Technical and Productivity Management Study of Crushing Plant to Achieve The Target of Split Stone Production in Rock Mining Companies in Kalimantan Barat

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Abstract
West Kalimantan has adequate and economically valuable rock reserves to be developed as a primary material for construction through rock-crushing activities using a rock crusher. Currently, in West Kalimantan, several mining companies produce rock, namely PT. Bukit Labu Mining and PT. Sulenco Wibawa Perkasa produces andesite, PT. Total Optima Prakarsa produces granodiorite, and PT Hasindo Mineral Persada produces granite. In general, production targets have not been achieved. This study aims to conduct technical and management studies on crushing plant productivity and the factors that cause the company’s production target not to be achieved and to make efforts to increase productivity so that production targets can be met. Based on the research results, it is known that the factors causing the production target not to be achieved the technical aspects of the equipment and the management factors of the operational production management, which have not been optimal. Increasing the technical capability of the tool is carried out by increasing the amount of incoming feed by optimizing work compatibility between the dump truck and the crusher, reducing the material entering the crusher's size, increasing the crusher's setting, and increasing the workability of the tool.

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1. Introduction
West Kalimantan has adequate and economically valuable rock reserves to be developed. Several mining companies in West Kalimantan engaged in the stone processing industry, including PT. Bukit Labu Mining built an andesite crushing plant in Sintang to meet the needs of consumers in the Sintang area and its surroundings, PT. Sulenco Wibawa Perkasa, an andesite mining company that produces split stone products in Peniraman Village, to meet the needs of consumers in Mempawah, Singkawang, and surrounding areas. PT. Total Optima Prakarsa conducts mining activities for granodiorite rock in Peniraman Village, Mempawah Regency. PT Hasindo Mineral Persada is mining granite in Peniraman Village, Mempawah Regency.

Rock (split stone) is used for basic construction materials through processing activities, namely rock crushing activities using a rock crusher or processing unit. Technical and management factors, such as the tool's capability, the site condition factor, the operator factor, the work efficiency factor, and the work planning and control factor in the field, influence the productivity capability of the crusher. The production targets set by stone mining companies in West Kalimantan have yet to reach the desired targets. PT Sulenco Wibawa Perkasa’s production target has only reached 49.33%. PT Bukit Labu Mining's daily production target is only 76.8%. PT Total Optima Prakarsa is 33,500 tons/month but still needs the desired production target. It becomes a problem, so it is necessary to assess the factors causing the production target not to be achieved. The research objective is to carry out
technical and management studies on the productivity of the crushing plant and the factors that cause production targets not to be achieved that the company has planned, as well as make efforts to increase the productivity of the crushing plant so that production targets can be met.

2. Materials and Methods
The research method used in this research is the descriptive analysis method. Research activities are carried out by collecting data and observing the research objectives directly from the crushing plant.

2.1 Theoretical Frame Work
1. Crushing Plant Equipment
The crushing plant unit consists of a series of tools arranged regularly with the required processing scheme and consists of jaw crushers, hoppers, feeders, belt conveyors, screens, and others.

- Hoppers
The hopper is a fundamental element for transferring bulk in excavations and mines. This tool accommodates rock from ROM before entering the rock crusher.

- Vibrating Feeders and Vibrating Grizzly Feeders
Vibrating feeders control the entry of stones into the primary Jaw. When the vibrating feeders enter the rock, to be broken up by the Primary crusher, it can be set continuously. If a lot of small raw materials are used, a grizzly bar can be added in front of the feeder to separate small stones or sand so that it does not enter into the crusher to increase the efficiency of the crusher.

\[ Q_A = Q \cdot D \cdot K \cdot w \cdot V \cdot H \]  
(1)

QA is total capacity, Q is vibrating screen capacity. D is the deck location factor. K is water content. w is the specific gravity of the material. V is an oversize factor. H is a half-size factor.

The efficiency of the vibrating sieve is the ratio between the material that passes through the sieve hole and the material that should give. The efficiency of the sieve depends on the length of time the feed is on the sieve, the number of open openings, the thickness of the feed layer, and the size of the material in the feed. (Peurifoy, 1988).

- Jaw Crusher
The crusher has two jaws, one movable and the other not movable. Based on the location of the shaft, the jaw crusher is divided into two, namely Blake Jaw Crusher, with the post located above, and Dodge Jaw Crusher, with the shaft situated below. This type of Blake Jaw Crusher is divided into Single Toggle Blake Jaw Crusher and Double Toggle Blake Jaw Crusher.

The resistance of the feed material causes the breaking of rock in the jaw crusher to be smaller than the compressive strength generated by the crusher, the material's tangent Angle (nip angle), and the direction of the resultant final force pointing downwards so that the rock breaks.

