OPTIMIZATION OF TAILINGS DEWATERING PROCESS IN GOLD PROCESSING PLANTS USING HYDROCYCLONES

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Abstract: Dewatering and water recycling operations in mineral concentration processes lead to not only cost-effective water use, but also less waste disposal to the environment. In this study, optimization of dewatering process at Zareshouran gold processing plant is carried out using a hydrocyclone containing circuit. Accordingly, 12 experiments were conducted using 4 spigots with 2, 3, 6, and 9 mm diameters, and in 3 operation states of spray discharge, transition state, and rope discharge . Dewatering capability of a hydrocyclone is evaluated based on percent solid by weight and solid recovery of underflow stream. Results indicate that in the same operation state, an increase in spigot diameter leads to an increase in solid recovery, and a decrease in percentage of solid by weight at underflow stream. On the other hand, as the operation state tends to rope discharge, an increase in the solid percentage by weight and the solid recovery of underflow is observed simultaneously. Therefore, it can be stated that spray discharge pattern has a higher dewatering capability. Solid recovery and percent solid by weight reached 75 and 61%, respectively, using a 6 mm spigot in the operation state of spray discharge. Under this condition, 75% of the feed solid content can directly be transferred to the tailings dam at a lower cost if hydrocyclone is considered as the first step of dewatering process. Additionally, the overflow stream carries only 25% of feed solid content. If the pressure filters used in current dewatering system are considered as the second step of dewatering process, their feed slurry will be reduced by 75%. This results in an overall rise in dewatering system capacity by hydrocyclones.

Keywords: hydrocyclone, dewatering, optimization, discharge pattern, spigot diameter, Zareshouran gold processing plant

INTRODUCTION

Most mineral separation and concentration processes take place in aqueous media. Therefore, the use of dewatering equipment and optimization of dewatering circuits is necessary to reduce the wastewater discharged to the environment and recycle it. Common dewatering equipment in mineral processing industry include different types of thickeners, pressure filters, and vacuum filters.

Hydrocyclones are often known as classifiers, while they can be used as dewatering equipment. Advantages of using dewatering hydrocyclones compared to other dewatering equipment include no moving parts, low energy consumption, wide operation range, need for smaller area, lower investment and operating costs, less maintenance required, shorter residence time of the materials, as well as higher versatility. In dewatering circuits, hydrocyclones can be used as an alternative to thickeners or to reduce their input feed.

The operating state of hydrocyclones changes with the change in their design and operational parameters, so the operation can be observed based on the operating state of hydrocyclone. Three operating states of hydrocyclones are introduced based on the discharge pattern: spray discharge, transition state, and rope discharge. At low feed solid concentrations, the underflow discharge pattern is spray discharge, and the air core expands steadily along the hydrocyclone. As the solid concentration of the feed increases, the rate of solid particle accumulation in the conical part of the hydrocyclone increases, thus prevents the proper suction of air into the hydrocyclone, destroying the air core and creating a rope discharge condition in the underflow.

Zareshouran is the largest gold mine in Iran, located 35 km west of Takab city in Azerbaijan province. After crushing and grinding operations at Zareshouran gold processing plant in order to achieve a product of 80% smaller than 45 µm, gold is extracted by cyanidation method. Tailings of the cyanidation process are transferred to the dewatering department with a percentage of solid by weight of 28-33%. Currently used dewatering equipment consists of 7 series of filter presses, with a total capacity equal to 120 cubic meters of pulp per hour. The filter cake with a moisture of 30-35% is transported to tailings dam as the final tailings using trucks.

In the present study, the effect of spigot diameter, as a design parameter, has been investigated on the operation of the hydrocyclone and its dewatering ability. Additionally, the optimal operating state of the hydrocyclone has been determined for dewatering purposes using the tailings of Zareshouran gold processing plant. Finally, the possibility of increasing the capacity of dewatering department at Zareshouran gold processing plant has been studied using a hydrocyclone, and the available options have been briefly evaluated for improving the dewatering process.

METHODS

The setup used to perform the experiments consists of a hydrocyclone, a pump, a feed control valve, a bypass valve, a storage tank, and a mixer. The diameter of the hydrocyclone is 58 mm and its cone angle is 16 degrees.

The feed used in the experiments is a pulp with a percent solid by weight of 28-33%, made by mixing dried filter cake in the dewatering department of Zareshouran gold processing plant with tap water. This is equal to the percent solid by weight of the pulp fed to the dewatering department of the plant. The overflow and underflow of the hydrocyclone were sampled simultaneously after achieving the equilibrium conditions.

