THE DEWATERING OF SMUTS USING A MULTI-ROLLER FILTER

By A. E. GORING

Tongaat Sugar Limited, Maidstone

Abstract

In recent years new anti-pollution laws and regulations have made sugar mills more aware of the need to control their effluent disposal. In particular, to solve the need for efficient gas cleaning systems in boilers, many mills have installed wet type scrubbers with the consequence that large quantities of dirty water are produced, which poses the ultimate disposal problem. Many different systems have been installed, from landfills to centrifugal solids separation. This paper deals with the experiences at Tongaat using a multi-roller filter for smuts dewatering.

Introduction

The installation of the Multi-Roller Filter caused a redesign of the whole smuts disposal system from the multitude of small beach-type settlers to an arrangement centred around a settling clarifier or subsider (Figure 1). In the new arrangement all the boiler scrubber smuts water, as well as any factory wash-down water, is gravitated in open channels to a beach-type settler. This settler acts as a primary sedimenter for large particles such as coal, tramp iron and the heavier sand particles. Also, due to the arrangement of the outlets, floaters are contained within the settler and removed by the slats.

The outflow from the settler is gravity fed to a sump from where it is transferred by a centrifugal pump into the clarifier. From here the overflow from the clarifier is led by a peripheral launder and a downpipe to a sump from where it is pumped back into the scrubber, with any surplus overflowing into the irrigation system. The underflow is fed directly to a diaphragm pump that transfers the mud to the Multi-Roller Filter, with flocculant added after the pump. The mud, having passed through the filter, emerges as a dry manageable cake which is then mixed with filter cake for disposal. The filtrate from the filter is fed back into the primary sedimenter.

Principle of Operation of Multi-Roller Filter

Basically, the Multi-Roller Filter (MRF) consists of two endless stainless steel belts passing around a number of rollers (Figure 2).

Initially, flocculated slurry is fed into a hopper at the front of the machine, from where, after a short period of time to allow the flocs to form, it overflows gently via a weir onto the bottom belt. Evenness of feed onto the belt is achieved by a series of rotating augers in the feed hopper helping to lift the mixture on to the belt. Initially the slurry is applied to the bottom belt only and, in the period before it comes into contact with the top belt, it passes over what is known as the gravity filtration zone. In this section free water passes through the bottom filter belt purely by the action of gravity. Sludge thickness on the belt is controlled for a given flow rate by altering the speed of the belts.

Where the top and bottom belts meet they are made to follow a section of a spiral path, sandwiching the slurry between them and giving a gentle linear increase in pressure independent of the sludge thickness. This stage is known as the floc stabilisation zone. The slurry then enters a pressure zone where the belts pass around a number of rollers of decreasing diameters. As the diameter of the roller becomes smaller the pressure applied to the slurry increases causing further dewatering. Finally, after the dry cake is discharged, the belts pass through a cleaning zone on the return where high pressure rotary sprays backwash the belts.

MRF Design Details

The filter belts used on the MRF are of stainless steel link type. Their construction allows water to pass freely through and give good drainage even when in contact with a pressure roller. It also allows correctly flocculated slurry to form a cake on its surface. The belt is so constructed as to allow it to be split at any point along its length. Thus

