CONTROLLING SOLID PERCENTAGES OF HYDROCYCLONES OVERFLOW BY A SOFT SENSOR AT CONCENTRATION PLANT NO.1 OF SARCHESHMEH COPPER COMPLEX

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Abstract: The primary grinding of the concentration plant No.1 at Sarcheshmeh Copper Complex includes eight ball mills working in a closed circuit with hydrocyclones. Due to the importance of the hydrocyclones pulp density in the classification process, the overflow density control loop was included in the initial plant design. But because of high cost, additional maintenance efforts, safety issues and constraints of nuclear density gauges, this control loop never became operational. In this research, the percent solids were determined based on the mass balance equations in form of a soft sensor. When the measured data was transferred to the control room, a program was prepared based on the mass balances of solid and water for all 8 ball mills. To start the overflow density control loop, a control valve was installed at the inlet of hydrocyclones feed tank. With installation of the hardware and use of the soft sensor, the control loop of hydrocyclones overflow density became operational for one of the ball mills. The monitoring of the circuit showed that the fluctuation of hydrocyclones overflow solid percentages decreased from 30.4 ± 4.5 (when the percentage of solids were not displayed) to a range of 28.0 ± 0.5 (when the percent solids control loop was operational). Furthermore, the measurement of the size distribution indicated that the percent of particles finer than 75 microns in overflow increased from 63.5% to 67% on account of the control loop installation.

Keywords: Ball Mill, Hydrocyclone, Control Loop, Percent Solids, Sarcheshmeh.

INTRODUCTION

A typical hydrocyclone, is a continuously operating classifying device that utilizes centrifugal force to accelerate the settling rate of particles. It is one of the most important devices in the minerals industry; its main use in mineral processing, working as a classifier, has proved extremely efficient at fine separation sizes.

Hydrocyclones are available in a wide range of sizes, depending on the application, varying from 2.5 m in diameter down to 10 mm. This corresponds to cut-sizes of 300 µm down to 1.5 µm, with feed pressures between 20 and 200 kPa (3-30 psi). Experimental work by Renner and Cohen (1978) showed that the interior of cyclones may be divided into four regions that contain distinctively different size distributions.

The dimensions and operating variables of a hydrocyclone affect its product properties such as particle size distribution, mass split, and solid density. These product properties influence the subsequent processes, for example, the hydrocyclone underflow quality may affect the grinding efficiency while the cyclone overflow affects the separation process like flotation or leaching. The increasing advancement of technology has led to a competition between industries. Thus, process control and automation have become very important.

Since most process variable parameters are measured by hardware sensors, the main factors for successful process are monitoring, control and automation, sensor accuracy in measuring,

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accessibility, and sampling frequency. In addition, a part of the data obtained from these sensors are unreliable. To overcome this problem, soft sensors are used to improve system reliability, process monitoring and control. These sensors are computer programs that are used as a cheap alternative to hardware sensors. Due to the wide number of parameters affecting the output of industrial processes, identifying and considering all factors are of the limitations of using software sensors.

The Sarcheshmeh copper complex primary ball mills

This study was carried out at Sarcheshmeh Copper Complex located southeast of Iran. The primary grinding circuit consists of eight single stage primary ball mills. This area is divided into two sections, each with four single-stage grinding ball mills operating in a closed-circuit with ten cyclones. The mill slurry discharges into a sump and is pumped to the cyclone cluster for size classification. Cyclone underflow recycles by gravity to the mill. Cyclone overflows from four grinding units (one of the two mill sections), with 28% solids, are combined and delivered to the corresponding rougher distributor.
Table 1 shows process characteristics of the hydrocyclone flows according to the initial design.

Table 1: Some characteristics of the hydrocyclone flows

Flows	Size (% smaller than 75 μm)	Percent solids
Feed	24.1	54
Overflow	70	28
Underflow	12.6	70

According to the importance of the hydrocyclones density in the classification process, the overflow density control loop was included in the initial plant design. But because of high cost, additional maintenance efforts, safety issues and constraints of nuclear density gauges, this control loop never became operational. In this research, the percent solids were determined based on the mass balance equations in form of a soft sensor.

METHODS

The method applied in this research was to mass balance the inlet and outlet water of the ball mill circuit. The percent solids were calculated based on the mass balance equations of circuit water in form of a soft sensor. These sensors are computer programs used as inexpensive alternatives to hardware sensors; therefore, the application of soft sensors has increased in the mineral processing industry in recent years. When the measured data was transferred to the control room, a program was prepared based on mass balances of solid and water for all 8 ball mills. To start the overflow density control loop, a control valve was installed at the inlet of the hydrocyclones feed tank. With installation of the hardware and use of the soft sensor, the control loop of hydrocyclones overflow density became operational for one of the ball mills.

FINDINGS AND ARGUMENT

The percent solids of hydrocyclones overflow was calculated based on all the inputs and outputs of water in the primary grinding circuit. Feed rate, input lime, slurry pump outlet, dust collector outlet, ball mill reject and moisture were considered in the equation.

$$X_h(\%) = \frac{(T-r)\times(1-w)}{T+W_1+W_2+W_3+W_4} \times 10$$

where:
X_h: percent solids of hydrocyclones overflow
T: ball mill feed rate (t/h)
w: feed moisture (fraction)
r: ball mill reject (t/h)
W_1: inlet water to ball mill (m^3/h)
W_2: inlet water to the hydrocyclone feed sump (m^3/h)
W_3: water content of slurry pump inlet (m^3/h)
W_4: water content of lime addition to ball mill (m^3/h)

The measured data were transferred to the control room and a soft sensor was prepared based on the mass balances of solid and water for all the ball mills. A control valve was installed at the inlet of the hydrocyclones feed tank to control the hydrocyclones overflow density. The monitoring process of hydrocyclones overflow density was performed during, before, and after changes.

CONCLUSIONS

Due to the importance of overflow density in the classification process, the density control loop of hydrocyclones overflow was included in the original plant design of Sarcheshmeh Copper Complex grinding circuit. Because of high cost, additional maintenance efforts, safety issues and constraints of eight nuclear density gauges, the calculated percent solids were used in this research instead of density. The overflow percent solid of hydrocyclones were determined based on the water mass balance of the circuit. After transferring the measured data to the control room, a soft sensor was prepared based on mass balances of solid and water for all 8 ball mills. To start the overflow density control loop, a control valve was installed at the inlet of the hydrocyclones feed tank. Using the proposed soft sensor, the hydrocyclones overflow density control loop became operational for one of the ball mills. Monitoring of the circuit showed that the percent solids fluctuation of hydrocyclones overflow decreased from the range of 30.4 ± 4.5 (when the percent solids were not displayed) to a range of 28 ± 0.5 (when the percent solids control loop became operational). Measuring the particle size distribution of hydrocyclones overflow showed that before implementation of the control loop, the average share of particles below 75 µm in overflow (feed to flotation circuit) was 63.5%. After adjusting the percent solids of hydrocyclones overflow to the nominal optimal (28%), the amount of particles below 75 µm in overflow increased to 67%.

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