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ALTERNATIVE TAILINGS DISPOSAL TECHNOLOGIES

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1. INTRODUCTION

The conventional method of disposing of gold tailings generally involves simply pumping them to a tailings dam at the density at which they exit the process plant. This density is often quite low. Upon discharge around the perimeter of the dam the coarser, grannular particles rapidly segregate from the flow, forming a beach. The finer particles flow to the centre of the dam where they slowly consolidate. Clear water is generally decanted from the top of the dam and pumped back to the plant. Because of the large surface area a large proportion of the water is lost due to evaporation.

The centre portion of the dam containing the finest particles is continually under water. The settled solids can therefore not lose water by surface evaporation. The settled solids concentration can only increase by drainage of moisture into the subsoil and by consolidation. The degree of consolidation largely depends on the height of the dam.

When the mine eventually ceases production the tailings deposit consists of a retangular shaped mass with coarser, grannular particles around the perimeter edges and fine, near colloidal sized particles in the centre. Evaporation can now begin from the top surface of the centre portion of the dam. This rapidly results in a crust forming which then hinders further evaporation. Complete drying may take ten or twenty years. During this period rehabilitation is difficult since machinery cannot operate on the surface.

An alternative disposal method is the high density slope disposal system. This involves thickening the tailings to a higher density than normal. Upon disposal they form a homogeneous, sloping deposit. This paper discusses various aspects of this approach including economic and environmental advantages.

2. STATE OF THE ART OF HIGH DENSITY DISPOSAL

The concept and development of tailings disposal by the thickened discharge method was first developed and tested by E.I. Robinsky, Canada (Robinsky 1978). It has since been applied in numerous industries, e.g. Robinsky (1981), Wood and McDonald (1984) and Yoemans (1986).

Robinsky investigated the relationship between percent solids of a tailing pumped and the resulting disposal behavior. Conventional tailing slurry densities resulted in segregation of solids on disposal and the resulting low slopes required high containment embankments. Increasing the slurry density to achieve a threshold slope of 2 percent and above resulted in non-segregation, with significant improvement in the environmental quality of the disposal of the tailing.

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Robinsky s pioneering work provided the impetus for development of processing and pumping alternatives to economically achieve the desired high density tailing slurries and to establish correlations and understanding to predict slope performance from pilot plant test samples.

Slurry Systems in association with Robinsky conducted extensive pilot plant tests and established technical feasibility of high density disposal by combing coarse and fine disposal streams for disposal of coarse bottom ash and fly ash in the power generation industry and disposal of coarse and fine refuse in the coal mining industry. This work allowed correlation to predict slope of deposits from testing of small (2 litres) representative samples of tailings.

Laboratory testing of samples provides a basis for establishing both technical feasibility and design of the disposal slope as well as the pumping and pipeline requirements for any system.

3. HIGH DENSITY DISPOSAL

The high density disposal scheme involves thickening of the tailings prior to disposal. The thickener overflow water is returned immediately to the plant. At the disposal site the thickened tailings do not segregate but form a homogeneous, sloped deposit. No water separates from the deposit. If discharge is from a single spigot the tailings will form a conical shaped deposit. Deposit slopes depend on the rheology of the slurry and the discharge rate from the spigot. Typically slopes will be from 2 to 6%.

The hill formed by the deposit uniformly spreads any runoff caused by rain falling on the deposit. The runoff does not channel to form gullys since the slope of the deposits is less than 10 percent. Rain falling on freshly deposited high density tailings will runoff with little entrainment of solids. The slurry properties preclude ready mixing of the solids and the rain water.

A small 1 to 2 metre perimeter embankment on the downstream side of the tailings deposit is installed to contain only low density off-specification slurry and to store rainfall runoff. The perimeter embankment volume is small and can be constructed at minimal cost.

The high density disposal concept relies on there being sufficient area such that successive layers partially dry out before the next layer is deposited over the top. Discharge from a single spigot or number of spigots in the centre of the tailings area will achieve this automatically. This occurs since the flow tends to flow in one sector until the height increases sufficient to divert the flow to another sector and so on.

The depth of fresh tailings deposited before the flow diverts to another sector is typically around 100mm. Once the flow ceases, evaporation begins. Capillary rise in this relatively thin layer aids the drying process and enables uniform moisture content to be achieved.

The slurry density and spigot flow rates are designed so that sufficient time occurs in winter months for the deposited layer to achieve a reasonable shear strength before fresh slurry is deposited over that layer. Further moisture reduction takes place by consolidation.

Shortly after mining ceases the deposit is sufficiently dry to enable machinery to operate on the surface.

The evaporation rates during the winter months dictate the areas needed. Based on pilot plant data the areas required in the Kalgoorlie region will be similar to those currently occupied by conventional tailings dams. At the cessation of mining a conical shaped deposit will cover an area similar to the conventional deposit.

Consider for example the particular case of 5.4Mt. of tailings. Assume the residual density in the dam when mining ceases is 65% and the ratio of dam wall height to width is 0.3. For wall heights ranging from 12 to 18 metres the area covered ranges from 50 hectares to 40 hectares.

With high density disposal the residual density is higher, around 85%. The area occupied by a cone shaped deposit will depend on the average slope. For the same 5.4 Mt the following areas and cone heights will apply:

Slope (%)	6	4	3
Area (ha)	40.4	52.8	63.9
Height (m)	21.5	16.4	13.5

The slopes attainable will depend on the particular tailings, the degree of thickening and the spigotting method. They are similar to the areas involved with conventional disposal.

