

IMPROVEMENT IN THE OPERATION OF THE SMUTS AND SCRUBBER WATER SYSTEM AT FELIXTON

D. B. WAGNER

Tongaat-Hulett Sugar Limited, Felixton

G. T. SCHUMANN

Tongaat-Hulett Sugar Limited, La Lucia

Abstract

This paper describes the experiences at Felixton in improving the operation of the smuts water clarification, smuts filtration and scrubber system. Problems arose firstly from the variable and often heavy loading of factory effluent into the scrubber circuit which caused poor clarification and filtration, and secondly from high calcium sulphate levels in the scrubber circulating water resulting from unsteady lime addition and high coal burning rates. The major improvement in performance has been the addition of lime to the clarifier underflow allowing good solids disposal. This has lowered the suspended solids in the overflow to the effluent treatment plant and reduced fouling in the scrubbers.

Introduction

The Felixton smuts treatment system is designed to supply recycled water to the scrubbers and ash hoppers and to remove suspended solids. It is also meant to handle all factory effluent and injection water overflow, as well. A simplified schematic layout is shown in Figure 1.

In essence of the plant is designed to clarify a mixture of factory effluent and smuts water from boiler scrubbers on the 3 boilers in 2 × 730 m³ clarifiers. The underflow from the clarifiers goes to 2 × 9 m² Delkor vacuum belt filters, where it is dewatered to give a handleable cake. The clear overflow from the clarifiers is recirculated back to the boiler

