Evaluation of Crusher Productivity in Coal Processing Plant in Pt. Bara Tabang, Kutai Kartanegara District, Province of East Kalimantan, Indonesien

Sakdillah[1], Tommy Trides[2], Marlinus Matius Lollong[3]

Mining Engineering Study Program, Faculty of Engineering , Mulawarman University
The Address is: Jl. Sambaliung No.9, Sempaja Selatan, Samarinda City, East Kalimantan Province, Indonesien

Abstract: ***PT. Bara Tabang is one of the companies engaged in coal mining, Located in Tabang District and Kutai Kartanegara District, East Kalimantan Province with a production target for January of 806,000 tons. From the observations, the actual productivity of crusher 1 was 598.50 tons / hour, with actual production time of 558.46 hours capable of producing coal at 334,236 tons, while the actual productivity of crusher 2 was 791,78 tons / hour, with actual production time amounting to 498.47 hours capable of producing coal of 394,680 tons it can be concluded that the production target has not been achieved. Then the analysis and calculation of the time of obstacle were carried out so that the addition of time for crusher one was 29.32 hours so that the production of crusher 1 became 351.784 tons while the addition of time for crusher 2 was 76, 36 hours so the production of crusher 2 became 455, 140 tons. So the total production of crushers for January was 806, 924 tons.***

Keywords: Coal, Crusher, Productivity

1. Background

Mining is mankind's second largest business after agriculture. Indonesia is one of the countries with the greatest potential resources in terms of mining materials, and one of them is coal. In this case, the mining industry has a very vital role to take advantage of the availability of coal existing for the sake of economic progress and development of the country. PT. Bara Tabang is one of the companies engaged in coal mining, located in the District of Tabang and Kutai Kartanegara District, East Kalimantan Province. PT. Bara Tabang has answered the challenge to always provide the best service for consumers, both in terms of quality and quantity of coal. One of the efforts made by PT. Bara Tabang to answer the challenge is by building a coal processing unit. In the mining business the main thing in the mining stage is production. But besides that there is one stage in the coal mining process that plays an important role in determining the sustainability of the mining business, namely coal processing. Unit processing (coal processing plant) is very important in the processing of coal because this processing unit is one of the determinants of the quality and quantity of products produced, coal processing conducted by PT. Bara Tabang is a process of reducing the crusher material according to the coal desired by consumers and the market. In meeting the production target, many problems will be faced, such as time delays, which can be avoided or not. In this situation, optimization is needed to get productive work time desired to production targets.

1.1 Research Purposes

The objectives of this research are as follows:
- To know the productive work time of the unit crusher.
- To know the productivity of the unit crusher.
- To know which obstacles are affect the productivity of the crusher.

1.2 Formulation of the problem

The formulation of the issues raised in this study are as follows:
- What is the productive work time of the unit crusher?
- What is the productivity of the crusher unit?

2. Literature Review

2.1 Definition of Coal

Coal comes from plants that have died and are buried in a basin filled with water for a very long time, reaching millions of years. In the process of coal formation, many factors influence. For example, the amount of temperature and pressure on dead plants will affect the condition of the coal seams that are formed, including the enrichment of carbon content in coal. This material stockpile then undergoes a process of peat and pembatubaraan so that it becomes coal (Irwandy Arif, 2014).

2.2 Processing of Mining Material

Processing minerals is a process of separating by processing quarrying materials, there are several advantages:

Economically
a) Reducing the freight per ton: metal from the mining site to the smelter because some of the valuable minerals have been wasted during the processing.
b) Reduce melting costs per ton: metal produced, because in smelting the tonnage of metal produced will be more (at the same time) when compared to metal smelting without starting with the processing of minerals.

Licensed Under Creative Commons Attribution CC BY

Technically

a) When it's done processing will produce concentrates that have relatively high valuable mineral content, making it easier to take metal.
b) There is a possibility of concentrate containing more than one valuable mineral, it is possible that other metals can be taken as a byproduct.

2.3 The meaning of crusher

Crusher is the first mechanical process in comminution stage where the main purpose is to free valuable material from impurities and reduce the size of the material. Crusher functions to break rocks nature becomes smaller size according to the specifications needed. For put rocks into the crusher, usually a tool called a feeder is used. For distributing the aggregate of the results of solving used conveyor in the crusher workflow.

