Advanced treatment of acid mine water

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During mining operations the mined material usually comes into contact with water and air and the drainage water can contain sulphuric acid, ferrous and ferric sulphate as well as calcium, magnesium and sodium sulphates and chlorides in varying concentrations.

Since mine drainage water contains a certain amount of sulphuric acid it cannot be re-used directly in the mine or discharged to the environment without prior treatment. However, neutralisation of the acid mine water is not a straightforward process. If these effluents are neutralised in the normal way, voluminous, gelatinous and sometimes colloidal precipitates are formed. This results in the creation of large volumes of sludge ranging from 10% to 30% of the original volume of effluent treated, with a solids content of only 1 - 2%.

Disposal of this voluminous sludge presents an environmental problem and makes the cost of the neutralisation plant prohibitively high.

To overcome these problems a special neutralisation technique was developed in the USA. The process, known as the High Density Sludge (HDS) process, reduces the volume of the sludge to be disposed of by producing a much denser sludge. A comparison of the traditional lime neutralisation process and the HDS process is illustrated in *Figure 1.*

HDS plants in South Africa

Aquazur has developed and commercialised this technology and is a recognised leader in acid mine water treatment.

The first full scale plant for acid mine water treatment was commissioned by Aquazur for Rand Mines Milling and Mining in March 1987. The plant was built at the City Deep sand re-treatment plant which treated 2,4 million tons of sand a year from old gold slime dams. Approximately 400 m^3/h of acid mine water was generated during the hydraulic transportation of slime dams.

This plant proved to be a great success. The solids content in the sludge was increased from 1 - 2% to over 17%.

The sludge for disposal from the treatment of 400 m^3/h of acid mine water was reduced from 40 m^3/h to 2 - 3 m^3/h.

Anglo American recently awarded Aquazur a contract for the treatment of 120 000 Ml/month of acid mine water at Navigation (Witbank area). The plant will have a third of the capacity of the City Deep sand plant. However, the iron concentration in this water could be as high as 650 mg/l and will therefore be much more difficult to treat.

Acid mine water treatment plant design

The plant will consist of three main systems - a pH correction system, an aeration/neutralisation system and a solid/liquid separation system.

The pH correction system will consist of milk of lime preparation and a dosing and sludge conditioning tank which will receive the recycled settled sludge from the clarifier/thickener underflow via variable speed recycle pumps.

The pH of this recycle flow will automatically be adjusted with lime via

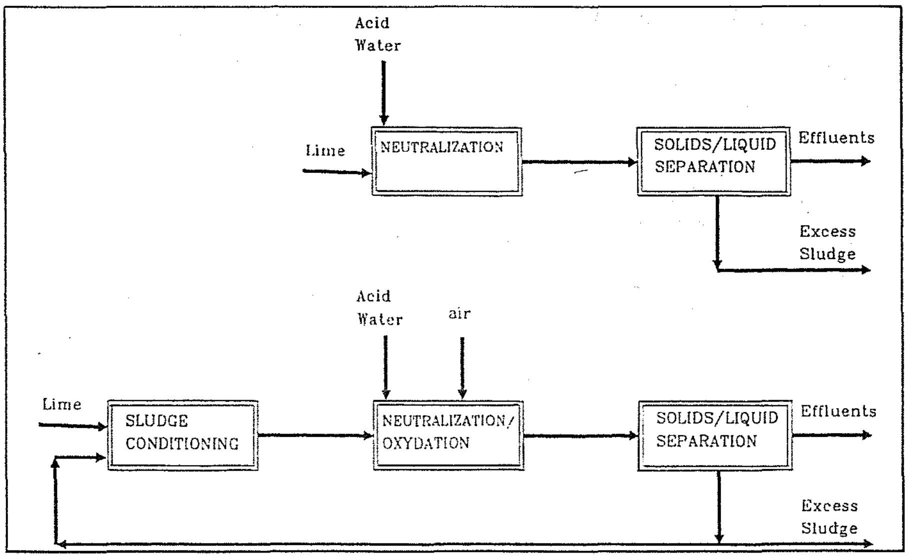

Figure 1: Comparison of conventional neutralisation with the HDS process

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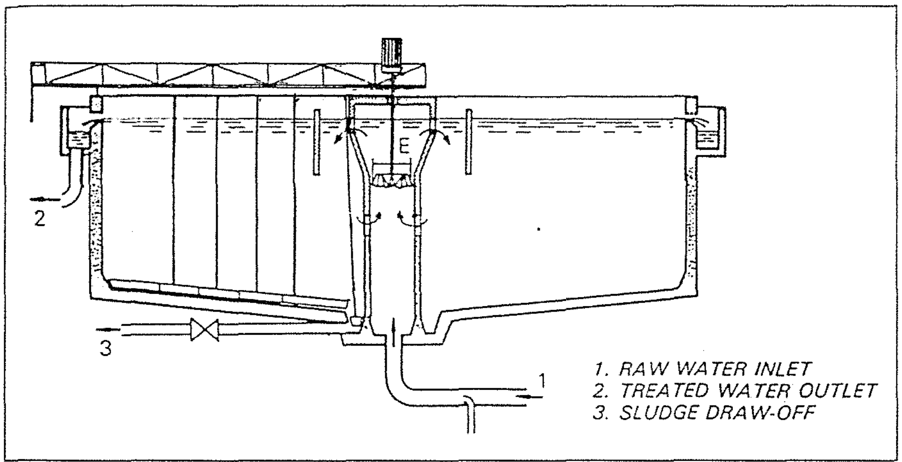