The crusher capacity is divided into design capacity and theoretical capacity. The design capacity is the production capability based on test results by the manufacturer. At the same time, the theoretical capacity is the actual capacity of the crusher based on the applied
production system, which is known from the effects of product sampling. According to Currie (1973), the ability of the crusher is formulated as follows:

\[ T_n = T_a \cdot K_c \cdot K_m \cdot K_i \]  
(2)

\( T_n \) is tons per hour of crushed rock at \( K_c \), \( K_m \), and \( K_i \) conditions. \( T_a \) is crusher capacity. \( K_c \) is the rock hardness factor. \( K_m \) is the water content factor. \( K_i \) is the material feed factor. The values of those factors are presented in Table 1, Table 2, and Table 3.

### Table 1. The Hardness Factors for Several Rock Types

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Material</th>
<th>Rock Hardness kg/cm²</th>
<th>C Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Stones</td>
<td>Hard Gravel, Basalt, etc.</td>
<td>2500 - 4000</td>
<td>0.8 - 0.9</td>
</tr>
<tr>
<td>Medium-Hard Stones</td>
<td>Andesite, Granite, etc</td>
<td>1000 - 2500</td>
<td>1</td>
</tr>
<tr>
<td>Soft stones</td>
<td>Limestone, marble, etc</td>
<td>1000</td>
<td>1.1 - 1.2</td>
</tr>
</tbody>
</table>

### Table 2. The Water Content Factor of Material for Each Crusher Orifice Size

<table>
<thead>
<tr>
<th>Aperture Size (mm)</th>
<th>M Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSS &gt; 100</td>
<td>1.0</td>
</tr>
<tr>
<td>OSS &lt; 100</td>
<td>0.9 - 0.95</td>
</tr>
<tr>
<td>OSS &gt; 100 (when moisture content &lt; 5%)</td>
<td>0.8 - 0.9</td>
</tr>
<tr>
<td>OSS &gt; 100 (when moisture content &gt; 5%)</td>
<td>0.1869</td>
</tr>
</tbody>
</table>

### Table 3. Factors for The Size of The Material Weight Distribution

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Material</th>
<th>F factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarry – Run</td>
<td>Material obtained by blasting does not contain mud or other materials</td>
<td>1.1</td>
</tr>
<tr>
<td>Quarry – Run (clean)</td>
<td>Material obtained by blasting, whose grain is smaller than the opening size of the crusher, has been sifted and removed beforehand</td>
<td>0.8</td>
</tr>
<tr>
<td>Quarry – Run (scaped)</td>
<td>Material containing only large lumps of size about 50 - 80 % of crusher feed opening</td>
<td>0.7 - 0.65</td>
</tr>
<tr>
<td>Large – lumps</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The real capacity of jaw crusher is calculated using this formula.

\[ K_n = \frac{3600 \times G}{1000 \times Q} \]

G is sample weight. Q is time. Factors that influence rock crushing by the Jaw Crusher include: rock compressive strength, feed material size, Reduction Ratio-80, Jaw Crusher tool settings, grinding energy, and crusher capacity (Taggart, 1964).

- Conveyor Belts

The theoretical capacity of the conveyor belt is strongly influenced by the cross-sectional area of the conveyor belt, the speed of the conveyor belt, and the weight of the material being transported. For more details regarding the cross-section of the Conway Belt, it can be seen in Figure 4. The theoretical capacity of the conveyor belt can be found using the following equation:

\[ A = K \left(0.9B - 0.05 \right)\]

A is the cross-sectional area of the load above the conveyor belt. K is the coefficient of the cross-sectional area of the bag on a conveyor belt. This price depends on the price through an angle (\( \beta \)) and the repose angle (\( \alpha \)) cost. B is the width of the conveyor belt. This value depends on the coefficient of the cross-sectional area of the conveyor belt. The value of the width of the conveyor belt and the coefficient of the cross-sectional area on the conveyor belt is presented in Table 4 and Table 5.

### Table 4. Material Cross-Sectional Area on Conveyor Belts

<table>
<thead>
<tr>
<th>Through of Angle (mm)</th>
<th>30°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idle rolls 0</td>
<td>0.0295</td>
</tr>
<tr>
<td>100</td>
<td>0.0649</td>
</tr>
<tr>
<td>150</td>
<td>0.0817</td>
</tr>
<tr>
<td>200</td>
<td>0.0963</td>
</tr>
<tr>
<td>250</td>
<td>0.1043</td>
</tr>
<tr>
<td>300</td>
<td>0.1113</td>
</tr>
<tr>
<td>350</td>
<td>0.1248</td>
</tr>
<tr>
<td>400</td>
<td>0.1426</td>
</tr>
<tr>
<td>450</td>
<td>0.1500</td>
</tr>
<tr>
<td>500</td>
<td>0.1538</td>
</tr>
<tr>
<td>550</td>
<td>0.1570</td>
</tr>
<tr>
<td>600</td>
<td>0.1668</td>
</tr>
</tbody>
</table>

