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Performance improvement of the Sarcheshmeh Copper Complex Cu-Mo thickener using a vane type feedwell

Gholamabbas Parsapour [a, *], Farhad Molhem [b], Hamidreza Montazari [b], Ehsan Arghavani [b], Gholamreza Biniaz [c], Samad Banisi [b]

[a] *Department of Mining Engineering, Vali-e Asr University of Rafsanjan, Rafsanjan, Iran*

[b] *Kashigar Mineral Processing Research Center, Shahid Bahonar University of Kerman, Kerman, Iran*

[c] *Sarcheshmeh Copper Complex, Rafsanjan, Iran*

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ABSTRACT

Water plays a key role in mineral processing plants. In order to process one ton of ore, 2.5 ton water is needed. Thickeners are commonly used for dewatering and recovering the water in most mineral processing plants. The underflow pulp density is increased by the sedimentation of particles and a clear water is then recovered from the overflow. One of the issues related to using the process water (thickener overflow) is the presence of suspended fine particles which create blockage in transfer pipes. The froth formed on top of thickeners is the main cause of this problem. In this study, a method is introduced and implemented to decrease the froth formed on the Sarcheshmeh Cu-Mo thickener surface. First, the old punched plate feedwell was removed and replaced by a vane type feedwell. A spray water ring was then installed using fish-tail type nozzles to break the froth layers by water. These modifications led to 63% relative reduction in the water turbidity, 11% relative increase in the underflow solids concentration, 20% relative reduction in torque, 19% relative reduction in its standard deviation and an increase of 6% in the water recovery.

Keywords : *Density, Fish-tail nozzle, Thickener, Torque, Turbidity, Vane Feedwell*

1. Introduction

The Sarcheshmeh copper complex is the largest copper producer in Iran and located in southern Iran. Over 250,000 m^3 of water is daily consumed in the processing plants of this complex, Due to the lack of water and the low annual rainfall (150 mm) in this area, water plays a vital role in this complex. As a result, it was decided to take necessary measures to maximize the water recovery. The recycled water should not contain any suspended solids that is commonly determined through the turbidity measurements.

Settling or sedimentation of solids inside a liquid by the gravity force is one of the most widely used methods of solid-liquid separation. This method is mainly used in chemical and mineral industries, especially in thickeners that are key units in mineral processing plants. Usually, the primary purpose of the application of thickeners is maximizing the separation of clear liquid from a diluted slurry and therefore the creation of a mud with the maximum concentration of solids [1].

The process of sedimentation in thickeners starts by entering the diluted pulp through the feedwell and after taking its energy it slowly and without creating turbulence moves down into the thickener. Solid particles are settled at the bottom of thickener and the clear water overflows from the top. After the initial sedimentation, the solid particles are transferred to the thickener bed and influenced by shear and compression forces. The process of compaction is resulted from the weight of the material in the upper layers on the thickener bed and shear forces are resulted from the movement of rake, vertical rods on the rake within the thickener bed, and the slope of the conical section [2]. Since the feed of Cu-Mo thickeners is the concentrate of the copper processing plant, it contains a large amount of chemical reagents including collectors and frothers. Therefore, the feed always contains a great deal of stable froth. When the pulp enters the feedwell, some air is entrained as well. Because of the presence of frother and hydrophobic particles, some stable bubbles are formed and the particles are floated on the thickener surface as it occurs in the flotation process. This layer of stable froth contains large amounts of particles and completely covers the surface of thickener as well as it increases the overflow turbidity. This, in turn, creates problems such as blockage in the process water pipes and disturbs the flotation circuit.

1.1. Feedwell

A feedwell is the core to the overall operational performance of a thickener [3]. Feedwells are designed in the center of thickeners to mute the incoming flow prior to entering the tank, and to reduce the turbulence. They direct the flow in a way that conditions are established to initiate the particle sedimentation from the center of the thickeners [3, 4]. Hence, the design of feedwell and its performance affect the overall performance of the thickeners [5]. A poorly designed feedwell results in jets or steaming beneath the feedwell skirt, which can turmoil the thickener resulting in a muddy overflow. The contact between the inlet pulp and the feedwell wall can distribute the feed around the feedwell.

In the current study, we considered the following criteria in designing the feeding system entering the feedwell and the feedwell itself [3, 6, 7]:

- Maximizing the dissipation of energy in the feedwell.
- Increasing the retention time of pulp in the feedwell.

* Corresponding author. *E-mail address:* g.parsapour@vru.ac.ir (Gh. Parsapour).