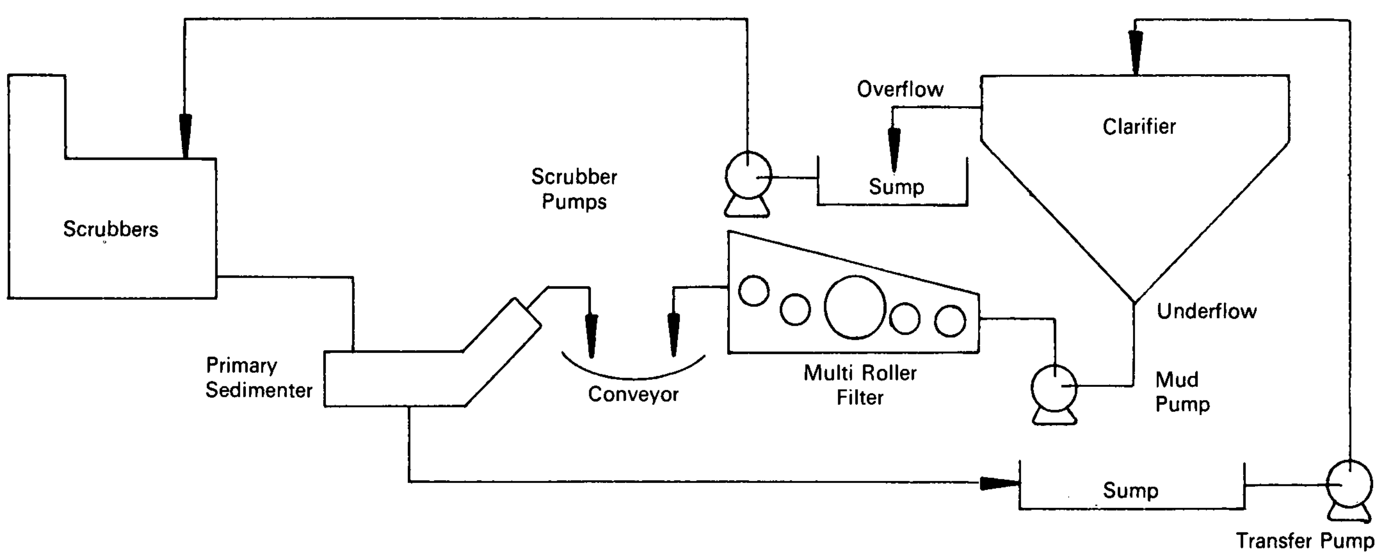

FIGURE 1 Schematic of Solids Separation System.

a particular portion of the belt can be removed and replaced if needed by a new section, overcoming the need to replace the complete belt should any damage occur.

Tensioning of each belt is achieved by a tension roll at the front of the machine. The required tension is applied by a lever system powered by a pair of double acting hydraulic rams, one on either side (Figure 3). To enable the rams to act in unison and to keep the roll from slewing, they are mechanically linked by a cross shaft. Provision is also made for the initial adjustment to be done manually.

Both belts are tracked automatically by individual steering rollers, which are activated by limit switches, one on either side of each belt. The lever arms on the switches are fitted with rollers and made to run against the belt edge. If the belt moves over to one side, the switch activates a solenoid valve which operates a hydraulic ram. The effect of this is to move the appropriate steering roller and bring the belt back into line. The steering system is semi-floating between the upper and lower belts enabling steering forces to be applied at all belt tensions. Should the steering system fail to bring the belt back, the same limit switches have a second position that trips the machine and all the auxiliaries to prevent damage to the belts. The drive for the belts is achieved by applying power to the two back rollers. The first roll, around which the top belt passes, is chain-driven from a variable speed drive unit, while the second roller is driven via the first by a set of gears, and in turn drives the bottom belt.

Commissioning and Operational Problems

One of the first major problems encountered was to find suitable pumps to transfer the subsider underflow to the MRF.

Initially a centrifugal pump was used with a variable speed drive, but accelerated wear and a lack of control on the feed made this pump unsuitable. Gravity feed using a valve to control the flow resulted in the smuts packing up behind it and choking the line. As a temporary measure a

