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Analysis of the Effect of Ore Characteristics on the Consumption of SAG Mill Steel Balls at the Milling Plant of PT. XXX

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Abstract. PT. XXX is one of the companies operating in Indonesia's mining sector, with copper concentrates operations mainly. Stockpile processing in PT XXX has the capacity of up to 120,000 tons/day. Based on historical survey data, PT XXX conducted a stockpile operations survey in 2009, 2013, and 2016 where there is an obstacle in the processed stockpile consumption of SAG Mill steel balls. These are influenced by the amount of throughput, ore characterization, namely rock quality designation (RQD) and point load index (PLI), SAG speed and discharge grate configuration. Therefore, Identifying the parameter efficiency of steel, such as throughput effect, ore characterization SAG speed, and discharge grate configuration, is needed to determine both that parameter and steel ball correlation. Identification is carried out by analyzing some steel ball samples from the SAG Mill steel ball bunker/storage. The analysis is done by measuring the diameter and weight of the SAG Mill steel ball to confirm the steel ball used has the required quality. The ball discharge sample calculation is carried out at the ball sholter. Analysis of the factors affecting the consumption of SAG Mill steel balls was carried out from all the data that has been collected. The results of the analysis showed that the highest throughput effect reached 2.8 million tons in March 2018, ore characterization with RQD values reached 50% in October 2018, and PLI reached 4.5 MPa, SAG speed reached 9.9 rpm, and discharge grate configuration reached 2.3%. These results showed that the highest effect of SAG Mill steel balls' consumption has occurred during the grinding process.

Keywords: *grinding ball, throughput, rock quality design, point load index, SAG speed, discharge grate*.

1. Introduction

PT XXX is an industry that operates in the mining and mineral processing sector where the deposit of mineral is based on hydrothermal process (Garwin, 2002). The PT. XXX project currently has a processing capacity of 80,000 - 120,000 tons of ore per day at 92% of factory availability and produces 2,000 to 3,000 tons of concentrate per day (Tenggara, 2018; Utami, 2015). The processing process at PT. XXX is divided into upstream and downstream zones. The upstream section focuses on the comminution process or the size reduction of ore. The ore that has been mined is crushed using two gyratory crushers located in the mining area. The crushed ore is then stored as stockpile ore or sent directly to the concentrator plant as fresh ore using an overland conveyor of 5.6 kilometers. The milling circuit is a closed circuit SABC (semi-autogenous, ball mill, crusher). In more detail, the milling circuit consists of the SAG mill circuit, ball mill circuit, and pebble crusher circuit. There are two identical milling lines, each consisting of a SAG Mill (semi-autogenous mill), two ball mills, and two hydro-cyclone clusters (Gupta & Yan, 2016; Lynch & Bush, 1977).

Several factors affect the operational conditions at the PT XXX Milling Plant, which lead to a lack of efficiency in the ore size reduction process. This has an impact also on the consumption of steel balls as the medium used during the grinding process. From the results of observations during the analysis process, the factors that influence the consumption of steel balls in addition to operational conditions are the amount of throughput, the characteristics of ore, the SAG Speed, and the discharge grate. The results of processing historical survey data carried out from 2016 to 2018 there were problems in the grinding circuit, namely the consumption of steel balls during the size reduction process at SAG Mill, which caused a high percentage of failure and the number of ball rejects at SAG Mill while processing fresh ore and stockpile ore (Tenggara, 2018; Utami, 2015).

Steel balls to support the size reduction process at SAG Mill. This is because one of the strategies implemented by PT. XXX is to increase the amount of throughput. It should be noted that in 2016 the amount of throughput reached 49.5 million tons/year and in 2017 the amount of throughput reached 39 million tons/year. It cannot be avoided if the amount of throughput increases, the consumption of steel balls will increase or vice versa, when the size reduction process is in the SAG Mill, the incoming ore feed has a high PLI and RQD value which causes the wear rate of steel balls to increase and the% failure to increase (Tenggara, 2018). Therefore, for the efficiency of the ore stockpile commission process, we identify the characteristics of the ore on the consumption of the SAG Mill steel balls at the Milling Plant.

2. Method

Identification of the consumption of SAG Mill steel balls at the milling plant is carried out by taking samples directly from the bunker/storage of each supplier at the PT XXX 130 concentrator plant. The diameter and weight of the samples were measured at the metallurgical and technical services laboratory of PT. XXX. Furthermore, the calculation of the SAG Mill ball discharge in the ball sholter, this steel ball calculation is done when there is a ball discharge from the SAG Mill, usually the ball discharge. This analysis was carried out to determine the number of balls rejects from the SAG Mill and the percentage of failures (chipping, split) of the total number of ball discharges from the SAG Mill (G.Kelly, Mineral Processing).

