored.

Drag measuring instrument

Preliminary work with this instrument suggests that it should be successful in measuring the % bagacillo in a mud mixer. More work needs to be done before accurate conclusions can be made.

Acknowledgements

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