FINDINGS AND ARGUMENT

The effect of cone ratio on the operating state of a hydrocyclone

The cone ratio of the hydrocyclone (ratio of spigot diameter to vortex diameter) determines the discharge conditions of the underflow.Two criteria have been proposed by Concha and Bustamante using this ratio to determine the mechanism of possible discharge in underflow. Table 1 shows the possible discharge patterns based on different cone ratios. Experiments have been conducted to evaluate the conditions for obtaining the three different discharge patterns, with the same input feed density (1.2 g/cm3) and an overflow diameter of 11 mm, with different spigot diameters of 2, 3, 6 and 9 mm (equivalent to cone ratios of 0.18, 0.27, 0.54 and 0.81, respectively). The possibility of observing three patterns has been investigated by changing the inlet feed pressure. Results of this study are shown in Table 2. The cells marked in red are the discharge patterns observed at the bottom.

Table 1. Comparison between presented criteria for predicting discharge pattern

criteria	Used hydrocyclone type and	Cone ratio	Discharge pattern
Bustamante	152mm, Krebs	< 0.34	Only rope discharge
		$0.34 - 0.50$	Rope or spray discharge
		$0.50 - 0.90$	Only spray discharge
Concha	100mm, AKW	< 0.45	Only rope discharge
		$0.45 - 0.56$	Rope, semi rope or spray
		> 0.56	Spray discharge

Table 2. Effect of hydrocyclone cone ratio on discharge pattern, vortex diameter 11mm

		Observed discharge pattern at underflow		
Spigot diameter	Cone ratio	rope discharge	transition state	spray discharge
9	0.818			
6	0.545			
3	0.272			
2	0.181			

According to Table 2, despite the determined cone ratio range for the formation of triple discharge patterns by Concha and Bustamante (Table 1), formation of spray discharge and the transition state mechanisms is possible in smaller values of the cone ratio (0.18 and 0.27). However, by increasing this ratio, (increasing the spigot diameter), the tendency of the discharge mechanism to spray is increased, in a such a way that for the cone ratio of 0.81 (or the 9 mm diameter) the only achievable mechanism in the underflow is the spray dischrge. At a constant concentration of feed, increasing the cone ratio raises the discharge angle. According to Table 2, for a higher cone ratio tendency of the discharge pattern to spray is more, so that for the cone ratio of 0.81, the only achievable pattern at the underflow is the spray pattern.

Effect of spigot diameter on solid percentage by weight and solid recovery of hydrocyclone underflow

The two most important parameters for selecting the optimal dewatering state using a hydrocyclone are the weight percentage of solid and the solid mass recovery of the underflow stream which must be maximized. In order to investigate the effect of spigot diameter on these two parameters, under the same conditions of spray discharge, the solids weight percentage and the solid recovery of the underflow have been measured for different spigot diameters. Figure 1 shows the effect of spigot diameter on the solid weight percentage and the solid recovery of underflow. According to the diagram in Figure 1, for a higher diameter of the spigot, there is an increase in the solid recovery to the underflow while the solid weight percentage of the fine decreases; and by changing the diameter from 2 to 9 mm, the solid recovery to the underflow increases by 33.60% and the solid percentage by weight decreases by 28.51%. It can be stated that the solid recovery to underflow has a direct relationship with the spigot diameter; with an increase in the diameter, the solid recovery to the underflow increases.

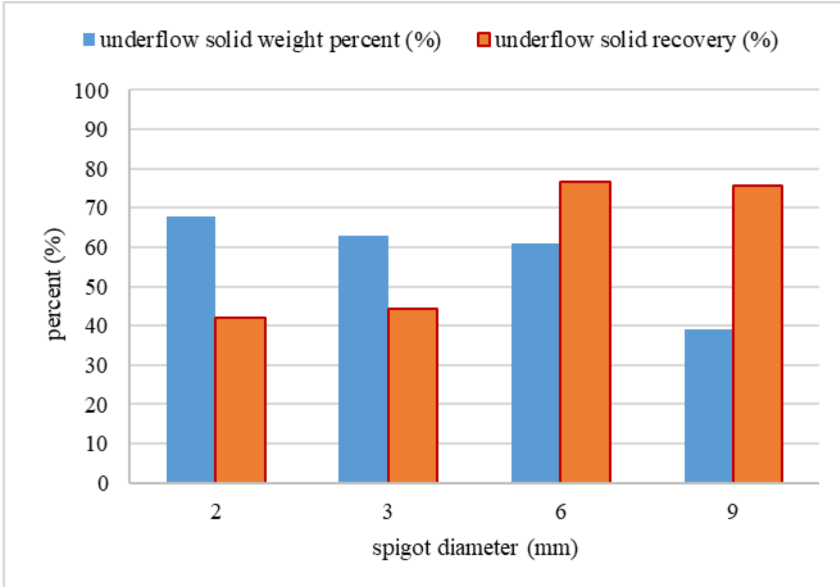

Figure 1. Effect of spigot diameter on percent solid by weight and solid recovery of underflow stream in Spray discharge pattern

Changes in solid weight percentage and solid recovery to underflow in three discharge patterns

The solid weight percentage and the solid recovery of underflow in different spigot diameters were calculated in order to compare the hydrocyclone dewatering ability under different discharge conditions. The corresponding results are shown in Figure 2. The values of percent solid by weight and solid mass recovery in all diameters are higher in the spray discharge mechanism, so it can be concluded that this mechanism has a better application for the dewatering process. According to the diagram shown in Figure 2-a, with the tendency of the discharge mechanism from spray to rope discharge, the solid weight percentage of the underflow decreases in all diameters. A similar trend is shown in Figure 2-b for solid mass recovery to the underflow . Obviously, decreasing the solid mass recovery to the underflow is equivalent to increasing this parameter in the overflow.