If the conveyor belt is used to transport materials with a maximum slope, then it depends on the following requirements:

a) The shape of the material is rolling, so it can only be transported at slight angles, namely 100-120°

b) The continuity of the feed grain will cause clumping or sealing of the lower belt end. To enlarge the possibility of material sliding

c) Uniform grain size will easily slip.
According to the Bridgestone Conveyor Belt Handbook (2006), in order to calculate the theoretical productivity of conveyor belt, it is calculated with this following equation:

\[ Q = 3600 \times A \times V \times \rho \times S \]

Q is conveyor theoretical capacity. A is cross-sectional area for conveyor. V is velocity. \( \rho \) is density. S is conveyor belt efficiency with 100% of assumption. Meanwhile, the actual capacity of the conveyor belt is calculated with this following formula:

\[ Q_b = \frac{W \times 3600}{1000 \times T} \]

Qb is conveyor belt capacity. W is weight of sample material. Q is sampling time. Sampling is carried out when the conveyor belt is in running conditions.

2. Technical and Management Factors Affecting The Productivity of Crusher

The productivity of the tool is the result of the device's work in producing its product per unit of time. Technically several factors affect the productivity of the instrument, namely:

- Mechanical factors relate to the ability of the tool to produce production both on the primary device and the supporting equipment. These factors include the specifications of the crusher tool, tool capacity, cycle time of feeder equipment, belt conveyor, and equipment conditions (tools must be in good condition and ready to operate).
- Operator skill
- Material factor, which is related to the size and hardness of the material

Other non-technical factors are:

- Non-mechanical factors are caused by factors outside the tool components, namely the cessation of the tool's operation even though the device is on standby and ready to use. These factors are rain, work breaks, work holidays, and others.
- Field conditions, such as ROM and stockpile conditions.
- Equipment or equipment management factors start from procurement planning, operation, maintenance, and repair.
- Planning equipment requirements are based on work targets, volume, implementation time, technical specifications, types of activities, and field conditions.
- Operation of the equipment includes: the operator's ability, the equipment is operated following the procedures for carrying out the work being completed, and K3 for operators, drivers, or mechanics in using the equipment.

Maintenance and repair consist of routine maintenance and periodic maintenance. For example, engine oil changes, transmission oil changes, clutch/torque converter oil changes, oil, air, and fuel filter replacement and V-belt tightness inspection/adjustment, minor repairs and heavy repairs, spare parts, and materials that include types of spare parts perishables, quality of spare parts, ordering of spare parts, safe limits on the amount of inventory, volume, and quantity.

2.2 Research Location

The research location is in Mempawah Regency, taking a case study on crusher unit PT. Total Optima Prakarsa processes granodiorite rocks in Peniraman District, Mempawah Regency.

2.3 Data

The data collected consists of primary data and secondary data:

a. Preliminary data, which will be taken include
   - The crushing process is how long the product takes, the flow of the rock crushing process, the amount of production per hour and per day, as well as any disturbances experienced by the crusher during production operations.
   - The size of the blasted material is the size of the blasted rock sample that will be put into the hopper and the amount of rock that enters the crusher per hour, which is carried by the dump truck to the mouth of the Hooper
   - Working days and the number of hours worked.
   - Production delay time, in the form of initial preparation time data, disruption time due to repairs to the hopper, feeder, jaw crusher I, jaw crusher II, jaw crusher III, vibrating sieve, and belt conveyor, lost time due to power outages.
   - The distribution of product material is in the form of crushing results taken from the four ends of the conveyor belt, which carry the marks of crushing rocks. The data is used to obtain information in the form of hourly production data

b. Secondary data, namely data obtained by a researcher indirectly from the object but through other sources, both oral and written, including:
   - Specifications of the rock crusher unit used and the capacity used in the tool (design and theoretical power of the instrument).
- Map of layout crushing plant, namely to obtain data information on the layout of crusher units with mining pits
- The size of the equipment used (length, width, area, and thickness).
- Production reports
- Working days and the number of hours worked by the company

2.4 Analysis Method

Data analysis in this study is then presented in tabular form. The calculation steps to be carried out are as follows:

1. Calculating the productivity of the crusher unit, namely calculating the Hopper Volume, the Screen Capacity, the Jaw Crusher Capacity, the Conveyor Belt Capacity, and the final capacity of the crusher.
   - Calculation of screen capacity using equation (2.1),
   - The measure of the theoretical capacity of the jaw crusher with equation (2.2) and the natural ability of the jaw crusher with equation (2.3)
   - Calculation of the visionary power of the Conveyor Belt with equation (2.5) and the natural capacity of the Conveyor Belt with equation (2.6)
   - Analysis of the final capacity or productivity of the crusher unit based on field observations by measuring the production produced per unit of time (ton/hour)

2. Calculate the equipment's effectiveness by comparing the actual product to the theoretical productivity of the tool and calculating the efficiency of working time by comparing working time to working hours.