- Preventing the direct entrance of the feed to the settling zone.
- Maximizing the natural dilution of the feed with the recycled clear water.
- Providing a uniform discharge pattern to maximize the use of the available settling area and to avoid inducing recirculation patterns in the bulk of the thickener.
- Coping with variations in the flow rate or solids concentration of the feed slurry.
- Improving de-aeration.
- Reducing/eliminating short-circuiting in the thickener.

There has been an increase in the number of research and development works focused on the feedwell in the recent years. These studies investigated the vital role of feedwells on the overall performance of the thickeners. As a result, various feedwell designs have been introduced such as the Outotec Vane Feedwell, the FLSmidth E-Volute, the WesTech Evenflo and the P266E feedwell [4, 7, 8, 14] (Fig. 1). The first efforts were focused on optimizing the small size feedwells, then moved to the medium and large feedwells and finally vane feedwells [6] (Fig. 1-a). Vane type have two upper and lower zones; the former is for mixing and momentum dissipation and the latter is for maximizing the aggregate growth [9]. Vanes have been installed to create zones within the feedwell, with the upper zones having more shear than the lower zone. In these feedwells, several shelves are installed to increase the kinetic energy dissipation from the inlet as well as to enhance the residence time of the feed within the feedwell [3, 7, 15].

Vane feedwells are designed based on the following criteria:

- Extending the feedwell shelf to increase the solids residence time.
- Adding directional dilution ports.
- Using horizontal but angled vanes to create the two feed zones within the feedwell.

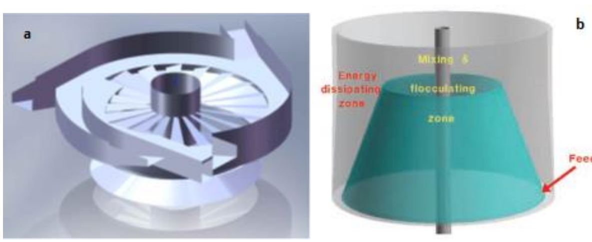

Fig. 1. (a) Vane feedwell [10,11] and (b) P266E feedwell [7].

1.2. Dewatering Cu-Mo concentrate of the Sarcheshmeh copper complex

Four thickeners are used in the Sarcheshmeh copper complex to dewater the Cu-Mo concentrate. The overflow of theses thickeners are used in the processing plant as the recycled water, and their underflows are fed to the molybdenum flotation plant. The average solids concentration of Cu-Mo concentrate is 16.2% and its dry solids density is 4200 kg/m^3 with a feed flow rate of about 185 m^3/h for each thickener. According to the original design, the overflow of these thickeners must be clear water, and the underflow percent solids must be 50% [12].

Since the thickeners feed (concentrate) contains a large amount of stable froth, upon entrance to the feedwell, it disperses over the thickener's surface and slowly moves to the overflow launder and increases the overflow turbidity (Fig. 2). The presence of solids in the thickener overflow creates multiple problems for the flotation process and blocks the pipelines causes an annual loss of 500 ton concentrate through each thickener overflow [13]. To prevent reaching the froth to the thickener overflow, a spray water ring was installed to break the froth layers in the thickener perimeter. In practice, however, these sprays were not capable of complete prevention of solids entrance associated with froth to the overflow launder. Since the water spray ring was installed near the overflow channel, the separated solids did not have enough time to settle down and were transferred to the overflow. This not only increased the overflow turbidity but caused some concentrate loss as well [13]. It was then decided to break the froth before reaching the overflow channel. A method to break the froth and reduce the overflow turbidity was proposed and implemented resulting in a reduction of about 60 percent in the turbidity of the overflow [13]. Fig. 3 shows a schematic illustration of the modifications applied in the Cu-Mo concentrate thickener at Plant No.1 of the Sarcheshmeh copper complex.

Fig. 2. Froth formed on the surface of the Cu-Mo concentrate thickener.

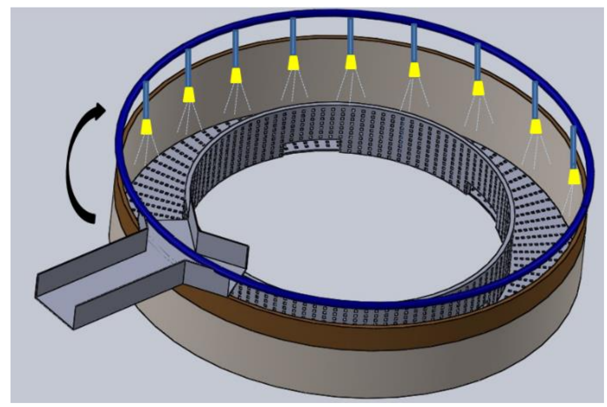

Fig. 3. A schematic illustration of modifications applied in the feedwell of the Cu-Mo concentrate thickener at Plant No.1 of the Sarcheshmeh copper complex (adding a water spray ring with fish-tail nozzles and increasing the height of the feedwell) [13].