The calipers used are manual calipers (vernier calipers) to determine the diameter of the steel balls. The scales used are digital scales to determine the weight of each steel ball sample. SAG Mill steel balls, which are calculated, weight, diameter, and grouping of SAG Mill steel balls into good and failure (chipping, split) categories (Lynch & Bush, 1977; Mular, 2002; Wills & Finch, 2016).

3. Results and Discussion

Table 1 shows the results of measurement analysis in order to know the diameter and weight value of each steel ball sample used at PT. XXX, especially at SAG Mill. In addition, Table 2 shows the results of the analysis of the SAG Mill ball discharge calculation in the ball shelter area, which aims to determine the number of balls rejects from SAG Mill and determine the percentage of failure (chipping, split), and in Fig. 1 shows the total throughput and ball consumption SAG Mill.

Table 1. Ball mill on SAG Mill

GA (Kg)	GA (mm)	Mollycop (Kg)	Mollycop (mm)
9084.2	130	9876.4	131.5
9085	130	9866.1	131.5
9181.3	130	9943.1	133.5
9158.1	130.5	9921.9	131
9150.7	130.5	9902.9	132
9098.8	131	9967.5	132
9010.2	130.5	9840.8	131
9096.1	131	9910.9	134

Table 2. ball discharge calculation.

Time	Numbers of Ball Mill reject	Number (cipping, split)	Total of samples	% failure
September	116	0	116	0
October	112	1.7	114	1.5
November	123	0.4	124	0.3
December	123	2.8	126	2.3

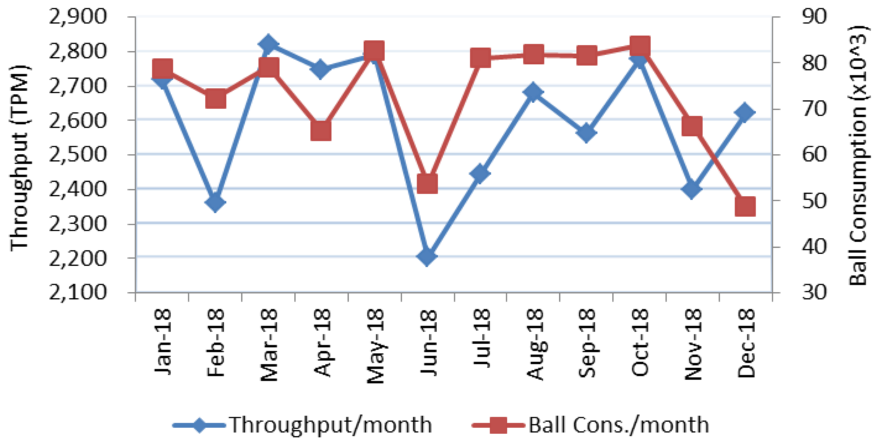

Fig. 1. The influence of throughput on ball consumption.

The effect of throughput on the consumption of SAG Mill steel balls per month, there is a significant effect between the throughput per month and the consumption of steel balls per month where there is an increase in the consumption of SAG Mill steel balls when there is an increase in the number of SAG Mill throughput, and vice versa. Because the ore feed continues to enter the SAG Mill, the consumption of SAG Mill steel balls increases to compensate for the 17% to 18% capacity of the SAG Mill volume. for example, when there was an increase in throughput from February to March, consumption of steel balls increased in the same month. Likewise, the effect of ball consumption on the average PLI (point load index) value as shown in Fig. 2.

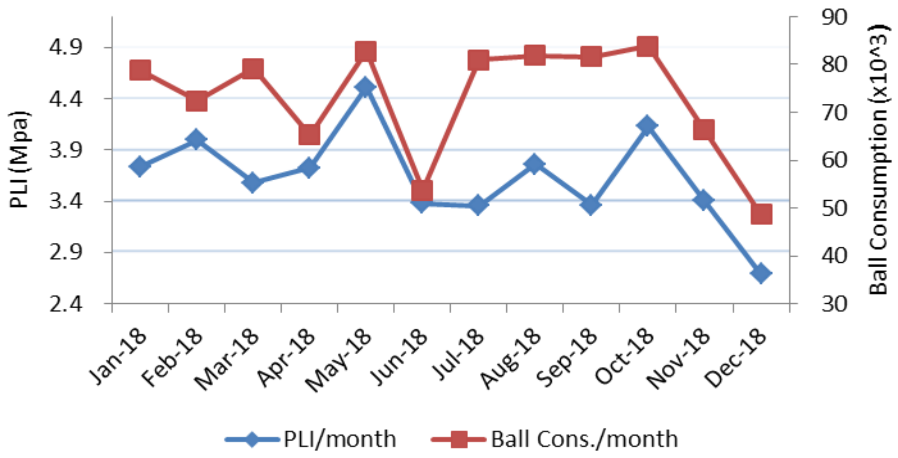

Fig. 2. The influence of point load index ore on ball consumption.