Data analysis was carried out to obtain temporary conclusions, including:

- Analysis of the production capacity produced in the crusher unit (crushing plant) and the factors that influence the production results both in terms of technical aspects and management aspects
- Analysis of efforts to achieve or increase production targets that have been set based on technical aspects and management of operational equipment management.
- From the results of this analysis, a discussion was then carried out on what solutions could be taken to increase rock production

3. Result and Discussion

3.1 Crusher Production Process

PT carries out the process of producing or processing granodiorite rock minerals. Total Optima Prakarsa starts with the blasted feed material dump truck brings to the hopper. Then the feed material will be vibrated to release waste or impurities carried along with the rock and fed to the primary jaw crusher with a feeder. The vibrated and escaped feed material is then held by the C-1 conveyor belt to the waste disposal site. The feed that enters the primary jaw crusher produces products carried by the conveyor belts C-2 and C-3 to the stone warehouse, where a second feeder has been prepared below. The outcome from the first jaw crusher is in the stone warehouse and then fed by the feeder to the C-4 belt conveyor to be brought to the secondary jaw crusher. The product resulting from the crushing of the secondary jaw crusher is then carried by the belt conveyors C-5 and C-6 to Vibrating Sieve No. 1. The products resulting from the sieve that do not pass are then held by the C-7 conveyor belt to be re-crushed in a tertiary jaw crusher. The product resulting from the third jaw crusher is then carried by the belt conveyor C-8 and C-9 back to the No.1 vibratory sieve and then held by the C-10 conveyor belt to the No.2 vibratory sieve, which consists of 3 decks with different sizes -different. The results of the sieve that carries stone products with a length of -5 mm (stone dust) are held by the C-11 conveyor belt to the stockpile. The results of the sieve that carries stone products with a size of 1×1 cm are taken by the C-12 conveyor belt to the stock. At the same time, the results of the sieve that holds stone products are 1×2 cm long and 0.

3.2 Results of Crusher Equipment Analysis

3.2.1. Hopper

The hopper volume is 37.5 m³, with a specific gravity of granodiorite rock material of 2.68 tons/m³, so it is known that the hopper capacity is 100.5 tons—Dump truck, which feeds to a hopper with a total of 10 m³. The actual power of the Dump truck is filled 5 m³ or 13.4 tons. The feed that enters the Hooper in one-hour amounts to around 16 trips or 80 m³/hour or 214.4 tons/hour

The ability of the crusher unit to crush rock from the Hooper into products in the stock file is ±3 minutes with a total time required of 48 minutes out of the 60 minutes available, so there are 12 minutes of waiting Time for the crushing plant before continuing production. It makes the amount of incoming feed not optimal, so productivity is not optimal.

3.2.2. Feeders

The feeder used is the Shanghai SCM manufacturer with the ZSW 490 type. In the rock crushing process, two feeder units are used under the hopper to feed the material to the Primary Jaw and located in the stone warehouse to provide the material to the Belt Conveyor C-4 to be put into secondary jaws. The maximum feed size is 850 mm with a
design capacity of 450 tons/hour or 167.91 m³/hour. The natural Capacity feeder that distributes the feed to Jaw Crusher Primary = is 214.4 tons/hour, and that distributes feed from the stone warehouse to Jaw Crusher Secondary = is 186.38 tons/hour. The value of the effectiveness of the feeder that distributes the feed to the Primary Jaw Crusher is 47.64 %, and the point of the feeder that conveys the feed from the stone warehouse to the Jaw Crusher Secondary is 41.42%. The effectiveness value shows that the feeder’s performance is not optimal because the size of the stone that enters the Jaw Crusher Primary and Jaw Crusher Secondary exceeds the setting in the two crushers.

3.2.3. Jaw Crusher I (Primary Jaw Crusher)
The first jaw crusher tool (primary jaw crusher) used in the crushing process is the jaw crusher manufacturer Shanbao with type PE-750x1060. It has a feed opening (750 – 1060 mm), an Adjustable Range (80 - 140 mm), and a tool design capacity of 72 - 130 m³/hour. In the ongoing crushing process, the tool is installed with a setting of 140 mm. The theoretical capacity is 278.72 tons/hour, and the actual power is 207.094 tons/hour, so the current jaw crusher's effectiveness is 74.30%. In this jaw crusher, there is a loss of 10%. This condition shows that the performance of primary Jaw Crushers still not optimal. The cause of these factors is the size factor of the stone material and the size of the tool settings. There is still a size of rock material that exceeds the toolset, which causes the amount of bait to increase log in every hour decreases.