2. Materials and Methods

Several samples were collected to determine the solids concentration in the thickener overflow over a period of four days. The samples were weighed, filtered, dried, and finally their solids concentrations were determined.

2.1. Feedwell

The feedwell of the Cu-Mo thickener of Plant No.2 of the Sarcheshmeh copper complex consists of a cylinder with a radius of 2 m and a height of 1 meter. The bottom and walls were punched with 10 mm diameter holes to collect any trashes and tramp materials in the feed (Fig. 4). In practice, the openings get blocked shortly after the start of operation and overflow the pulp and froth from the feedwell to the thickener (Fig. 4). To reduce the extent of this problem, the feedwell was used to halt the process every month and was washed for a period of one working shift. When the openings of the floor and walls are blocked, the feedwell does not properly perform which significantly reduces the thickener efficiency. As a result, the feedwell modification was thought to be essential in increasing the thickener efficiency.

3. Results and Discussion

3.1. Modifications applied on the thickener

A vane type feedwell was designed, constructed, and installed to solve the feedwell related problems and to increase the thickener's efficiency (Fig. 5). The feedwell consists of a cylinder with a radius of 4 m and a height of 0.8 m. A shelf of 30 cm wide and blades with a certain angle relative to the horizontal level were attached from the top. The feed enters tangentially from the opposite direction to the blades angle. The shelf and blades make particles move downward from the upper section of the feedwell to the lower section in a spiral path. In this fashion, in addition to the feed energy dispersion, the residence time of particles increases which increases the rate of settling of particles in the central part of the thickener.

Fig. 4. (a) Pulp and froth overflowing from feedwell (b) blocked openings of the feedwell.

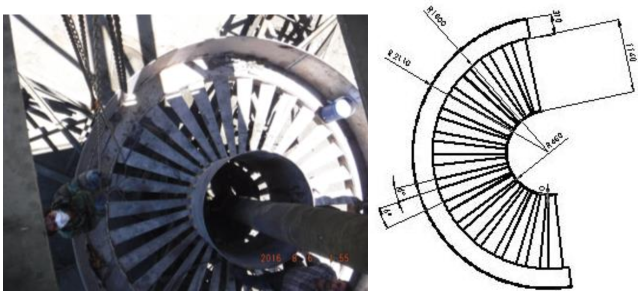

Fig. 5. Vane type feedwell (left: the installed feedwell; right: a part of feedwell plan).

The major thickener problem was the presence of a thick stable froth on the thickener surface (Fig. 2) which increased the overflow turbidity and contributed to the loss of concentrate. To break the froth layer and prevent its dispersion on the thickener surface, a spray water ring of fish-tail type nozzles was installed on the perimeter of the feedwell. The main reason for selecting the feedwell perimeter was the fact that the first place of the formation and growth of the froth usually is the center of thickener (feedwell). This caused the breakage of the froth at the formation point. The feedwell perimeter is much smaller than the thickener perimeter; therefore, a less amount of water is required to break the froth. It should be noted that in the original design of the thickener, the water was sprayed in the thickener perimeter to break the froth (Fig. 6).

Fig. 6. Modifications applied on the feedwell to break the froth.

3.2. Effect of modifications on the thickener torque

When solids concentration of the Cu-Mo thickener underflow increases, the amount of depressant needed in the molybdenum flotation circuit reduces. This is because the underflow water contains reagents that are suitable for the flotation of copper minerals. As a result, this water is not suitable for the molybdenum flotation plant because it significantly increases the amount of copper depressant (sodium cyanide). Modifications in this thickener increased the thickener underflow density from 1679 to 1571 kg/m^3, which was equivalent to an increase of 6% in the water recovery (Fig. 7).