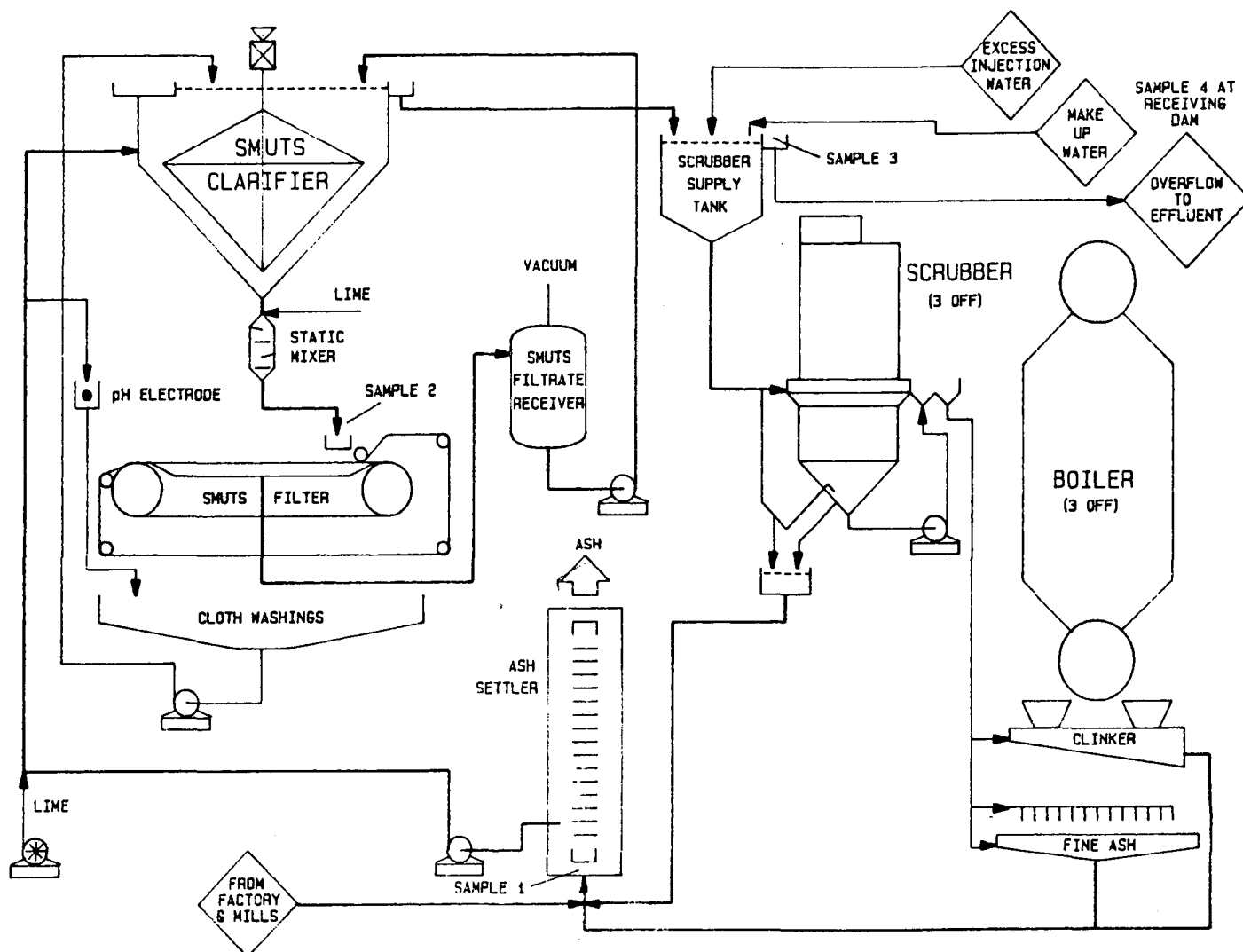


FIGURE 1 Simplified Layout of Felixton Smuts Water Treatment and Scrubber Circuit.

scrubbers. All surplus water streams ie effluent, cooling tower overflow and sweetwater are sent to this system. If additional water make-up is required eg for greater blowdown, raw water is added. Any surplus water overflows to the effluent treatment plant where the treated water is discharged into the Umhlatuze River. Hence the importance of good smuts removal and effluent treatment.

During factory shutdown periods the quantity of factory effluent and its sugar content entering the smuts clarifier system both increased. This caused the pH to drop as sugars degraded to organic acids and resulted in poor filtering smuts muds, and high carryover in the clarified effluent.

This continued for 12 to 24 hours after a shutdown and usually resulted in the need to dump most of the clarifier underfeed on to the ground, causing an unsightly mess.

To confirm that the factory effluent was causing the problems of poor settling and filtration, the effluent was bypassed directly to the effluent treatment plant for two months. This improved the performance of the smuts clarifier considerably. However, the operation of the effluent plant became unsatisfactory due to high solids loading and foaming. The factory effluent was then reintroduced into the scrubber circuit, and attention given to improving the operation of the plant.

Experimental Procedure

Routine two hourly samples of water were taken from:

1. Clarifier feed (before liming)
2. Clarifier underflow
3. Overflow to anaerobic dams
4. Receiving dam at the effluent treatment plant.

The position of the sample points are shown in Figure 1. For the purposes of this investigation the samples were composited and analysed daily for the following:

1. Clarifier feed for pH, pH decrease with time, suspended solids and settling test.
2. Clarifier underflow for filtration rate.
3. Clarifier feed and overflow for sulphate, calcium as calcium carbonate and conductivity.
4. Effluent plant feed composited weekly for pH, COD and suspended solids.

Analytical Procedures

the pH, COD, and suspended solids tests were done according to SASTA laboratory methods¹, while the other tests are outlined below:

- (a) *pH decrease with time:* A sample of clarifier feed was kept in the laboratory at room temperature for 24 hours. The pH was read every hour.
- (b) *Settling test for smuts clarifier feed:* Three 500 ml aliquots of well mixed feed were poured into 1 litre beakers. One aliquot was allowed to stand untreated while milk of lime was used to adjust the pH's of the other two to 8,0 and 9,0 respectively. After standing for 20 minutes, a sample of the clear supernatant was removed by pipette. The optical absorbance of this sample was measured in a 1 cm cell at 720 μm against distilled water. This test was carried out at room temperature.
- (c) *Filtration test for smuts clarifier underflow:* The sample was well mixed and 1 litre rapidly poured into a 2 litre beaker. The sample was heated to 55°C in a water bath.