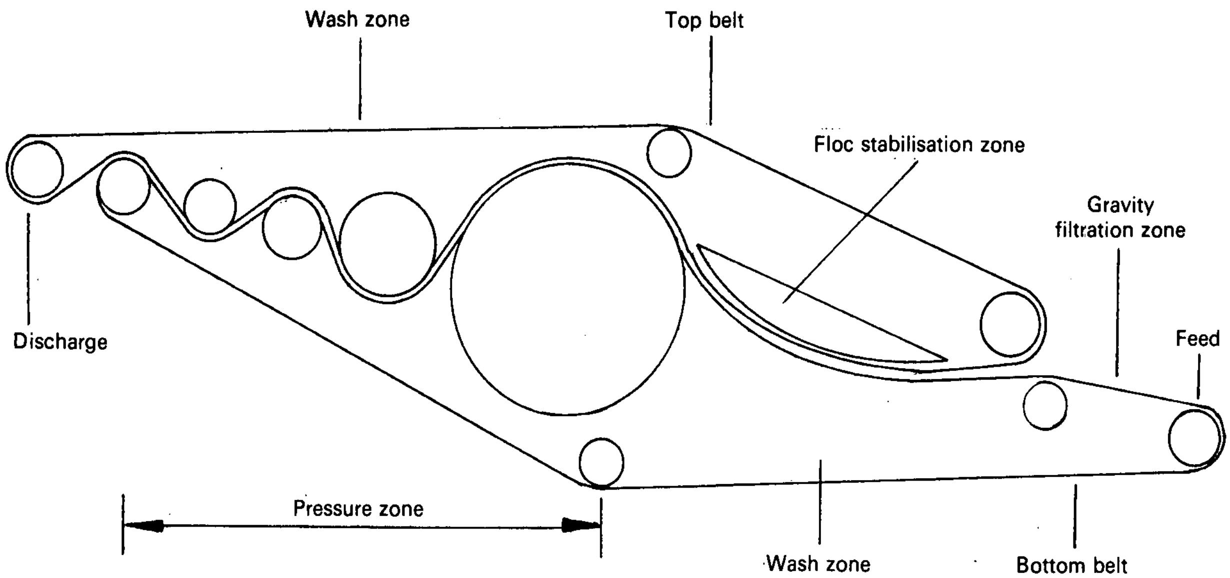

FIGURE 2 Belt Path through M.R.F.