At an existing mine high density disposal can be used to extend the life of the conventional tailings dam. Overlaying the existing tailings will consolidate and remove water from them. In some cases the high density tailings can be allowed to spill over the dam walls. By this action the existing tailings dam is engulfed and converted to a cone shaped deposit. This may suit cases where an existing mine is undergoing major expansion.

The sterilisation of valuable minerals by placement of tailings may be a long term consideration, in the same manner as retreatment of tailings is a long term option as technologies change. The high density tailings disposal system allows for removal or reclaim for retreatment of the tailings using conventional low cost mining equipment. This is in contrast to the conventional tailings dam, which cannot be removed for many years or requires a dredging operation.

Further, the small quantities around the shallow edges of a slope deposit can be readily removed. For example, by removing just 6.5% of the total material from around the perimeter the area can be reduced by one third.

4. IMPLEMENTATION

To implement the disposal scheme a method of thickening to high densities is required. Table I illustrates the capabilites of conventional equipment.

TABLE I

Typical Dewatering Processes for Tailings

Process or Equipment	Typical % Solid Range	
Direct from process	30 - 40	
Conventional thickener	40 - 50	THICKENING
High rate thickener	42 - 53	---------- 53
Range for slope disposal	45 - 65	75
Vacuum filters	75 - 85	----------
Pressure filters	80 - 90	MECHANICAL DEWATERING

The most common process for water recovery from a slurry is by static settling under hindered settling conditions in a thickener.

At the other extreme the slurry can be dewatered using mechanical equipment such as filters and centrifuges. These produce solid cakes with moisture contents in the range of 10 - 25 percent. These cakes are handled by conveyer for spreading and depositing using mechanical equipment.

The ideal density requirements for slope disposal are seen to lie intermediate between those typically achieved in thickeners and filters. The conventional and high rate thickeners can produce a slurry suitable for slope disposal at the lower range of slopes. i.e. 2 to 3 %.To obtain higher slopes than these special equipment is necessary. Some options are as follows:

Increase in Thickening area

A larger thickener than normal will allow higher densities to be achieved. With conventional thickeners this neccessarily means a proportional increase in cost. Most of this cost is in the vessel itself and the rake mechanism. A far cheaper approach is to build a small dam or utilize an existing tailings dam as the settling area. An unmanned floating barge can then be used to recover the thickened slurry for high density slope disposal. SSPL has designed such systems for the diamond and coal industries.

Increase Thickener Depth

An increase in the depth of a thickener causes greater compression and hence higher underflow densities. This approach is the basis of the Deep Cone thickeners developed in the UK coal industry and the Jamaican aluminium industry (Abbot et al, 1973; Akers, 1975)

Special Filter Thickeners

E.I. Robinsky is developing a special filter thickener in Canada purposely designed to achieve the intermediate range of densities required. A prototype is currently being tested.

Combining Dry Material with Tailings

This approach is being implemented for tailings disposal in the coal and mineral sands industries. The mineral sands industry mixes dry sand with thickener underflow slimes to achieve a high density slurry. In the coal industry it is economically attractive to purposely crush the coarse rejects for mixing with fine tailings thickener underflow to achieve the high density combined tailings. In some cases in the gold industry it may be feasible to mix overburden material with the tailings to achieve a high density slurry.

Substream Filtering

This option involves splitting the tailings stream and using conventional filters or centrifuges to produce a low moisture cake. This is then recombined with the low density stream to produce the desired high density slurry.

Chemical Treatment

Addition of lime or caustic to adjust pH commonly results in a thinning of the slurry. The converse is also true - if the pH of the tailings is lowered by acid addition the slurry will thicken. pH is not the only factor which influences the slurry viscosity. The Boddington mine will rely on special chemical thinning agents. Similarly chemical thickening agents are available. By this approach a simple chemical dosing plant could achieve the required density without a thickener being required.

5. SUMMARISING THE ADVANTAGES OF HIGH DENSITY DISPOSAL

Some environmental advantages of this method of disposal are:

a. Elimination of large tailings dams - visually pleasing cone shaped hills instead.

b. A few months after mining ceases the deposit is completely dry and rehabilitation can begin.

c. Cyanide dispersal depends on contact with the atmosphere. The cone shaped deposit together with the fact that no area is submerged mean maximum contact with the atmosphere and therefore maximum rate of cyanide dispersal.

d. The continuous slope on the deposit means that sub surface drainage after rain will leach salts from the top layer leaving an ideal surface for revegetation. The salt will appear around the perimeter but this area could be covered by scraping a thin, salt free layer from the deposit.

e. Steep tailings dam walls, with their susceptibility to erosion and failure, are avoided.

From an economic viewpoint the advantages are:

a. No tailings dams walls required.

b. No water recovery system, pumps and pipeline required. Consequently no power is required at the disposal site.

c. Less pipe blockages due to the inherantly non-settling pulp. This reduces labour requirements for tailings disposal management.

d. The ground beneath the tailings area is not permanently sterilized since the tailings can be moved if necessary. With removal of only a small proportion of the material around the perimeter the area required can be less than that required for a conventional dam.

6. CONCLUSIONS

The high density slope disposal method of tailings disposal is an attractive alternative to the conventional tailings dam. It has obvious environmental advantages. There can also be significant economic advantages.

This concept has been successfully applied in many other industries including aluminium, coal, copper, mineral sands, power generation and uranium industries. In Western Australia it is being used by Alcoa, Argyle Diamond Mines and Associated Minerals Consolidated.

The technology exists now to implement this scheme in the gold industry. Design methods developed in other industries can be utilized. Conventional thickening methods can be used to achieve the required high density slurries. There are also a number of other methods available which have been utilized in other industries. These should be considered in any evaluation of the technology for gold application.

7. REFERENCES

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