Figure 2: The Degremont Turbocirculator is modified to act as a thickener

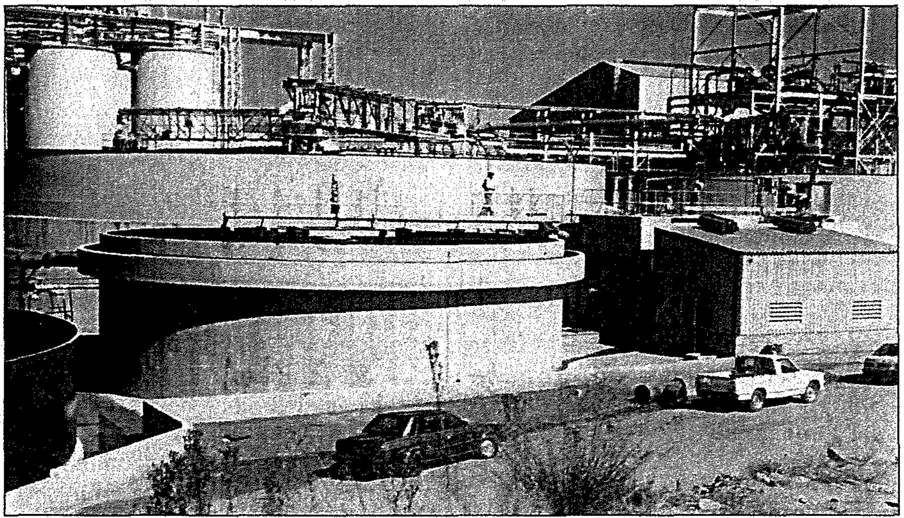
Figure 3: The City Deep sand neutralisation plant

a lime feed control valve, controlled by a pH controller. The pH will be adjusted to give a final pH of about 8 in the treated effluents. The sludge conditioning tank will be fitted with an electric mixer for mixing the lime suspension and the recycled sludge.

The retention time in the sludge conditioning tank will be selected to yield the best possible settling in the clarifier/thickener.

The conditioned sludge will overflow from the sludge conditioning tank into the aeration tank which is fitted with a fixed surface aerator which has a dual function: firstly, it serves as a mixer to maintain solids in suspension and mix the conditioned sludge with the acid mine water entering the tank. Secondly, the aerator introduces oxygen into the water. This oxidises the ferrous iron to ferric iron which later precipitates as iron oxide.

The neutralised and oxidised effluent will overflow via an adjustable overflow weir used to vary the immersion depth and the oxygenation capacity of the aerator.

The Degremont Turbocirculator, modified to act as a thickener *(Figure 2)*, will be used as the clarifier/thickener for solids/liquids separation.

The turbocirculator, a sludge recirculation type clarifier, has been used successfully in the clarification of industrial effluents and surface water.

The tank is equipped with a sludge scraper mechanism which scrapes the sludge towards the centre of the tank from where the recycle and excess sludge pumps recycle or waste a controlled quantity of sludge. The turbocirculator is equipped with a variable speed internal sludge recirculating impeller. This mixes the sludge with the incoming water to promote particle growth and densification of the sludge. The turbocirculator is designed for a high rise rate and operates with a high sludge loading rate. A polyelectrolyte can be dosed at the centre of the turbocirculator to promote flocculation. The clear settled water is collected in a circumferential launder at the top of the turbocirculator.

The sludge height in the turbocirculator and the sludge density are controlled by taking samples of the recycled sludge and allowing it to settle in a one litre measuring cylinder.

The clarified neutralised effluents from the treatment plant will be stored in a 14 000 m^3 clean water reservoir and reused in the mine. The sludge produced will be pumped to the slimes dam approximately 1 km away.

Benefits of the process

The acid mine water treatment plant has a number of attractive qualities:

The capital cost of the plant is significantly lower than that of conventional neutralisation plants. To achieve the same degree of solids/liquid separation offered by the turbocirculator, a conventional plant would require a large clarifier (or thickener).

Comparisons of the costs of a standard clarifier and a turbocirculator at the 'Navigation' Liming Plant indicated that the cost of the standard clarifier was over 60% higher than that of the turbocirculator. The savings were due mainly to the size of the turbocirculator.

There were additional savings on sludge disposal and storage facilities since the volume of sludge produced in the Aquazur plant was ten times lower than that on a plant with a conventional clarifier.

In the case of the Navigation plant, the sludge pond capacity required for storage of a year's sludge production was estimated at 35 000 m^3. For the conventional process, a sludge pond with the capacity of 350 000 m^3 would be required. If the capital costs of erecting a sludge pond and corresponding pumping and piping facilities average between 1R/m^3 and 3R/m^3 of storage capacity, the estimated saving resulting from the application of the HDS process amounts to between R300 000 and R900 000.

The technology has been proven on a large industrial installation and the risk normally associated with transfer of technology from the laboratory to the industry has been eliminated.

The City Deep sand neutralisation plant, commissioned in March 1987, provided Aquazur with a significant experimental database which allows the company to design acid mine water treatment plants for effluents at various degrees of contamination. ■