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Article

Performance Evaluation of Crushers in Efforts to Optimise Production Capacity: A Case Study at PT Hoffmen International, Bangkele Site, North Morowali

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Abstract: PT Hoffmen International's Bangkele site in North Morowali has set a crusher production target of 2.5 tonnes per day for processing rocky saprolite-type laterite nickel ore; however, this target is frequently not met. This study aims to evaluate crusher performance, analyse the gap between production targets and actual output, identify limiting factors, and formulate optimisation measures. The research method employs a quantitative descriptive approach with data collection conducted directly in the field through observation and interviews over six working days. The parameters calculated include crusher productivity, Mechanical Availability (MA), Physical Availability (PA), Use of Availability (UA), Effective Utilisation (EU), and equipment effectiveness. The results of the study show that the average actual production reached only 1.42 tonnes per day (56.7% of the target) with an average gap of 1.08 tonnes per day. MA values ranged from 73.42-83.54%, PA from 74.39-85.86%, UA from 81.57-95.08%, EU from 70.73-86.95%, and productivity from 0.16–0.30 tonnes/hour. The main limiting factors are the high repair time, averaging 103.5 minutes per day, and the hard, rocky nature of the saprolite, which causes crusher components to wear out more quickly. Consequently, the production target of 2.5 tonnes per day has never been achieved. Optimisation efforts are required, including improving the effectiveness of equipment maintenance, ensuring a consistent feed rate, and handling the feed material before it enters the crusher.

Keywords: crusher; laterite nickel; rocky saprolite; capacity optimization; productivity.

1. Introduction

The mining industry plays a strategic role in national economic development, with the crushing process being a crucial stage that determines the success of mineral processing operations [1], [2], [3]. Crusher units serve to reduce the size of mined material to a size suitable for subsequent processes, so their performance directly influences the overall production capacity of the processing plant [4], [5]. The efficiency of the crushing process is a determining factor because this activity consumes a significant amount of energy, with specific electricity costs reaching 40-60 kW per tonne [6]. Research into crusher modelling has developed rapidly, beginning with the matrix model proposed by Whiten [4], [5], [7], which was subsequently modified by integrating the appearance function from single-particle breakage tests [8].

PT Hoffmen International, which operates at the Bangkele site in North Morowali Regency, has set a crusher production target of 2.5 tonnes per day. However, in practice, the company is often unable to meet this production target [9]. The gap between production targets and actual output is a common issue in the mineral processing industry that requires systematic evaluation [10]. Studies on

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equipment availability indicate that crushers with low availability require higher throughput targets to maintain production rates, which ultimately impacts equipment sizing requirements and project capital costs [11].

This failure to meet production targets can be attributed to various factors, such as inconsistent feed characteristics, wear and tear on crushing equipment, operational downtime, and on-site working conditions [12], [13]. Obstacles such as feed material becoming jammed in the primary crusher, sticky soil on the vibrating feeder, conveyor belt tears, and weather conditions are the main causes of production targets not being met in various case studies [14], [15]. The characteristic behavior of material breakage, specifically the lack of normalization with respect to particle size, presents a distinct challenge in modeling and evaluating the performance of crushers, particularly for materials with complex properties [9], [16].

Previous research has shown that crusher performance evaluation has a significant impact on productivity improvements. Equipment availability increased from 96.17% to 99.27% and utilization efficiency from 91.57% to 98.55% in andesite processing, enabling the production target to be met [13], [17]. On the other hand, reducing downtime can result in a 53% increase in actual production [7]. Meanwhile, Previous studies have reported that improvements in crusher productivity increased the actual production rate to 259 t/h, with equipment utilization efficiency reaching 85% [4]. Cone crusher performance is strongly influenced by several operating parameters, including the closed side setting (CSS), eccentric speed, and feed material characteristics [9], [12], [13]. In addition, systematic evaluation and optimization of crushing circuits have been shown to significantly improve operational efficiency and overall production capacity [15].

Based on the above, this study is important to evaluate the performance of the crusher at PT Hoffmen International, Bangkele Site, North Morowali, which has a target of 2.5 tonnes per day but often fails to meet it. Identifying the factors causing the failure to meet production targets is necessary to formulate targeted efforts to optimise production capacity, drawing on evaluation methodologies proven effective in previous studies.

2. Research and Methodology

2.1 Materials

The material used in this study was rocky saprolite-type laterite nickel ore extracted from the Bangkele site in North Morowali. Rocky saprolite is a zone of laterite nickel ore located at the bottom of the laterite profile, characterised by physical properties that are harder, more compact, and more rocky than those of the limonite or soil saprolite zones.