A 10 cm Buchner funnel was prepared with a disc of Delkor belt filter material, and a heavy ring to keep it

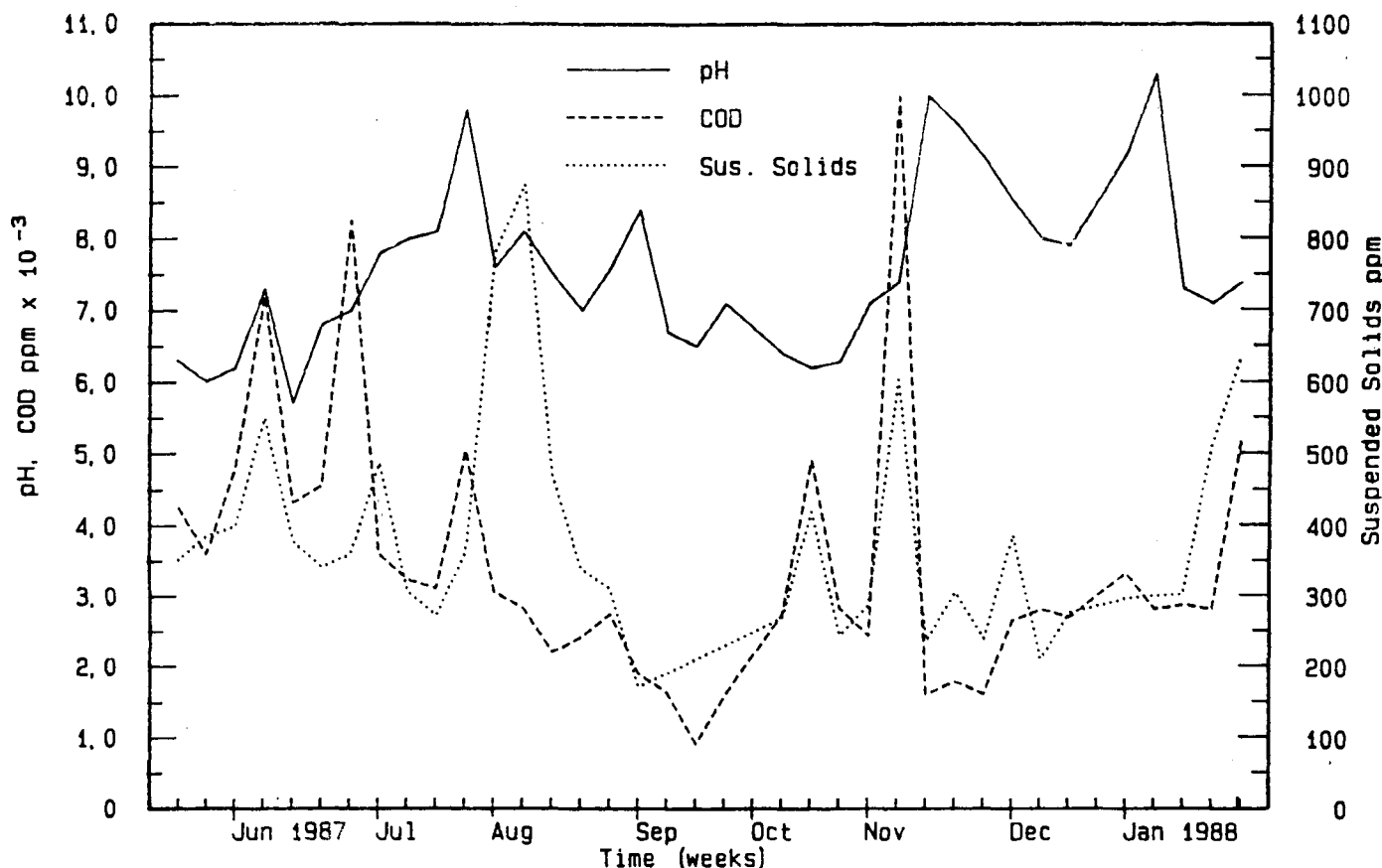


FIGURE 2 pH, COD and Suspended Solids Comparisons in Effluent.

flat. The sample was stirred and filtered at -50 kPag noting the total time in seconds to filter one litre. The sample was restirred before each addition to the funnel. The filtration rate was expressed in m^3/m^2 min. The residual cake can be dried and weighed as a further test of suspended solids. This was a relative test to establish the filtration rate of the underfeed on the plant. It was later modified to include a second aliquot limed to pH 8,5 to test the effect of lime on the filtration rate.