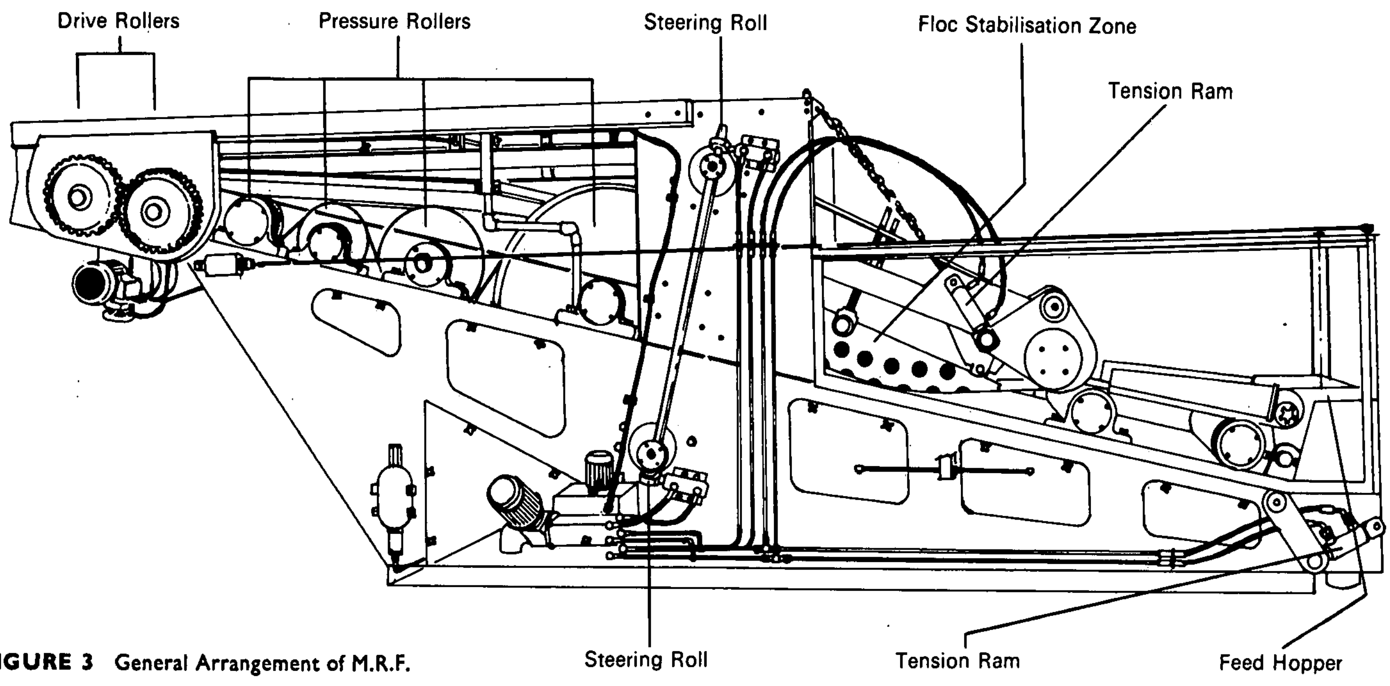

FIGURE 3 General Arrangement of M.R.F.

steam-driven duplex mud pump was used, but, although it worked well enough, its major problem was also wear. The pistons and cylinder bores soon became badly scored while wear of the shafts caused excessive leakage and mess from the packed glands.

Finally an electric powered diaphragm pump was installed which worked extremely well. It was extensively modified from the original, the first addition being a variable speed drive unit for flow control to the MRF. The drive to the diaphragm was via an eccentric, clamped and keyed onto the gearbox output shaft, then through a conrod rotating about the eccentric pin on a needle roller bearing. However, various problems were encountered with this. The output shaft from the gearbox frequently sheared due to it having been lengthened to accommodate the eccentric, but was now unable to take the loading. A temporary solution was the use of 60-ton steel, but this then led to the failure of either the key on the eccentric or the roller bearing. Eventually, it was decided that an outboard bearing was required to take the load off the gearbox. This was achieved by replacing the eccentric with a large circular block, with provision for the drive shaft made off centre to give the required eccentricity and hence stroke of the diaphragm. The drive shaft ran through the eccentric block, to which it was keyed, to an outboard bearing on a pedestal. Around the block was a large needle roller bearing, whose outer race was housed in, as it were, the big end of the connecting rod.

The only disadvantage of this type of pump for this application is that, due to the flap valve type system it employs, the discharge head must be greater than the suction head to enable the discharge valve to close on the suction stroke. This has been overcome by pumping to a tank located just above the water level in the clarifier and then gravity feeding to the MRF.

Initially the MRF had been used experimentally on smuts, prior to the installation of the subsider, with reasonable success. For part of the experiment polyester belts were used but were found to be unsuitable as they could not tolerate high temperatures (although temperatures in the new system are much lower). The excessive temperatures encountered caused the belts to stretch quite badly and gave numerous tracking problems. Although the cost of the polyester belts is much less than that of the stainless steel belts used, their major disadvantage is that should any damage occur to a portion of the belt, the whole length would have to be replaced as they are not repairable.

Feed problems were initially encountered, including pipe blockages and dead spots in the feed hopper. This was overcome in the present installation by the use of augers to lift the slurry on to the belt and to give an even distribution across the belt width. Modifications were made during the season to the augers, namely lifting the chain drive and bearing units to keep them well clear of the slurry.

A major tracking problem occurred during the season with the bottom belt whereby the belt separated from the top one beneath the second pressure roller. This caused the hydraulic tensioning rams to retract fully and the belt to become overtight, so that the steering rollers were virtually ineffective. The problem was traced to a partial seizure of the tensioning lever system. Insertion of a grease nipple and regular greasing solved the dilemma.

Investigation of a bearing failure resulted in modifications to their lubrication system. This involved repositioning of some of the grease nipples on the end covers and the relocation of some nipples on more accessible parts of the machine, requiring connections to the bearings by short runs of tubing. Beneath the top belt rotary wash sprays is a collection tray, part of which came adrift and travelled with the belt, becoming entangled with the drive roller. The consequence of this was to stretch the belt badly on one side. Although it would have been expected that this would cause tracking problems, no such problems occurred, but a close eye was kept on the belt and the location of the tray was made more secure.

