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Research Paper

The Hydrocyclones Performance Monitoring Based on Vibration Wave Analysis at Sarcheshmeh Processing Plant

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Abstract: Hydrocyclone is one of the main important equipment applied for the classification of materials in mineral processing plants. Presence of coarse particles in the hydrocyclone overflow adversely affects the performance of the downstream processes. This research was carried out to provide a solution for these problems by using vibrational wave analysis. The results of vibrometer analysis showed that the average rate of vibrational signal increased from 6 dB at normal condition to 11 dB at the chock condition and variation increased more than 2 times. To stabilize the hydrocyclone vibratory behavior, a rubber layer was fitted under the hydrocyclone base and tightened with an equal torque. In order to reduce the cost and increase the accuracy of the work a piezoelectric sensor was manufactured and installed by designing the printed circuit board and installing an alarm. Analysis of piezoelectric sensor data showed that the average vibrational amplitude increases from 13 dB at normal time to 23 dB during clogging. The size distribution results showed that the amount of K80 (the size at which 80% of the particles are smaller) increased from 119 microns under normal conditions to 725 microns during clogging due to the miss classification of materials transferred to the overflow. This result indicated by using these sensors the efficiency of mineral processing circuits increases significantly.

Keywords: Ball mill, Liner, Lifter angel, Sarcheshmeh.

INTRODUCTION

Coarse particle in the hydrocyclone overflow decreases the flotation efficiency, increases the fracture and failure of the rotor and stator, enhances the formation of sediments in the primary flotation cells, and reduce the valuable mineral recovery. A typical hydrocyclone (Figure 1) consists of a conically shaped vessel, open at its apex, joined to a cylindrical section, which has a tangential feed inlet. The top of the cylindrical section is closed with a plate through which passes an axially mounted overflow pipe. The pipe is extended into the body of the cyclone by a short, removable section known as the vortex finder.

The vortex finder forces the feed to travel downward, which prevents short-circuiting of feed directly into the overflow. The feed is introduced under pressure through the tangential entry, which imparts a swirling motion to the pulp. This generates a vortex in the cyclone, with a low pressure zone along the vertical axis. An air core develops along the axis, normally connected to the atmosphere through the apex opening, but in part created by dissolved air coming out of solution in the zone of low pressure [1]. Hydrocyclones are used in many and various duties in mineral processing flowsheets. There is a wide range of sizes, styles and fittings to select from, however, and the focus of this paper is to provide a basis to specify a hydrocyclone for a given application. A general description of how a hydrocyclone works is included to provide background to the discussion of process and hydrocyclone geometry variables [2]. Uniform feed conditions regarding solids concentration and particle size distribution are a precondition for a good separation efficiency of hydrocyclones. Varying feed conditions lead to considerable fluctuations of the cut size and the separation sharpness [3]. Over the last years, efforts have been made to devise proper monitoring techniques to allow better control of hydrocyclone performance [4-10].

This study was carried out at the Sarcheshmeh copper complex located southeast of Iran. At the new concentration plant of the Sarcheshmeh copper complex which comprises of two parallel phases, two (9.75×4.87 and 9×4.87m) SAG mills are used to grind a feed all under 17.5 cm which is the product of a gyratory crusher. The discharge of the SAG mill is transferred onto a vibrating screen. The oversize material is crushed in a pebble crusher and the undersize is combined with the ball mill (6.71×9.91 m) discharge and is sent to the cyclones. This paper presents a solution to the challenge of maintaining the optimal particle size in these hydrocyclones overflow.

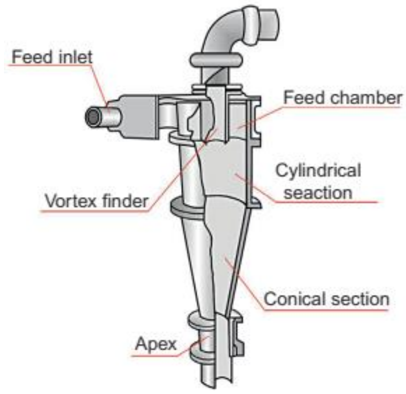

Figure 1. Main components of hydrocyclone [1]

METHODS

Due to the fact that time of the hydrocyclone plugging was not clear, synthetic clogging of hydrocyclone was performed in the sampling intervals. Due to the low cost and operational nature of vibration signal recording, sampling was performed by measuring the amplitude of the vibration signal. Thus, vibrations were measured in different modes of hydrocyclone performance to determine the axis at which there is the greatest response. Data acquisition was performed under different operating conditions that included the normal state of operation, the critical state resulting from the plugging and the no load conditions. The analysis of data performed by the MATLAB software.