(d) *Relationship between conductivity, calcium and sulphate*: Details are given in Appendix 1.

Results and Discussions

Figure 2 illustrates the quality of the effluent at the receiving dam in terms of pH, COD and suspended solids, from May 1987 to January 1988.

It had been the practice at Felixton since commissioning to slug dose lime into the factory drains whenever the scrubber water pH was low. This however was not done on a regular or controlled basis, and was done more to prevent corrosion of pipes and pumps, than for good operation. The amount of lime was dependent on the amount of coal burnt in the boilers due to scrubbing of sulphur oxides from the flue gas.

When the factory effluent was reintroduced to the scrubber circuit it was decided to install a pH dosing system. This was started in August 1987 and commissioned over the next two months. The system consisted of a variable speed peristaltic lime dosing pump, controlled by pH measurement using a Polymetron pH probe. This system gave problems on a daily basis, particularly due to the line feeding the probe blocking up with ash.

While the dosing system and the factory were both running, the smuts clarifier performed well with the mud filtering easily and the overflow below 200 ppm suspended solids. When half the factory closed down alternately, either on a Monday or Thursday for routine maintenance, sugar entered the effluent from:

1. Washings from emptying and cleaning the evaporators.
2. Oliver filter and clarifier washing after emptying.
3. Mill washings.
4. Caustic washings from evaporators.

After start up the smuts plant would take from 12–24 hours before the underflow would filter properly. The clarifier had to be dumped onto an adjoining area next to the plant. This caused a mess which had to be cleared up twice per week by payloader. In addition to the cake filtering very poorly, it was also very wet and often washed the Oliver filter cake off the common belt onto which it was fed.

Figure 3 shows the effect of increasing pH on the turbidity of the settled feed. This is the laboratory test described above. The variability can also be seen from day to day showing the peaks after a shutdown period.

Figure 4 shows the results of some daily pH trials done in November. Although these are catch samples they illustrate how the pH sometimes decreased by up to nearly 4 units after 12 hours.

The plant was also badly affected by unsteady cane supply not only immediately after the September floods but throughout October and November. This caused frequent liquidating of vessels and therefore sugar into effluent, even though the pH control of the incoming feed was now steady.