Maintenance

During the season the only mechanical breakdowns that occurred with the MRF were a collapsed bearing on a pressure roller and a burst hydraulic pipe. Various operational errors gave problems such as damage to the filter belt and the auger system. Having run for most of the 1981/82 season, being the first time it had been operated continuously for a long period, it was stripped down to the bare framework during the off-crop.

All the bearings on the rollers were replaced at a cost of about R1 100. Some of the hydraulic hoses, the seals on the hydraulic pistons as well as the oil were changed. The Nylotron strips in the floc stabilisation zone were quite badly worn and required replacing, incurring a cost of about R315. Whilst the MRF had been on trial severe tracking problems had occurred and upon investigation it was found that some rollers (mainly the rubber ones) had become tapered by as much as 1 mm, and so they were stripped down and chromed They were measured again at the end of the season and found to have no more than 0,1 mm taper in the worst case, so rechroming was felt unnecessary. The only rubberised rollers now are the two steering rollers and the first pressure roller, which is somewhat larger in diameter and hence exerts less force on the belt than the other smaller rollers. The pressure roller surface was in very good condition but excessive wear had taken place on the steering rolls requiring a new coating to be applied at a cost of about R300 per roller. Total maintenance costs for the season should be in the region of R3 500, excluding belts.

Change was also made to the main drive unit of the MRF, a variable speed motor and gearbox, which initially was mounted upside-down. It was found that should it need to be removed for repairs re-installation was much easier with it mounted on top of the machine. A point to note here is that the reason for its initial location was that the machine was designed to fit exactly into a container for ease of transportation, as it is completely assembled at the factory and only requires connecting up on site to electricity, water and feed material.

Belt wear has been extremely good with one belt on the machine having run all season as well as for some time on the experimental unit. Some flattening of the links had occurred, but wear and stretch between links seemed acceptable, although exactly when a belt should be rejected has not yet been determined, as one has never been run to destruction. Previously the belts had been changed due to damage during operation that occurred when the machine was still a relatively unknown quantity.

Presently imported belts from the manufacturer are about R7 900 each.

Results

Unfortunately, due to commissioning problems with the MRF and the overall system, full flow rates and mass balances were unable to be taken. However, during the 1982/83 season full experimentation will be run on the system. It is known that an average moisture content of the cake discharged from the MRF was 70,7% last season. A higher than anticipated flocculant usage on the machine, attributable to poor initial mixing of the polymer and the smuts and the subsequent rough handling of the flocculated sludge, was apparent. An in-line mixer was installed in the downpipe to the machine to improve matters and it helped slightly. Further modifications to the system will be tried next season with the objective of minimising the use of flocculant.

Previously published results[1] indicated a solids concentration of the cake of between 27,8% and 35,2%, with the best results being obtained with a thicker cake on the belt. Solids in the filtrate varied between 1,5% and 3,7% and the mud flow rate of 10,5 to 32,2 tons per hour. It should be noted that these tests were conducted prior to the installation of the present system, and at that time the feed was a prepared sample to simulate what was expected in the new arrangement.

Conclusions

Despite initial problems that are bound to plague any new and untried installation, the consensus of opinion by those involved in the project is that the MRF has proved itself to be a success. A far superior end result was achieved than previously, and the cake produced was easily handled and suitable for transportation. Other benefits of the system are much cleaner return water to the scrubbers with the hope of more efficient scrubbing and cleaner stacks. The low power consumption of the machine, which has a 7,5 kW drive motor, the two wash pumps 2,2 kW each and the mud pump 2,2 kW, makes it attractive in terms of running costs. Initial installation is expensive, an equivalent machine currently costing in the region of R150 000.

Acknowledgements

The co-operation of the staff at Maidstone is gratefully acknowledged for their valuable assistance and perseverence in making the system work smoothly, and to Messrs. P. Pottage and P. Alder of Tate & Lyle and Messrs. Assheton and Cooper of Wickhams for guidance with the MRF.

REFERENCES

1. Moult, J. M. (1980). Wickham Multi Roller Filter Dewatering Plant. SMRI Technical Report No. 1257.