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UNE ÉTUDE EN USINE PILOTE DE LA PRODUCTION DE BOUES À HAUTE DENSITÉ DURANT LE TRAITEMENT DES EAUX DE DRAINAGE MINIER ACIDE

(A PILOT STUDY ON HIGH DENSITY SLUDGE PRODUCTION DURING TREATMENT OF ACID MINE DRAINAGE)

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ABSTRACT

Acid mine drainage (AMD) is the single most important environmental problem facing the mining industry today. To prevent impacting the immediate environment, mine site drainage is collected and treated prior to release. Treatment requires that the AMD meet a specific pH range and maximum levels for metals as enforced by legislation. There are many methods used for treating AMD but the most common is chemical treatment. The topic of study in this thesis is the production of high-density sludge in the treatment of AMD.

Chemical treatment of AMD is typically completed by neutralisation with lime, precipitation of metals as hydroxides, and solid-liquid separation. Separating the solids creates a sludge and a clear effluent which meets discharge criteria. The sludge can contain 1 to 30% solids, depending on the applied process. High-density sludge (HDS) is typically defined as having at least 20% solids content. Producing a dense sludge is important as the resulting reduction in the volume of sludge generates significant savings in storage costs.

This study was completed using a pilot plant with two processes under evaluation: the conventional HDS Process and the Geco Process. Both these processes recycle sludge collected from the clarifier in order to form a high-density sludge. The difference between the two is primarily that sludge is contacted to lime slurry in the HDS Process. This contact coats the sludge particles and the mixture is used for AMD neutralisation. In the Geco Process, the recycled sludge is contacted directly to the AMD in the first reactor of the process.

The processes were tested in a pilot plant designed for treating a flowrate of 1 litre per minute of AMD. The unit is modular and can therefore be arranged to simulate different processes by modifying the reactor arrangement. The AMD was fed from a collection pond at Noranda Inc., Heath Steele Division. The primary objective of this pilot campaign was to compare the two processes mentioned above. Seven pilot trials were completed; four applying the HDS Process and three using the Geco Process.

Another objective of the pilot campaign was evaluating the need for a Rapid Mix Tank (RMT). The RMT is a small reactor used primarily for pH control and has been included in all

major plants operating the HDS Process in years prior to the construction of the Heath Steele plant. With the complex automated process control systems now available, it was considered unnecessary to include this reactor for pH control. This had to be tested in the pilot scale, not only to verify that the pH control is adequate, but also to ensure that removing this reactor did not affect the process chemistry.

An objective which was developed during the pilot campaign concerned aeration in the Geco Process. Normally, air is added in the second reactor of the Geco Process for oxidation of ferrous iron to ferric iron. This is done because ferric sludges are considerably more stable than ferrous sludges when stored. Sampling showed that oxidation was occurring in the first reactor, where only sludge was added and no air was supplied. This observation prompted further investigation into the effects of aeration. This was done by running with and without air in both reactors.

Test results show that the Geco Process produces a slightly better effluent quality. Due to a poorly designed clarifier, both processes often surpassed the 0.5 mg/L effluent Zn target concentration, but the Geco effluent always met it when the polymer dosage was at least 25 mg of flocculant per gram of solids. Even at this dosage, the HDS effluent Zn concentration most often exceeded this limit.

The HDS Process reached a maximum sludge density of 27%, while the maximum from the Geco Process was of 25% solids. Conversely, the Geco Process produced less mass of solids due to the formation of less gypsum and calcium carbonate. The final volume of sludge formed by the two processes does not differ significantly. In all cases, the sludge viscosity was low enough that no problems would be expected with pumping in a full scale treatment plant. That being said, the Geco Process produced sludge with a lower viscosity than the HDS Process on average.

Sludge leaching tests show a little more mobility of zinc and cadmium in the Geco sludges. This means that sludges produced with the HDS Process are more stable. Analytical results show this to be caused by higher calcium carbonate and magnesium hydroxide contents in the HDS sludge. This excess alkalinity in the HDS sludge can be directly related to greater lime consumption. As the Geco sludge contains less of this excess alkalinity, less lime is used to form the sludge. Stoichiometry calculations show that more than $18,000 per year can be saved in lime costs by applying the Geco Process over the HDS Process in the full scale.

The operating efficiency is considered lower with the HDS Process because the Lime/Sludge Mix Tank is a high maintenance item. This reactor requires frequent cleaning as the mixture of lime and sludge is very viscous and difficult to handle. The Geco Process does not have such a mixture and is therefore considered lower maintenance.

Even though the two evaluated processes recycle sludge to a different location, both can form a dense sludge. High-density sludge formation is principally due to precipitation reactions occurring on the surface of existing particles. For the HDS Process, the action of coating the sludge particles with lime forces the precipitation reactions to occur on the surface of the particles and thereby increases their particle size. Liquid samples extracted from the first reactor of the Geco process show that essentially all the metals are precipitated in this reactor. As only sludge is added to the AMD in this vessel, it is clear that precipitation is caused by partial dissolution of the sludge to increase the pH. As the dissolving minerals are an integral part of the sludge, the dissolution and precipitation reactions occur on the surface of the sludge precipitates and result in growth of these particles.

The Geco Process therefore consumes less lime as the alkaline mineral by-products are used for partial neutralisation of the AMD within the process. A greater concentration of those same alkaline minerals being part of the HDS sludge causes it to be more stable than the Geco sludge. For a particular site, the choice of process would require prioritisation of sludge stability versus lime consumption. It is also possible to add alkalinity to the Geco sludge to increase long-term stability, but this would likely bring the total lime consumption in-line with that of the HDS Process. Nevertheless, this shows that more flexibility is available when using the Geco Process.