2.2 Experiments

Data collection for this study was carried out directly in the field at the crusher unit of PT Hoffmen International's Bangkele site in North Morowali. The data collected included daily production targets, actual daily production, and data on the crusher's operational efficiency. Data collection was conducted using two methods: direct observation of the crusher's operational processes and interviews with the laboratory manager regarding the equipment's performance and the technical challenges frequently encountered. Subsequently, the collected data was processed by calculating the equipment availability parameter, taking into account the lost operating time due to repairs resulting from mechanical breakdowns (mechanical downtime). Furthermore, operational efficiency was calculated based on the equipment's standby status (ready for operation but not in use) and the utilisation rate of the equipment actually used for production activities. Data analysis in this study was conducted based on the results of operational data summaries over six working days, representing the normal operating conditions of the crusher at the study site. The crusher production process can be seen in Figure 1 below.

Figure 2. The crusher production process

2.3 Data Processing and Analysis

Data processing and analysis in this study were carried out by calculating six crusher performance parameters, namely crusher output, mechanical availability (MA), physical availability (PA), use of availability (UA), effective utilisation (EU), and equipment effectiveness. Crusher production was calculated based on the ratio of feed material weight to effective operating time. MA was calculated by taking into account operating time and downtime due to mechanical failure, whilst PA accounted for all downtime, including scheduled maintenance. UA was calculated to determine the percentage of equipment usage relative to total available equipment time, whilst EU measured the effectiveness of equipment utilisation relative to total available calendar time. Equipment effectiveness is calculated by comparing actual production capacity against the equipment's theoretical capacity. All these parameters are calculated based on a summary of operational data over six working days to identify the factors causing the failure to meet the production target of 2.5 tonnes/day and to formulate appropriate optimisation measures.

3. Results and Discussion

3.1 Crusher Performance Data

The data from the six-day observation period can be seen in Table 1 below.

Table 1. The data from the six-day observation period

Date	Crusher effectiveness				
	Standby (Min)	Working Hours (Min)	Repair Time (Min)	Effective Time (Min)	Production Actual (ton)
07 March 2025	27	480	120	360	1
08 March 2025	30	480	97	413	1.5
09 March 2025	20	480	80	400	2
10 March 2025	25	480	108	372	1.2
11 March 2025	28	480	90	390	1.8
12 March 2025	20	280	126	352	1

Based on data from six days of operation (March 7-12, 2025), the production target of 2.5 metric tons per day was never met, with the highest production at 2.0 metric tons (March 9) and the lowest at 1.0 metric tons (March 7 and 12). High repair time, ranging from 80 to 126 minutes per day (an average of 103.5 minutes per day), was the primary factor hindering production, leaving only 352–413 effective minutes out of a total of 480 working minutes, plus 20-30 minutes of standby time per day, which further reduced operational efficiency. This high repair time is caused by the hard and sticky nature of the rocky saprolite, which accelerates wear on critical components such as liners, mantles, and concaves and causes blockages that require manual cleaning. This rapid wear is not offset by an optimal scheduled maintenance program, and the equipment design is poorly suited to the material's characteristics, resulting in increasing repair times and overall crusher performance that remains far below the company's targets.

These findings indicate that the production shortfall was influenced not only by equipment downtime but also by the interaction between material characteristics and operational performance. Frequent interruptions due to component wear and material blockages reduced the effective operating time and limited the crusher's ability to maintain a stable production rate [15], [17], [18]. Therefore, improving production performance requires both reducing mechanical downtime through more effective preventive maintenance and optimizing crusher operating parameters to better accommodate the challenging characteristics of rocky saprolite, thereby increasing equipment reliability and overall productivity.

3.2 Crusher Productivity

The results of the crusher productivity calculations can be seen in Table 2 below.

Table 2. The results of the crusher productivity calculations

Date	Crusher Production					
	Productivity (Ton/Hour)	MA (%)	PA (%)	UA (%)	EU (%)	TE (%)
07 March 2025	0.16	75.00	76.19	93.75	71.43	40.00
08 March 2025	0.29	80.95	82.02	93.15	76.40	80.00
09 March 2025	0.30	83.54	85.86	83.64	86.95	84.00
10 March 2025	0.19	77.50	80.85	81.57	73.81	48.00
11 March 2025	0.27	81.25	82.35	92.85	76.47	72.00
12 March 2025	0.17	73.42	74.39	95.08	70.73	40.00

Based on this data, the Mechanical Availability (MA) and Physical Availability (PA) figures fluctuated over the six-day operational period. The highest MA was recorded on 9 March 2025 at 83.54% and the lowest on 12 March 2025 at 73.42%, indicating that mechanical disruptions remain quite significant. The PA values, which tend to be higher than the MA (for example, on 9 March: 85.86%), suggest that scheduled maintenance time is relatively minor compared to mechanical downtime. Meanwhile, the Use of Availability (UA) value is relatively high, ranging from 81.57% to 95.08%, meaning that when the equipment is available for operation, it is utilised effectively. This is reinforced by the highest UA value on 12 March of 95.08%, although actual production on that day was only 1.0 tonnes.