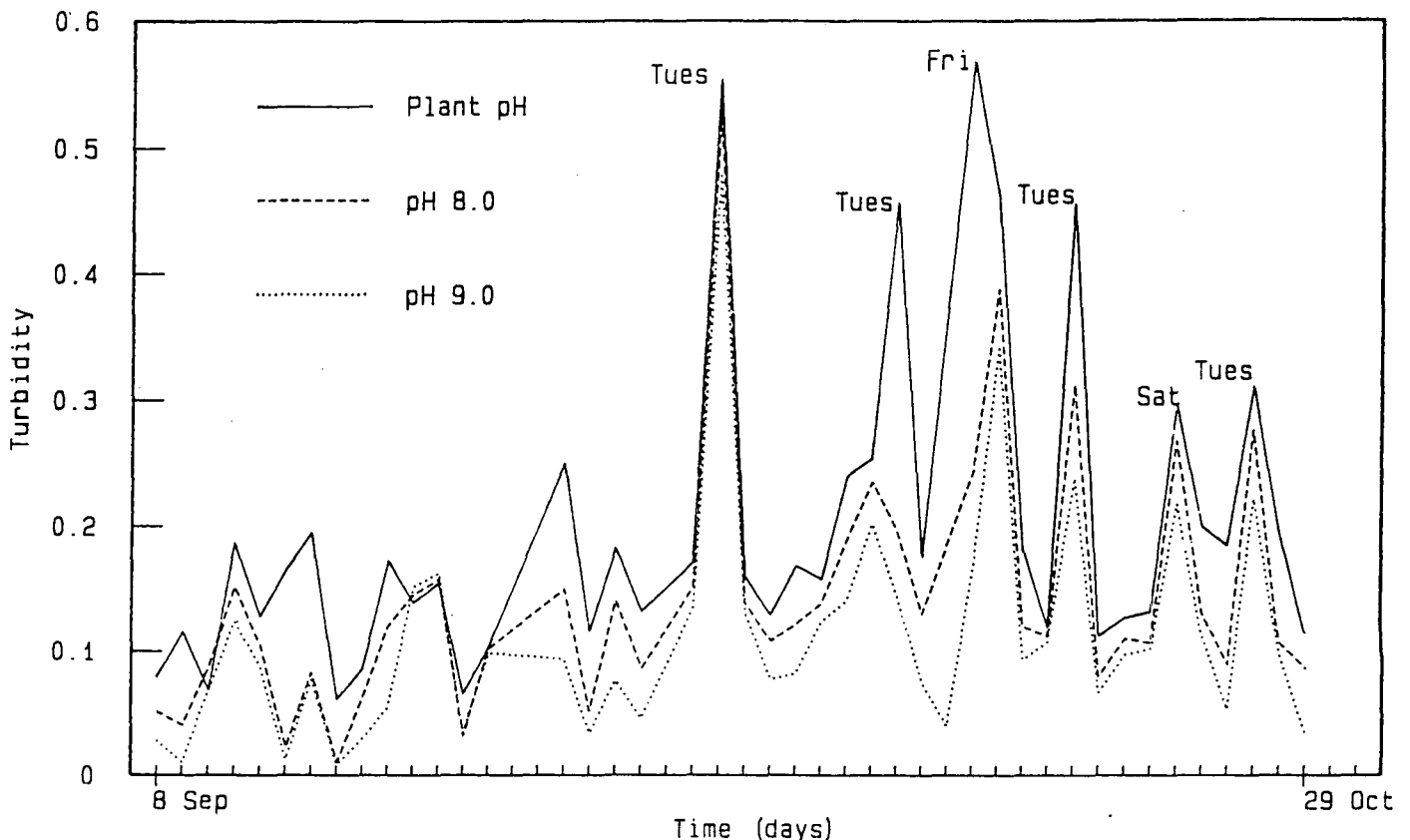


FIGURE 3 Trend in Turbidity of Feed at Various pH's.