In order to use the vibration sensor and make it operational in the industry, it was necessary to reduce costs and increase the accuracy of detection. To achieve this, a sensor was designed and built based on the use of electrical pressure phenomenon (piezoelectric phenomenon). The sensor was placed inside a layer of rubber (vibration damping) under the hydrocyclone bases.

FINDINGS AND ARGUMENT

This paper presents a solution to the challenge of maintaining the optimal particle size in the flotation feed.

In general, reducing the amount of coarse material whilst maintaining throughput can significantly improve cash flow. The results showed that the hydrocyclone vibration signal was not affected by environmental disturbances such as the ball mill charging. To investigate the vibration signal in different conditions, the average vibration rate after 20 times of measurement using an accelerometer and piezoelectric sensor in normal conditions, clogging and opening of the valve was obtained, which is shown in Table 1.

Table 1. Vibration rate (dB) average after 20 times measurement using accelerometer and piezoelectric sensors

Method	Valve opening	Clogging condition	Normal condition	Background noise
Accelerometer	7	15	10	0
Piezoelectric sensor	20	23	13	7

As the result indicated the average vibration amplitude increases from 13 dB at normal time to 23 dB during clogging. Thus an industrial sensor was designed and installed on one of the phase 2 concentration plant hydrocyclones at Sarcheshmeh Copper Complex. The size distribution results showed that the amount of K_{80} (the size at which 80% of the particles are smaller) increased from 119 microns in normal conditions to 725 microns in clogging condition due to the miss classification of materials transferred to the overflow. This result indicated by using these sensors the efficiency of mineral processing circuits increases significantly.

CONCLUSIONS

This paper presents a solution to the challenge of maintaining the optimal particle size in the flotation feed. Due to the fact that time of the hydrocyclone plugging was not clear, synthetic clogging of hydrocyclone was performed in the sampling intervals. Due to the low cost and operational nature of vibration signal recording, sampling was performed by measuring the amplitude of the vibration signal. Thus, vibrations were measured in different modes of hydrocyclone conditions.

The results indicated that vibration signals not affected by the environmental disturbance and a clear distinction between the critical state (large particles entering the overflow) and the normal operational condition was detected. In order to reduce the cost and increase the accuracy of the work a piezoelectric sensor was manufactured and installed. The results obtained by piezoelectric sensor showed that this sensor is more accurate than vibrating sensor. Analysis of piezoelectric sensor data showed that the average vibrational amplitude increases from 13 dB at normal time to 23 dB during clogging. The size distribution results showed that the amount of K_{80} (the size at which 80% of the particles are smaller) increased from 119 microns under normal conditions to 725 microns during clogging due to the miss classification of materials transferred to the overflow.

REFERENCES

[1] Wills, B. A., and Finch, J. A. (2015). *"Will's Mineral Processing Technology"*. 8nd Ed., Elsevier.

[2] Gupta, A., and Yan, D. S. (2006). *"Mineral Processing Design and Operation: An introduction"*. Elsevier.

[3] Neesse, T., Schneider, M., Golyk, V., and Tiefel, H. (2004). *"Measuring the operating state of the hydrocyclone"*. Minerals Engineering, 17(5): 697-703.

[4] Ranjbar, M., and Sam, A. (2011). *"Hydrocyclone Diameter Selection Using a Modified Particle Density Correction Factor"*. Iranian Journal of Mining Engineering, 6(11): 43-48. (In Persian).

[5] Gigliaa, K. C., and Aldrich C. (2020). *"Operational state detection in hydrocyclones with convolutional neural networks and transfer learning"*. Minerals Engineering, 149: 106211.

[6] Cirulis, D., and Russell, J. (2011). *"Cyclone Monitoring System Improves Operations at KUC's Copperton Concentrator"*. Engineering and Mining Journal, 212(10): 44-49.

[7] Cirulis, D., and Jerin, R. (2017). *"Cidra cyclonetrac SM at Kennecott Utah copper"*. International Mining, 1-20.

[8] Buttler, B. (2016). *"New mining sensors go wireless, smart cyclone delivers new opportunities"*. FLSmidth wireless wear detection and roping detection sensors, FLSmidth catalogs, https://www.flsmidth.com.

[9] Van Deventer, J. S. J., Feng, D., Petersen, K. R. P., and Aldrich, C. (2003). *"Modelling of hydrocyclone performance based on spray profile analysis"*. *International Journal* of Mineral *Processing,* 70(1): 183-203. DOI: https://doi.org/10.1016/S0301-7516(03)00002-4.

[10] Krizhevsky, A., Sutskever, I., and Hinton, G. (2017). *"ImageNet classification with deep convolutional neural networks"*. *Communications* of the ACM, 60(6): 84-90. https://doi.org/10.1145/3065386.