3.2.4. Jaw Crusher II (Secondary Jaw Crusher)
The secondary jaw crusher used in the crushing process is the jaw crusher manufacturer Shanbao with the PEX-250x1200 type, which has a feed opening (250 – 1200 mm), Adjustable Range(25 - 60 mm), and the design capacity of the tool is 12.5 – 37.6 m³/hour. In the ongoing crushing process, four units of tools were used and installed with a setting of 45 mm/unit so that the design capacity of the jaw crusher II was 29.67 m³/hour or 79.53 tons/hour and a theoretical capacity of 23.73 m³/hour or 63.62 tons/hour for each unit. So it is known that the total theoretical capacity of the four secondary jaw units used is 94.95 m³/hour or 254.48 tons/hour. Through field research, it is known that the actual capacity of the four jaw crushers is 184.521 tons/hour, so the effectiveness of the second jaw crusher is still not optimal. The cause of these factors is the size factor of the stone material and the size of the tool settings. There is still a size of rock material that exceeds the toolset.

3.2.5. Jaw Crusher III (Tertiary Jaw Crusher)
The third jaw crusher (tertiary jaw crusher) used in the crushing process is the same as the second jaw crusher, namely the manufacturer Shanbao with type PEX-250x1200, has a feed opening (250–1200 mm), Adjustable Range(25 - 60 mm), and the design capacity of the tool is 12.5 – 37.6 m³/hour. During the ongoing crushing process, four units of tools were used and installed with a setting of 20 mm/unit so that the design capacity of the jaw crusher III was 8.91 m³/hour or 23.89 tons/hour and a theoretical capacity of 7.13 m³/hour or 19.11 tons/hour for each unit. So it is known that the total capacity of the four tertiary jaw units used is 28,525 m³/hour or 76,449 tons/hour. Through field research, it is known that the actual capacity of the four jaw crushers is 54,803 tons/hour, so the effectiveness of the third jaw crusher is 71.68%. In this III jaw crusher, there is a loss of 1%. This condition shows that the performance of Jaw Crusher Tertiary is still not optimal. The cause of these factors is the size factor of the stone material and the size of the tool settings. There is still a size of rock material that exceeds the toolset, which causes the amount of bait to increase log in every hour decreases. Another factor is the frequent damage to the crusher, which affects the production time of the tools and the resulting productivity.

3.2.6. Vibrating Sieve No. 1
Vibrating sieve No.1 used is Shanghai SCM brand with type 2Y1860, has a double Deck vibrating screen 2000 mm long, 1500 mm wide. Currently, the sieve hole size is 33 x 33 mm for deck 1 and the type of deck opening is square. The resulting sieve capacity is 554.4 tons/hour

3.2.7. Vibrating Sieve No. 2
Vibrating sieve No.2 used is Shanghai SCM brand with type 3Y1860, has a double Deck vibrating screen 2000 mm long, 1500 mm wide. The kind of deck opening is square and 5 x 5 mm for deck III. The resulting sieve capacity is 226.8 tons/hour.

The capacity of sieve no 1 is 554.4 tons/hour with an actual capacity of 184.52 tons/hour. And sieve no 2 of 226.8 tons/hour with an exact total of 182.68 tons/hour. The effectiveness of Sieve No. 1 is 32.95%, and Sieve No 2 of 80.55. It shows that the performance of Sieve No. 1 could be more optimal. It is because the fineness of the material still exists that it does not pass as a percent by weight of the fines less than half the size of the vibrating sieve. The calculation results in comparison of the actual
and theoretical production capacity of all crusher units can be seen in Table 6.

### Table 6.

<table>
<thead>
<tr>
<th>Unit Tools</th>
<th>Theoretical Production</th>
<th>Actual Production</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(ton/hour)</td>
<td>(ton/hour)</td>
<td>(%)</td>
</tr>
<tr>
<td>Feeder to Primary Jaw</td>
<td>450</td>
<td>214,4</td>
<td>47.64</td>
</tr>
<tr>
<td>Feeder to Secondary Jaw</td>
<td>450</td>
<td>186,385</td>
<td>41.42</td>
</tr>
<tr>
<td>Primary Jaw Crushers</td>
<td>278.72</td>
<td>207,094</td>
<td>74.30</td>
</tr>
<tr>
<td>Secondary Jaw Crushers</td>
<td>254.48</td>
<td>184,521</td>
<td>72.5</td>
</tr>
<tr>
<td>Tertiary Jaw Crushers</td>
<td>76,449</td>
<td>54,803</td>
<td>71.68</td>
</tr>
<tr>
<td>Screen I</td>
<td>554.4</td>
<td>182.68</td>
<td>32.95</td>
</tr>
<tr>
<td>Screen II</td>
<td>226.8</td>
<td>182.68</td>
<td>80.55</td>
</tr>
</tbody>
</table>

3.2.8. **Conveyor Belt**

Conveyor belts used to carry product material from crushing results are 14 units. The results of calculating the theoretical capacity and actual capacity of the conveyor belt can be seen in Table 7.