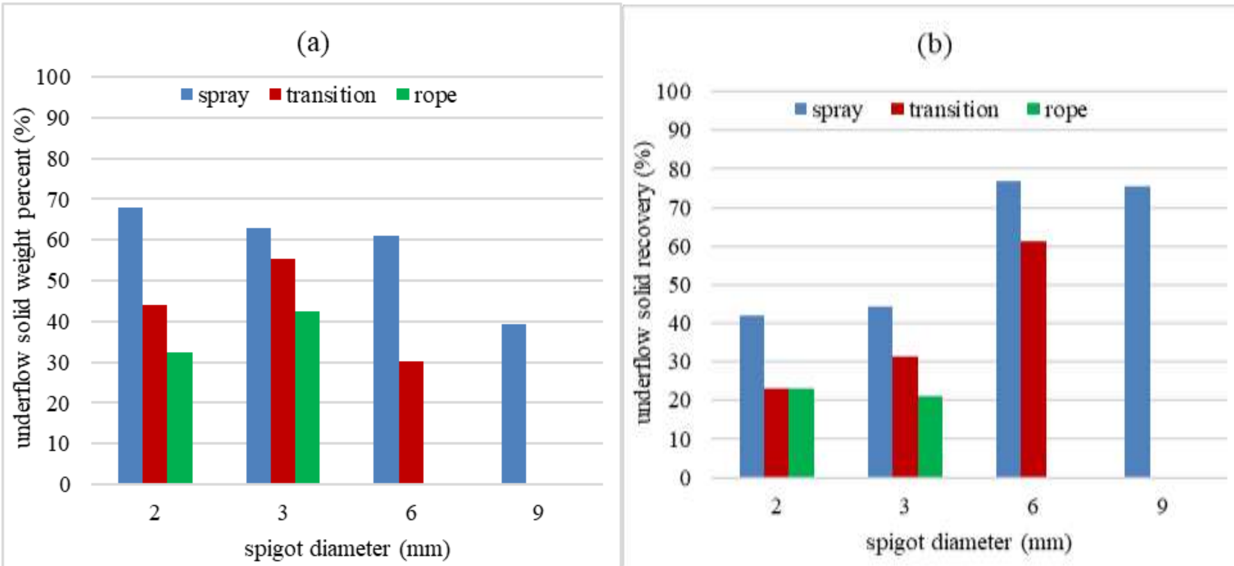

Figure 2. variations of a) percent solid by weight and b) solid mass recovery of underflow in different underflow discharge patterns

CONCLUSIONS

In this study, the circuit design and the possibility of increasing the capacity of the dewatering department at Zareshouran gold processing plant have been studied using hydrocyclones . The effect of operational and design parameters including the spigot diameter, and the discharge pattern were investigated on the solid weight percentage and solid recovery to the underflow stream. Based on the results, with an increase in the spigot diameter, the discharge mechanism tended to the spray state, and at the diameter of 9 mm, the only achievable discharge mechanism was the spray state. Spray discharge was also available at smaller values of the cone ratio, for example 0.18, and 0.27. With the tendency of discharge pattern from the rope to the spray state, an increase was observed in solid percentage by weight, and solid mass recovery to the underflow stream, for all diameters of the spigot . Therefore, it can be stated that the discharge mechanism has the highest dewatering ability. Also, for the same discharge mechanism, increasing the diameter of the spigot raised the solid recovery to the underflow and decreased the solid percentage by weight of the underflow stream, with the highest values in the spray discharge state.

The use of a 58 mm diameter hydrocyclone and a spigot diameter of 6 mm in the spray discharge state led to a 75% solid recovery in the underflow, in addition to providing a solid percentage by weight of 61% in the underflow. In this case, the solid percentage of hydrocyclone underflow was close to the percent solid by weight of the filter cake in the current dewatering circuit at Zareshouran, which can be pumped directly to the tailings dam. Using a hydrocyclone with the mentioned specifications instead of the plant dewatering system can reduce costs and increase the capacity of dewatering circuit. If the pressure filters are used in the current circuit of Zareshouran to dewater the hydrocyclone overflow in the mentioned case, the feed load can be reduced from 110 tph to 27.5 tph, resulting in an increase in the total capacity of the dewatering department.

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