According to (Suryadharma, 1998) in the work of stone crushing, a number of crushing processes are needed, that stage along with the type of stone crusher used:
1) The first stage breaker is used primary crusher type stone crusher.
2) The second stage solver is used type secondary crusher.
3) Solver of the following stages if further stone breakers are needed, with using a tertiary crusher

The types of heavy equipment commonly used for the three stages of stone crushing work mentioned above in the sense that they do not always have to be available, can be developed or combined are as follows:
1) For primary crusher
   a) Jaw crusher
   b) Gyratory crusher
   c) Impact crusher
2) For secondary crusher
   a) Cone Crusher
   b) Roll crusher
   c) Hammer mill
3) For advanced crusher (tertiary crusher)
   a) Roll crusher
   b) Rod mill
   c) Ball mill

2.4 Crusher Tools

According to Rochmanhadi (1982) for get the crusher material as perfect as possible, tools are needed auxiliary / equipment in the crusher unit.The following are crusher assistive devices:

1) Feeder (Feeder / Regulator)

This feeder is mainly used for handle and at the same time channel another:
- Apron Feeder
- Reciprocating Plate Feeder
- Grizzly Feeder
- Chain Feeder

2) Scapling Unit

Scapling units are often used as advanced feeder, this scapling unit is lattice- silent or vibrating grids, placement between feeder and primary crusher, the intention is to break material that is too big to solve by primary crusher.

3) Grizzly Bar

Grizzly Bar is also used in scapling units, the construction is in the form of parallel bars which are spaced apart from each other, tilted towards the feed so that it rocks whose size is greater than the distance of the stems just past it does not enter into the crusher.

4) Screen

For the purposes of separating these various gradations, a screen is needed, generally this screen is made of braided wire so that forming "mesh" which is spaced regularly squares between the wires that are close together, some are made of slotted holes

2.5 ROM (Run of Mine)

Run of mine is a piling place while coal is the result of mining is near the hopper location, if on at present the processing unit is processing a coal product with a certain quality, so coal is not of the same quality for while stacked in ROM if it occurs damage to the processing unit so that the unit cannot work.

2.6 Belt Conveyor

A conveyor belt (conveyor belt) is a device transporting material in the form of rubber and can work continuously on a slope certain or horizontal. Belts are made by joining several types of woven cotton, or nylon, rayon, and steel cables, into construction of reinforcement which gives the strength to resist the pull in the belt. The layer is covered with an adhesive made of rubber which is then combined into a fused structure. The running belt is driven by a drive motor that is mounted on the head pulley. The belt will return to place originally because it was deflected by the initial pulley and final pulley. Material distributed through the feeder will be carried by a walking belt and ending at the head pulley. During the work process in the crusher unit starts, the running belt must move before the crusher starts. This aims to prevent overload on the belt. The use of a walking belt is influenced by several factors, namely: physical properties and material conditions, topographical conditions, and hauling distance.

1) Physical Properties and Material Conditions of Rocks: The ability of a walking belt to transport material is closely related to the material it is transporting. The material conditions include:
a) Material size and shape: A walking belt can be used to transport materials that have a size that is not too large. This is adjusted to the shape of the walking belt which has a small cross section. The small size of the material makes it easy to transport and does not easily spill out of the belt. In order to meet these requirements, mining material needs to be reduced in size.
b) Water content: The water content in the material can affect the condition of the running belt. Material with high water content cannot be transported with a large slope. Conversely, if the water content is too little, the material is too small will fly.
c) Material composition: The material in the quarry is not only material, but also inserted by it soil (soil). At the time

Licensed Under Creative Commons Attribution CC BY

of water content at large material, the soil will become sticky. If such conditions occur, it can cause sticky or material stick to the return idler, so that the course of the belt will be bumpy and the motor power will increase.

2) State of Topography
Field conditions can affect the use of running belts. Areas with hilly characteristics where the slope of the area is quite large, so compared to the use of lorries or trucks in transporting material, the walking belt is more likely to be used because in overcoming the slope the ability of the walking belt is greater, which can reach 30% - 35%. This can be used as an alternative in the choice of a conveyance

3) Transport Distance
The walking belt can be used to transport both short and long distance material. For long distance conveyor belts are made in several units. The results of the work of transporting material with a walking belt take place continuously, so that it can produce a large production of running belts, but if one day the belt runs damaged, then production will be greatly decreased or even not able to produce at all. Thus consideration of this possibility needs to be done in the use of a walking belt.