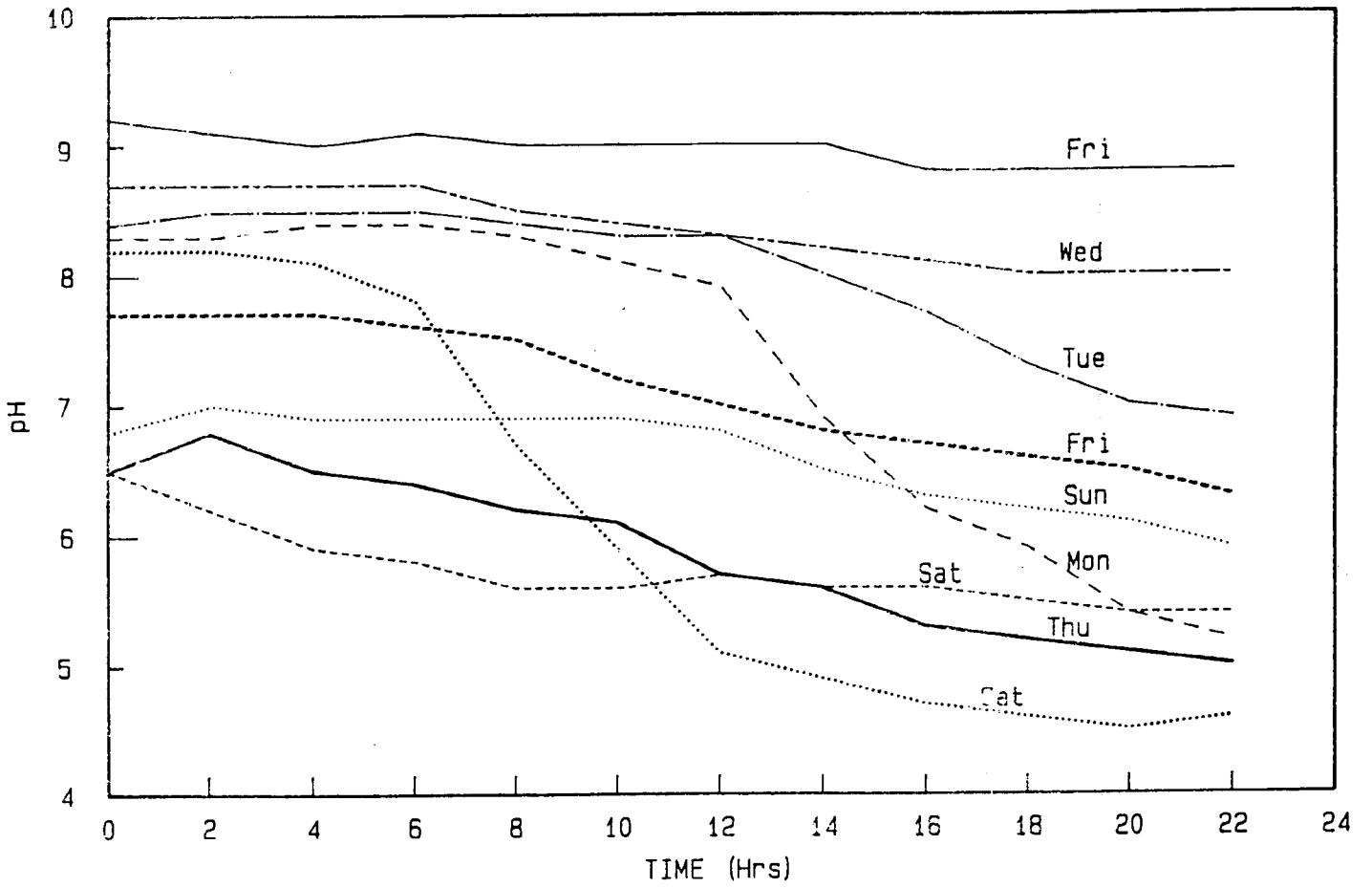


FIGURE 4 pH Changes in Clarifier Feed on Standing.