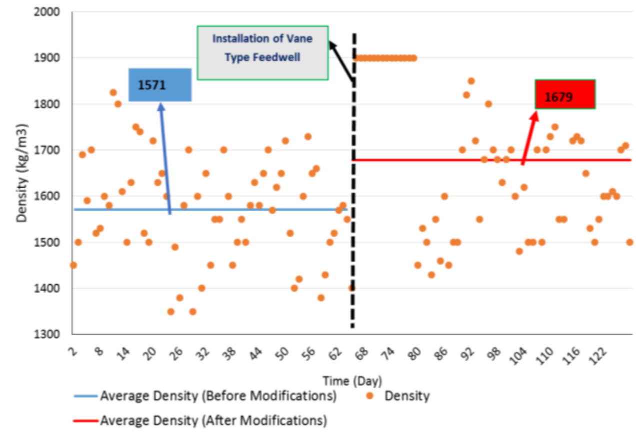

Fig. 7. Thickener underflow density before and after modifications.

In conventional feedwells, the feed moves directly downward from one side of feedwell to the settling zone and thus the feed is not distributed uniformly in the thickener. In the vane type feedwells, however, the shelf and blades rotate the feed and finally move it uniformly downward from the feedwell to the settling zone. It is therefore expected to have an approximately uniform mud line level when using this kind of feedwell which could naturally reduce the torque and variations. Monitoring the operation after the modifications showed a relative reduction of 20 % in the torque and a relative reduction of 19% in the torque fluctuations (Fig. 8). A comparison of Fig.s 7 and 8 show that the modifications increased the underflow density while reducing the torque.

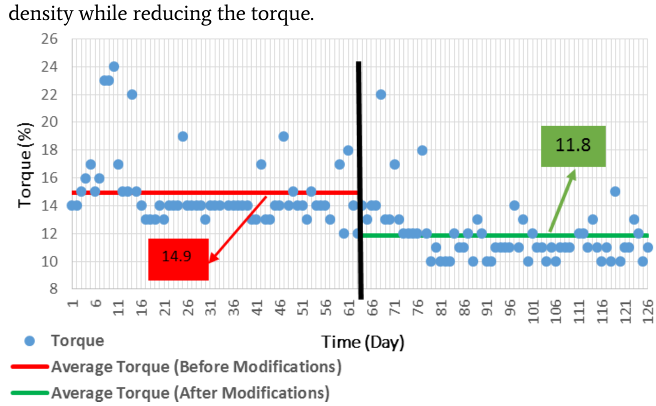

Fig. 8. Effect of modifications on the torque.

3.3. Effect of modifications on the overflow turbidity

The main factors of increasing the turbidity of the overflow are the transportation of very fine particles to the thickener overflow and the presence of a froth layer on the thickener surface. The use of a vane type feedwell increases the effective retention time of particles in the feedwell and reduces the horizontal speed of the particles. These in turn reduce the possibility of transportation of particles to the thickener overflow. In addition, the use of spray water in the center of the thickener also reduces the froth on the thickener surface and prevents the movement of the froth to the overflow channel. The concentration of solids in the overflow reduced from 0.35 g/l to 0.13 g/l (63% relative reduction) (Fig.s 9 and 10). Finally, the modifications saved 350,000 $ annually by the reduction in the copper loss through the thickener overflow.

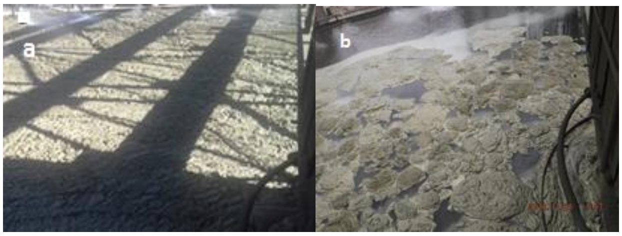

Fig. 9. Froth on the thickener surface; before (a) and after (b) modifications.

Fig. 10. Overflow turbidity; before (a) and after (b) modifications.

4. Conclusions

The major problem of the Cu-Mo concentrate thickeners of the Sarcheshmeh copper complex was the presence of a thick and stable froth on the thickeners surface. In addition to turmoil the overflow water and block the water pipes, this froth layer results in the loss of about 500 tons of concentrate from each thickener per year.

The feedwell of the Cu-Mo concentrate thickener of Plant No.2 had a low performance due to the blockage of the holes in the walls and the bottom plate of the feedwell. This halted the operation for a period of one working shift per month to wash and clean the feedwell.

To improve the performance of the Cu-Mo concentrate thickener of Plant No.2, the conventional feedwell was replaced with a vane type feedwell. Water was also sprayed to the perimeter of the feedwell to break the froth.

The modifications applied on the thickener decreased the torque by about 19% and its relative variations decreased by 20%.

Another outcome of the modifications was a 63% relative reduction in the concentrate loss through the overflow which is equivalent to saving 350,000 $ annually.

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