### Table 7. **Conveyor Belt Capacity Analysis**

<table>
<thead>
<tr>
<th>No</th>
<th>Conveyor Belt</th>
<th>Average Time (s)</th>
<th>Cross-sectional Area (A)</th>
<th>Velocity (m/s)</th>
<th>Actual Capacity (ton/hour)</th>
<th>Trough of Angle (°)</th>
<th>Conveyor Belt's Effectiveness (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>C-1</td>
<td>0.084</td>
<td>15</td>
<td>0.067</td>
<td>214.4</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>2</td>
<td>C-2</td>
<td>0.091</td>
<td>15</td>
<td>0.068</td>
<td>194.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>3</td>
<td>C-3</td>
<td>0.091</td>
<td>15</td>
<td>0.068</td>
<td>194.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>4</td>
<td>C-4</td>
<td>0.091</td>
<td>15</td>
<td>0.068</td>
<td>194.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>5</td>
<td>C-5</td>
<td>0.091</td>
<td>15</td>
<td>0.068</td>
<td>194.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>6</td>
<td>C-6</td>
<td>0.076</td>
<td>15</td>
<td>0.063</td>
<td>1201.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>7</td>
<td>C-7</td>
<td>0.086</td>
<td>15</td>
<td>0.065</td>
<td>1201.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
<tr>
<td>8</td>
<td>C-8</td>
<td>0.086</td>
<td>15</td>
<td>0.065</td>
<td>1201.2</td>
<td>1201.2</td>
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<td>9</td>
<td>C-9</td>
<td>0.086</td>
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<td>0.065</td>
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<td>1201.2</td>
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<td>11</td>
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<td>15</td>
<td>0.057</td>
<td>1201.2</td>
<td>1201.2</td>
<td>110</td>
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<tr>
<td>12</td>
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<td>15</td>
<td>0.057</td>
<td>1201.2</td>
<td>1201.2</td>
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<td>13</td>
<td>C-13</td>
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<td>15</td>
<td>0.057</td>
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<td>14</td>
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<td>15</td>
<td>0.057</td>
<td>1201.2</td>
<td>1201.2</td>
<td>110</td>
</tr>
</tbody>
</table>

Results Based on existing data, it is known that the performance of the conveyor belt is deficient. It can affect the overall cycle time in rock-crushing activities. Cycle time becomes longer and causes low productivity produced by the crusher. Factors driving the low performance of conveyor belts are:

- The speed factor.
- The Angle of repose factor.
- The Angle of inclination of the retaining edge (Trough of Angle).
- The cross-section size.

Performance improvements can be made by increasing the Conveyor Belt's velocity, the sectional size, and the Angle of inclination lengthwise and edge retaining.

3.2.9. **Crusher Productivity**

The total production of the crusher unit is 182.68 tons/hour with an adequate working time of 370 minutes or 6.17 hours, so the resulting productivity is 1,127.135 tons/day (= 420.57 m³/day) or 28,178.375 tons/day per month (= 10,514.25 m³/month). With a good 370 minutes or 6.17 hours of the available 480 minutes (8 hours), the work effectiveness is 77.08%.

The production target of the crusher unit is 1,340 tons/day or 500 m³/day. Meanwhile, the current production capacity is 1,127.135 ton/day or 420.57 m³/day. The current production is 84.12%. Thus, the company's desired production target has yet to be achieved.

3.3 **Technical and Management Study of The Factors Causing The Failure to Achieve The Production Target of Crusher Equipment**

Based on the analysis of the results of calculations on the productivity and effectiveness of the tool, it can be seen that the cause of not achieving the production target of the crusher is due to technical factors and tool management factors as follows:

1) **Technical factors**

- The amount of bait that goes to the Hooper carried by the dump truck could be more optimal, and there are still time 12 minutes of waiting Time for Crushing Plant tools before continuing production waiting for dump trucks.
- The resulting rock fragmentation is still not able to adjust to the tool settings in the crusher unit, so the harmony of all crushing activities is not optimal, and production cannot be maximized.
- Long cycle time of feeder and belt conveyor.
- Damage to the tool during production operations.
- Spare parts of equipment that are often damaged, such as screens, feeders, and conveyor belts not available at production operations.
- The average effectiveness of the tool has not reached 80%.
- The ability and capacity of the Conveyor Belt are still low.

2) **Management factors**

- The initial preparation, namely warming up the machine, which is carried out during working hours and takes 45 minutes before the tool is ready to operate.
- Workers are late for work.
- The frequent occurrence of damage to tool parts during production operations. The obstacle in repairing this tool is the
lack of availability of adequate workshop spare parts, so it takes quite a long time to fix it (repair time 20.4 minutes)
• Power outages resulting in the cessation of equipment operations and the Crushing plant take ±30 minutes to be ready to be fed back when restarting operational activities
• Workers rest before the break time begins.