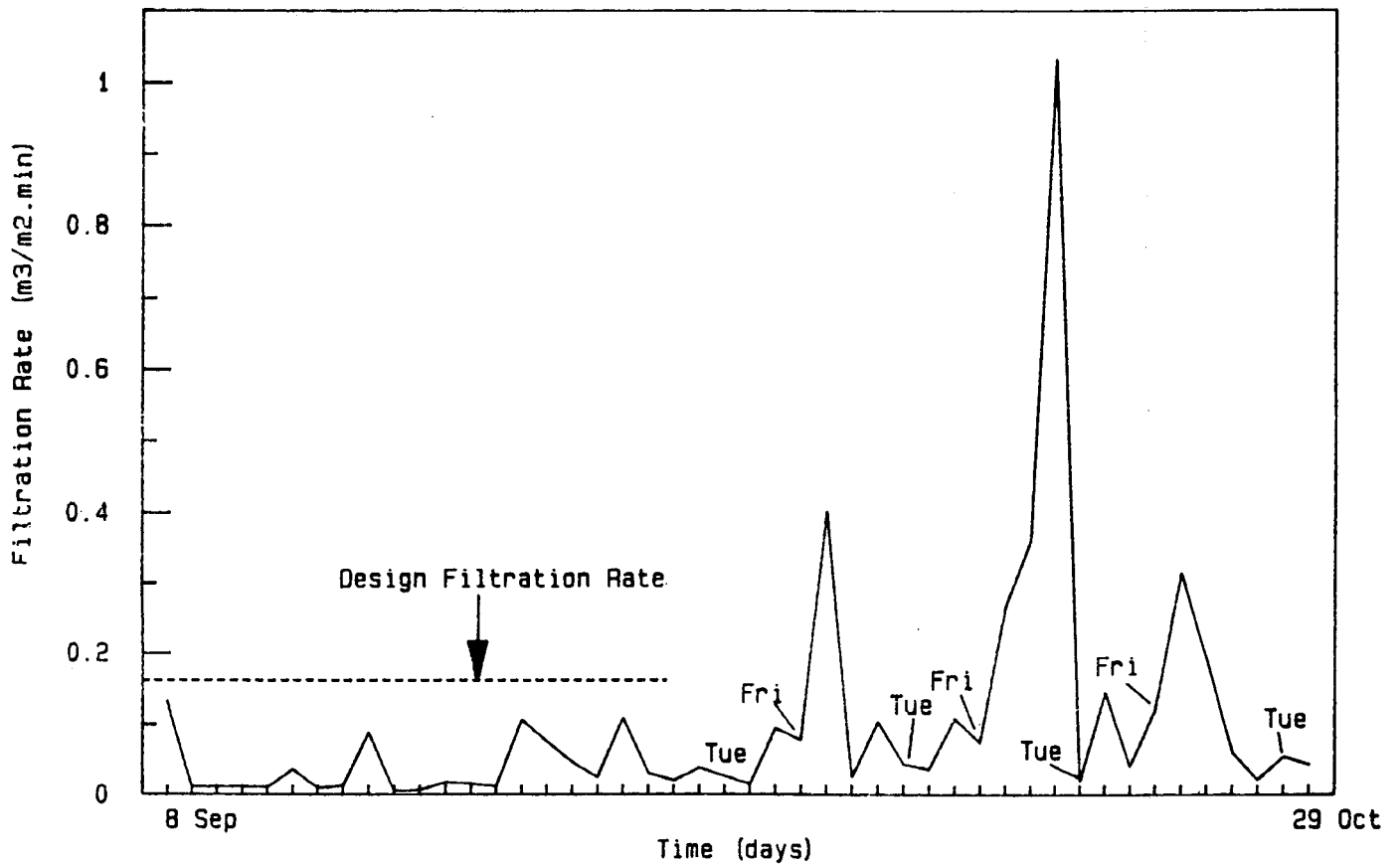


FIGURE 5 Trend of Underfeed Filtration Rate compared with Design Specification.

Figure 5 shows the results of the filtration rate test on daily composites of clarifier underfeed. Again the variability can be seen. Tap water filters at 1,5 m³/m² min. in the same test, while the design rate is 0.16 m³/m² min. Some improvement in the trend can be noticed as the pH control system was improved, but very low values still occurred particularly after shutdown. There is little correlation in the laboratory test between filtration rate and solids loading.

In November the filtration test on the underflow was expanded to test the filtration rate at plant pH and at pH 8,5.

Table 1

Results of filtration rate improvement after liming to pH 8.5

| Test | Temp. °C | pH | Filtration rate m ³ /m ² min | | Dry solids g/litre in feed |
|------|----------|-----|--|-----------------|----------------------------|
| | | | Unlimed | Limed to pH 8,5 | |
| 1 | 54 | 6,3 | 0,04 | 0,16 | — |
| 2 | 30 | 5,2 | <0,005 | 0,02 | 338 |
| 3 | 55 | 6,2 | 0,03 | 0,11 | 40 |

Samples 1 and 2 were taken during shutdowns and sample 3 the day after during periods of very poor filtration. It can be seen that by increasing the pH to 8,5 a fourfold improvement in filtration rate can be expected under these conditions. These tests were repeated using 5 ppm of flocculant without improvement.

As a result of these tests it was decided to install a static mixer in the underfeed stream and dose lime ahead of it. The mixer consisted of 4 semicircular baffles offset consecutively at 90° and installed in a 300 mm diameter pipe. pH was controlled with a hand pH meter in the range 8–10 pH. Although this system only needed to be used after a shutdown or whenever the filtration was poor it had the immediate result of alleviating a serious operating problem on the filter. Furthermore since the mud levels could be kept low, the retention time was reduced and the quality of the overflow also improved.

Felixton burn coal at up to 10 tons per hour. The removal of sulphur oxides from the flue gas in the scrubbers and the need to add lime for pH control has caused calcium sulphate deposits on the sieve plates and subsequent blocking. This was particularly so before the pH control became steady and it was necessary to clean the sieve plates weekly. An empirical test to establish the relationship between the sum of the Ca⁺⁺ and SO₄⁻ ions and conductivity is described in Appendix 1.