The effect of PLI (point load index) ore on the ball consumption per month, there is an increase in the consumption of steel balls when there is an increase in the average PLI (Point Load Index) value of ore per month, and vice versa. because the greater the strength index value of ore rock and the rock material that enters the SAG Mill, the consumption of steel balls must be increased so that the grinding process runs efficiently. For example, when there was an increase in the average value of PLI (point load index) in April to May and consumption of steel balls increased in the same month and vice versa, the average value decreased from May to June while the consumption of steel balls decreased. The same is the case with the average RQD (rock quality designation) value in Fig. 3.

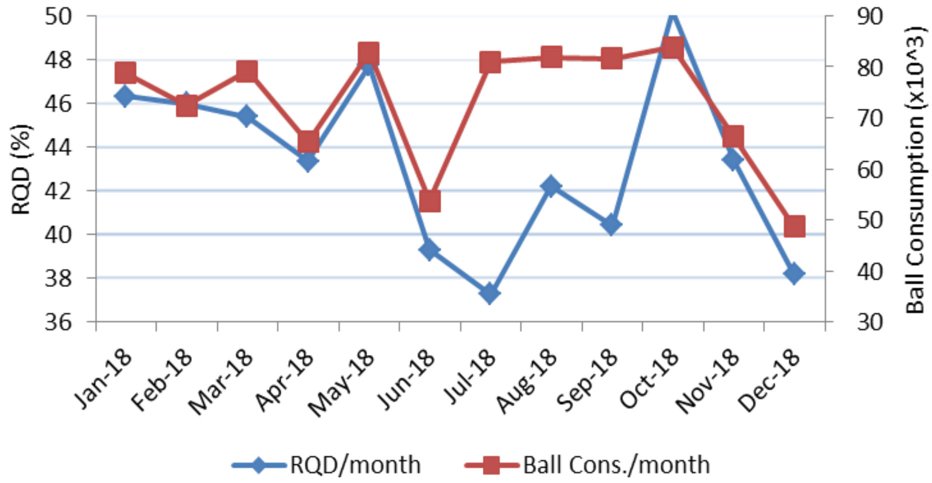

Fig. 3. The influence of rock quality designation on ball consumption.

In the RQD (rock quality designation) for the ball consumption per month, there is an increase in the consumption of steel balls when there is an increase in the average value of RQD (rock quality designation) per month and vice versa. Because the value of RQD (rock quality designation) aims to determine the value of rock qualitatively based on its properties and quality, so the higher the RQD (rock quality designation) value of feed ore that goes to SAG Mill, the use of steel balls increases. For example, when there was an increase in the average value of RQD (rock quality designation) in April 2018 to May 2018, and consumption of steel balls increased in the same month and vice versa, the average value decreased in May and June and the consumption of steel balls decreased. Meanwhile, from June to July, the average value of the RQD (rock quality designation) decreased but the consumption of steel balls increased. The average SAG speed value is revealed in Fig. 4.

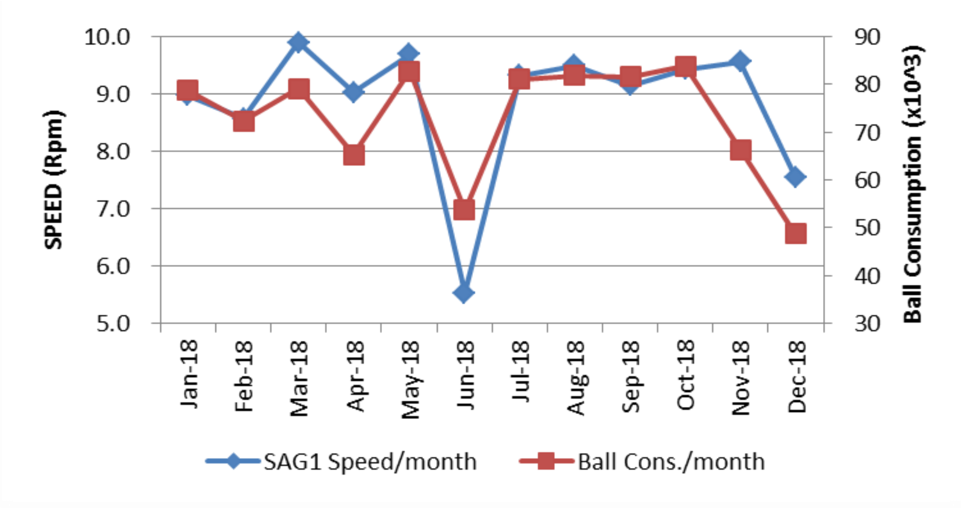

Fig. 4. The influence of SAG1 speed on ball consumption.