3.4 Efforts to Increase Productivity of Crusher Equipment
Efforts to increase productivity must be carried out by increasing the technical capabilities of tools and equipment management.

1) Increasing the technical capabilities of the tool can be done in the following ways:
• Increase the amount of incoming feed by optimizing work compatibility between the dump truck and the crusher
• Minimize the size of the material that enters the crusher
• Enlarge Crusher Settings
• Regulates the work cycle of all components in the crusher to match
• Improve the workability of the tool

2) Increasing the management capability of tool management is carried out by implementing tool management, starting from work planning activities, tool production operation activities, production control activities, tool maintenance activities, and activity evaluation and reporting.
• Work planning, namely planning tool work compatibility, planning work methods, planning work time, planning organizational work structures, and planning OSH for workers
• Tool operation management includes activities arranged so that the feed that enters the Hooper is according to the cycle time, the amount of feed that documents must be following the capacity of the Hooper, the work harmony of the tool is maintained, adjusts the settings on the instrument according to the existing material, controls the rock fragments produced to match the tool settings and operates the device according to the procedure for using the tool.
• Production control management is needed to regulate the production course to follow the correct implementation rules and impacts, increasing output to the maximum. Control management includes controlling planned work schedules and controlling production activities.

Production control is carried out under direct supervision by the head of the production/crusher, who is responsible for the summit. The chief mechanic always coordinates with the head of the production if there is a disturbance in the equipment
• Tool maintenance management, namely carrying out equipment maintenance activities according to the instructions for using the tool and preparing spare parts, aims for the device to function optimally and not experience damage that will hinder the production process.
• Reporting and evaluation management, namely by making reports on the production performance of the Crushing Plant unit from the head of production regarding the amount of incoming feed and production produced for one hour, a day and a month, reports on working hours of workers, reports on available production time after deducting obstacles available, report hours of use of the tool and damage to the device. The report must be discussed in the evaluation meeting, which is held every week. The goal is to find alternative solutions to problems that occur in production operations.

3.5 The Productivity of The Crusher after The Improvement of Technical Capability and Equipment Management
Several alternatives can be made to increase the crusher's productivity after expanding the tool's technical capability and management of the device. Alternatives are as follows:

Alternative 1: Improvement of Effective Working Time
Improvement of sufficient working Time, namely by minimizing lost work time caused by factors of initial preparation and machine heating during working hours, workers arriving late, equipment damage due to poor maintenance and spare parts not available at work, electricity blackouts, and lack of discipline workers in adhering to a predetermined schedule. The efforts that can be made to minimize the above obstacles are as follows:
• Improvement of tool operational management capabilities
• Company supervision of workers so that workers work according to a predetermined time
• The company provides incentives for the performance of employees who are disciplined at work and have a high work
Ethic and provides sanctions for employees who are not disciplined.

- Tool maintenance needs to be done, both routine and periodic maintenance, according to the operational standards of the tool.
- Spare parts that are difficult to obtain/reach must always be available such as screens, feeders, and conveyor belts, because these three tools can be done during initial preparation, and the company must prepare mechanical experts at the location of production operations.
- Preliminary preparation and machine warm-up are carried out before working hours begin.

With the above efforts, the last work delay time of 110 minutes becomes 38.4 minutes, so the adequate working time after repair becomes 441.6 minutes or 7.36 hours with work effectiveness of 92%.

The production capacity produced by the crusher unit after the repair is as follows:

\[ 182.68 \times 7.36 = 1,344.525 \text{ tons/day} \]
\[ = 501.68 \text{ m}^3/\text{day} \]
\[ = 33,613.125 \text{ tons/month} \]
\[ = 12,542 \text{ m}^3/\text{month} \]

Alternative 2: Improve the adequate working time and increase the amount of incoming feed

With the capabilities of the existing Crushing Plant unit, the amount of feed that enters the Hooper in one hour should be around 20 cycles. 1 equals 5 m³ or 13.4 tons with a granodiorite density of 2.68 tons/m³. Thus, the feed that enters the Hooper can amount to 100 m³/hour or 268 tons/hour. By knowing the effective working hours after the repair, which is 7.36 hours from the time available for 8 hours a day, the amount of production that can be produced if the amount of feed is added is 1,972.48 ton/day or 736 m³/day. If you add up the 25 working days a month, the monthly production can amount to 49,312 tons/month or 18,400 m³/month so that it exceeds the number of existing production targets.