This shows that scaling is likely to occur above a conductivity of 2 500 μS cm⁻¹. With effective pH control and after blowdown control was introduced using a conductivity limit of 2 500 μS cm⁻¹, the sieve plates were inspected during routine three weekly boiler shutdowns. The scaling of the sieve plates was reduced to the extent that only light cleaning was necessary every six weeks.

Conclusions

1. The clarification of all factory effluent, scrubber and smuts water for the removal of suspended solids greatly improves the performance of subsequent effluent treatment. The addition of sugar to the system however causes the pH to drop which needs to be corrected by steady lime addition to the feed and when necessary to the clarifier underflow as well to ensure good clarification and filtration.

2. The burning of coal causes sulphates to react with the lime in the scrubbers. The calcium sulphate concentration must be kept within its solubility range to prevent scaling on the sieve plates. This can be achieved by steady pH control and by controlling the blowdown through a simple conductivity test.

REFERENCES

1. Anon. (1985) *Laboratory Manual for South African Sugar Factories*. SASTA, Mount Edgecombe.
2. Anon. (1979) *Principles of Industrial Water Treatment*. Drew Chemical Corporation, Boonton 73.
3. Vogel, AI. (1961) *A Textbook of Quantitative Inorganic Analysis*. 3rd Edition, Longmans, London 436, 275.

APPENDIX 1

The Dependence of Conductivity on the sum of Calcium as Calcium Carbonate and Sulphate Ion.

The solubility of CaSO₄·2H₂O is approximately 2 000 ppm (2 g/l) in the temperature range 50–70°C.²

The molecular wt. of CaSO₄ = 136

$$\therefore \text{Molar concentration [CaSO}_4\text{] at saturation} = \frac{2}{136} = 0.0147 \text{ g/l}$$

If both ions are present in equal quantities ie 0.0147 molar then the concentrations are:

$$\text{for Ca}^{++} = 0.0147 \times 40 = 0,588 \text{ g/l}$$

$$\text{or as CaCO}_3 = 1,470 \text{ g/l}$$

$$\text{and for SO}_4^{-} = 0.0147 \times 96 = 1,411 \text{ g/l}$$

If the sum of Ca⁺⁺ as CaCO₃ and SO₄⁻ is added together, it gives a rough idea of the level at which precipitation can be expected.

$$\text{i.e. the sum of Ca}^{++} \text{ as CaCO}_3 \text{ and SO}_4^{-} = 2,881 \text{ g/l} = \pm 3\,000 \text{ ppm}$$

Sixty-four samples were taken over a five week period in June and July 1987 from the clarifier feed and clarifier overflow. These samples were analysed for conductivity, calcium as calcium carbonate and sulphate ion³. The results are shown in Figure 6. There is good correlation between conductivity and the sum of calcium and sulphate at Felixton during this period. When the sum is greater than 3 000 ppm then scaling is likely to occur on the sieve plates. The conductivity corresponding to this value is 2 500 μS cm⁻¹.

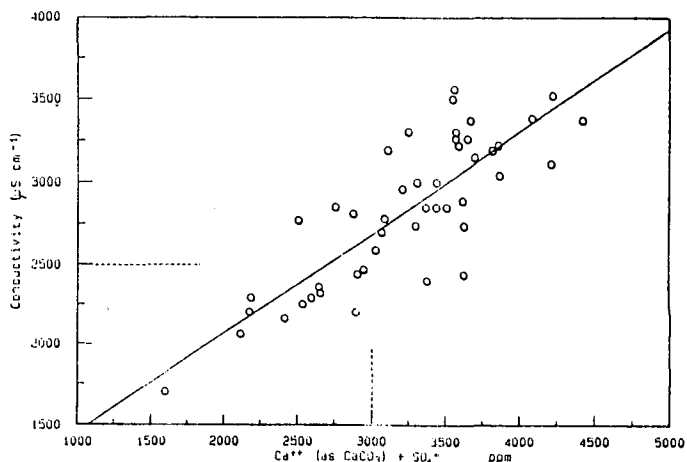


FIGURE 6 Comparison of Conductivity and the sum of Calcium as Calcium Carbonate and Sulphate ion.