The Effective Utilisation (EU) rate ranged from 70.73% to 86.95%, indicating that the utilisation of equipment relative to total calendar time is still not optimal. The productivity (tonnes/hour) achieved was very low, ranging from 0.16 to 0.30 tonnes/hour, well below the theoretical capacity. The Total Effectiveness (TE) value also varies from a low of 40% (7 and 12 March) to a high of 84% (9 March).

Overall, although the UA value is relatively good (the equipment is frequently used when available), the low actual productivity and inconsistent TE values indicate that the production target of 2.5 tonnes/day has not yet been achieved due to other factors such as the hard characteristics of the rocky saprolite material and the still high maintenance time.

The results indicate that high equipment utilization (UA) alone was insufficient to achieve the production target. Despite the relatively high UA values, the lower MA and EU values suggest that mechanical downtime and operational constraints remained the primary factors limiting productivity. In addition, the hard characteristics of the rocky saprolite material likely increased cycle time and reduced production efficiency. These findings are consistent with previous studies, which reported that production performance is strongly influenced by equipment availability, operating conditions, and material characteristics [15], [19], [20].

3.3 Crusher Capacity

Based on productivity data from six days of operations, the actual capacity of the crusher at PT Hoffmen International's Bangkele site remains well below the company's target of 2.5 tonnes per day. Average actual production reached only 1.42 tonnes per day, or approximately 56.7% of the target, with an average shortfall of 1.08 tonnes per day. The best performance was recorded on 9 March 2025 with a production of 2.0 tonnes (80% of the target), whilst the lowest performance on 7 and 12 March 2025 was only 1.0 tonne (40% of the target). To achieve the target of 2.5 tonnes per day, an increase in average production capacity of 76% from the current actual conditions is required. This low capacity is primarily due to the still high repair time (an average of 103.5 minutes per day) and the hard nature of the rocky saprolite material, which requires a longer crushing time and accelerates wear on the crusher components.

The low production capacity observed in this study is consistent with previous findings that crusher performance is strongly influenced by equipment availability, operating conditions, and material characteristics [21], [22], [23]. The high repair time reduced effective operating hours, while the hard and abrasive rocky saprolite accelerated component wear and lowered crushing efficiency. Previous studies have also demonstrated that optimizing crusher operation and reducing downtime can significantly improve production performance [24], [25].

3.4 Measures That Can Be Taken to Optimise Crusher Production

Several measures can be implemented to optimise crusher production capacity. First, The motor needs to be replaced because the current motor's specifications are not suited to the characteristics of hard saprolite rock, causing the motor to frequently experience overloads and overheating, which trigger repeated shutdowns. A new motor with appropriate crusher-duty specifications is expected to operate stably without frequent overloads, thereby reducing downtime and increasing production capacity. Second, preparation activities should be completed more efficiently to minimise idle time while the crusher is on standby, thereby improving operational efficiency. Third, routine inspections and preventive maintenance should prioritise equipment components that are most susceptible to failure, ensuring that potential faults are identified and addressed before they disrupt crusher operations. Finally, downtime should be minimised by adhering to the company's scheduled operating hours and implementing effective maintenance and operational management practices [26].

4. Conclusion

The production target for the crusher at PT Hoffmen International's Bangkele site in North Morowali-set at 2.5 tonnes per day-was never met during the observation period, with actual average production standing at just 1.42 tonnes per day, or 56.7% of the target. Factors contributing to the failure to meet the target include high repair time, averaging 103.5 minutes per day, fluctuating

Mechanical Availability (MA) values ranging from 73.42% to 83.54%, and the hard, rocky saprolite material characteristics that accelerate wear on crusher components. Based on the identification of these factors, targeted optimisation measures need to be formulated, including improving the effectiveness of equipment maintenance, ensuring a consistent feed rate, and handling feed material prior to entry into the crusher, so that the production target of 2.5 tonnes per day can be achieved.

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