Alternative 3: Improve the adequate working time and reduce the size of the incoming feed

Based on the calculations, the current feed size into the Hooper is ± 500 mm, so it takes ± 3 minutes to produce the product. Therefore, if the feed size is reduced, the time needed by the crusher unit to make the product can be faster. It can be calculated by the scheme of blasting results that will be inserted into the Hooper. The fragmentation blasting design must produce a bait size of ± 300 mm. So, based on calculations, with the feed size reduced to ± 300 mm, the crusher unit takes ± 2 minutes to produce the product. From these calculations, the total feed from the Dump truck to the Hooper can be as many as 30 trips. One race is equal to 5 m³ or 13.4 tons. So in 1 hour, the Dump truck spills 150 m³/hour or 402 tons/hour of feed.

Knowing the effective working hours after the repair, which is 7.36 hours from the time available for 8 hours a day, the production amount is 2,958.72 tons/day or 1,104 m³/day. If you add up the 25 working days a month, the monthly output can amount to 73,986 tons/month or 27,600 m³/month. The production exceeded the number of existing production targets. Results production of the rock crushe unit before and after repair can be seen in Table 8.

<table>
<thead>
<tr>
<th>Presentation</th>
<th>Production Before repair</th>
<th>Alternative I</th>
<th>Alternative II</th>
<th>Alternative III</th>
</tr>
</thead>
<tbody>
<tr>
<td>(ton/month)</td>
<td>(ton/month)</td>
<td>(ton/month)</td>
<td>(ton/month)</td>
<td>(ton/month)</td>
</tr>
<tr>
<td>Before repair</td>
<td>28,178.375</td>
<td>33,5</td>
<td>33,613.125</td>
<td>49,312</td>
</tr>
<tr>
<td>Percentage of Actual Production to Target Production</td>
<td>100.34 %</td>
<td>147.2 %</td>
<td>220.85 %</td>
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</tbody>
</table>

Other efforts that can be made to increase the crusher's productivity are: to enlarge the theoretical size of the Crusher Tool, improve the working compatibility of the tool and increase the workability and capacity of the Conveyor Belt.

4. Conclusion

Based on the results of the discussion in the previous chapter, the following conclusions can be drawn:

1) The company’s current production target has only reached 84.12% of the planned target. The resulting production was 28,178.375 ton/month from the intended target of 33,500 ton/month ton/month.

2) Factors causing production targets that the company has yet to achieve are technical factors of tools and management factors of operational production management that have not been optimal. The technological factors of the device include:

- The amount of bait that goes to the Hooper carried by the dump truck could be more optimal, and there are still time 12 minutes of waiting Time for Crushing Plant tools before continuing production waiting for dump trucks.
- The resulting rock fragmentation is still unable to adjust to the tool settings in the crusher unit, so the harmony of all crushing activities is not optimal, and production cannot be maximized
- The cycle time of the feeder and belt conveyor is quite long.
• Damage to the tool during production operations, especially on parts screens, feeders, and conveyor belts, and unavailability of spare parts
• The average effectiveness of the device has not reached 80%
• The ability and capacity of the Conveyor Belt still need to improve.

Operational management factors related to production activities must be better to cause minimal adequate working time. The effectiveness of work per day only reached 6.17 hours or 77.08% of the total working time of 8 hours, so the lost work time per day was quite a lot, namely 110 minutes.

3) Efforts that can be made to increase productivity are by increasing the technical capabilities of tools and the management of devices. Improving the technical capacity of the agency is carried out by increasing the amount of incoming feed by optimizing work compatibility between the dump truck and the crusher, reducing the size of the material entering the crusher, increasing the setting of the crusher, and increasing the workability of the tool. They improve tool management capabilities, minimize obstacles during production operations by planning work methods and procedures, control and supervise equipment maintenance activities, and evaluate and report. With these efforts, there was an increase in adequate working time per day from 7.16 hours to 7.36 hours.

4) The results of the calculation after the improvement efforts are Alternative I by increasing the effective working hours, the productivity produced was 33,613.125 tons/month, an increase of 0.34% from the production target. Alternative II, namely by increasing effective working hours and increasing the amount of incoming feed, the resulting productivity was 49,312 tons/month, an increase of 47.2% from the production target and Alternative III by increasing the effective working hours and reducing the size of the bait, the resulting productivity is 49,312 tons/month, an increase of 120.85% from the production target.

5. Acknowledgment
First and foremost, I would like to thank my parents and sister for their unwavering support, which is one of the main factors in completing this study. I am also immensely thankful to Mr. Syahrudin, Mr. Safarudin for their invaluable guidance, suggestions, and expertise, which have contributed to the creation of a useful reference for productivity management study in West Kalimantan. Lastly, I would like to express my gratitude to the Jurnal Teknik Sipil UNTAN (JTS) team for agreeing to publish the results of this study, making it a valuable reference for everyone.

6. Author’s Note
All of the content written in this article is original, which summarizes my research with Mr. Syahrudin and Mr. Safarudin. This study is reviewed at thesis defence at the department of Civil Engineering, University of Tanjungpura.

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