The average value of SAG1 speed on ball consumption per month, there is a significant influence between the average value of SAG1 speed per month and the amount of steel ball consumption per month, there is an increase in the consumption of steel balls when there is an increase in the average value of SAG1 speed per month. month and vice versa. Due to the higher velocity, the steel ball is projected to free of charge rotating in the direction of Mill rotation before free-falling into the charge. This leads to a steel ball impact and a rougher product. For example, when there was an increase in the average value of SAG1 speed in February 2018 to March 2018 accompanied by an increase in steel ball consumption in the same month and vice versa, there was a decrease in the average value of SAG1 speed from May to June and consumption of steel balls also decreased in the same month. The effect of SAG2 speed is revealed in Fig. 5.

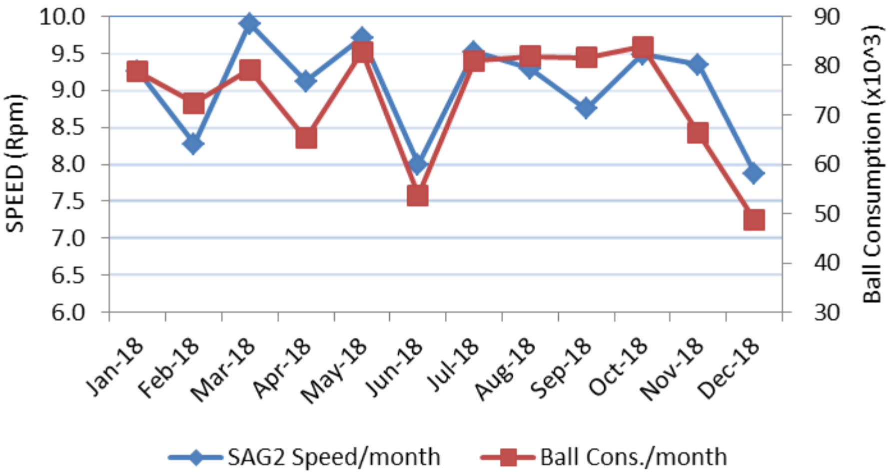

Fig. 5. The influence of SAG2 speed on ball consumption.

In the figure of SAG2 speed on ball consumption per month, there is a significant influence between the average value of SAG2 speed per month and the amount of steel ball consumption per month. Because the lower speed rotates in the direction of Mill's rotation so that the steel ball is projected to produce only abrasion force so that grinding is less efficient on an ore that has a larger size. For example, when there was an increase in the average value of SAG2 speed in February to March, the consumption of steel balls increased in the same month, and conversely, there was a decrease in the average value of SAG2 speed in May 2018 to June 2018 where the consumption of steel balls also decreased.

4. Conclusion

SAG Mill's ball consumption is proportional to the average value of the PLI (point load index). For example, from April to May the PLI (point load index) from 3.7 MPa to 4.5 MPa and consumption of steel balls increased in the same month from 65 thousand/month to 83 thousand/month and vice versa the average value decreased in May to June from 4.5 MPa to 3.4 MPa and consumption of steel balls decreased from 83 thousand/month to 54 thousand/month. The consumption of SAG Mill steel balls is proportional to the average value of the RQD (rock quality designation). For example, the average value of RQD (rock quality designation) in April 2018 to May 2018 from 43% to 48%, and consumption of steel balls increased in the same month from 65 thousand/month to 83 thousand/month and vice versa there was a decrease in the average value. the average RQD (rock quality designation) in May 2018 and June 2018 from 48% to 39% and consumption of steel balls decreased from 83 thousand/month to 54 thousand/month. The SAG Mill steel ball consumption is proportional to the average value of the SAG Speed. For example, the average SAG Speed value in February 2018 to March 2018 from 8.6 rpm to 9.9 rpm and the consumption of steel balls increased in the same month from 72 thousand months to 79 thousand/month and vice versa there was a decrease in the average value of SAG1 Speed at May to June from 9.7 rpm decreased to 5.5 rpm and consumption of steel balls also decreased in the same month from 83 thousand/month to 54 thousand/month.

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