2.7 Value of Equipment Availability

There are several meanings that indicate the state of the equipment and the effectiveness of operations include mechanical availability, physical availability, willingness to use and effective willingness (Yanto, 2005).

Mechanical availability (Mechanical Availability/ MA)
Is the actual mechanical state of the tool being used by looking at the comparison between the amount of work time used and the repair time of the tool. The influencing factor is the number of hours worked by the tool and the number of hours used to repair the device. The equation is:

$$MA = \frac{W}{W + R} \times 100\% \quad \ldots\ldots(2.1)$$

Explanation:
MA = Availability of tools
W = Number of hours worked, i.e. which is given to the tool in conditions that it can operate in the sense of being undamaged (hours), this also includes the obstacles (delay) experienced by the tool while doing work.
R = Number of hours for repairs, i.e. time spent on repairs and also time lost due to waiting for repairs including time to supply parts.

Physical Willingness (Physical Avaibility/ PA)
Is a record of the physical willingness of the tool being used. Factors that influence physical availability are the number of hours worked by the tool, the waiting time and the amount used to repair the tool being used. The equation is:

$$PA = \frac{W + S}{T} \times 100\% \quad \ldots\ldots(2.2)$$

Information:
PA = Physical availability
S = Number of hours that a device cannot be used which is actually not damaged and in a state ready for use
T = W + R + S = Total number of hours worked where the device is scheduled to operate.

Willingness to Use (Use of Avaibility/ UA)
Willingness to use shows what percentage of time is used by a device to operate when the tool can be used. Factors affecting the willingness to use the tool are the number of hours worked by the tool and the time it waits for the device. It is a comparison between the number of working hours of a device and the hours of waiting for an inefficient tool. The equation is:

$$UA = \frac{W}{W + S} \times 100\% \quad \ldots\ldots(2.3)$$

UA = Willingness,

Effective Utilization (EU)
Effective willingness to indicate what percentage of the work time is available to be utilized for productive work. Effective willingness has the same meaning as work efficiency. Factors influencing the willingness to be effective are the number of working hours of the tool, and the amount of time spent on repairing the tool. Effective availability is a comparison between the number of hours worked with the number of hours waiting for a device and the time for repairing an inefficient tool. The equation is:

$$EU = \frac{W}{T} \times 100\% \quad \ldots\ldots(2.4)$$

Note: EU = Availability effectively

2.8 Productivity of Crusher

Calculation of production targets on the crusher can be used equations namely:

Production Target = crusher capacity x time production plan x work factor

The work factor is obtained by knowing the effectiveness of the day and then averaged for one month or the same as the availability effective (EU) Formula for calculating tool productivity crusher is:

$$\text{Crusher Productivity} = \frac{\sum \text{Production}}{\sum \text{production time}} \quad \ldots\ldots(2.5)$$

To calculate crusher productivity

There are two formulas for comparison, as follows:

1) Calculation of theoretical crushing productivity

$$\frac{\text{Production target}}{\text{Theoretical Production Time}} \quad \ldots\ldots(2.6)$$

2) Calculation of actual crushing productivity

$$\text{Actual crushing productivity} = \frac{\text{Actual Production}}{\text{Actual production time}} \quad (2.7)$$

Meanwhile, to calculate the target time

$$\text{Corrected production time:} = \frac{\text{Production Target}}{\text{Actual Crusher Production}} \quad \ldots\ldots(2.8)$$

2.9 Factors that Influence Crusher Performance

There are several factors that influence crusher performance, including: Material Characteristics Factors material characteristics play an important role in the quality of the final product results from a crushing plant. Material entering

Licensed Under Creative Commons Attribution CC BY

the crusher will affect the performance of the crusher, both of material composition, material size and material moisture. In addition, material containing impurities, such as latex, the material is too wet and too dry, wood, and plastic can affect the performance of the crusher, cause the productivity of the crusher to be lower. Crusher capacity will drop dramatically if a lot of material is in the form of chunks, material that contains a lot of impurities, and material that is too wet. This will make the material more sticky, resulting in the speed of reducing the size of the material will be slower.

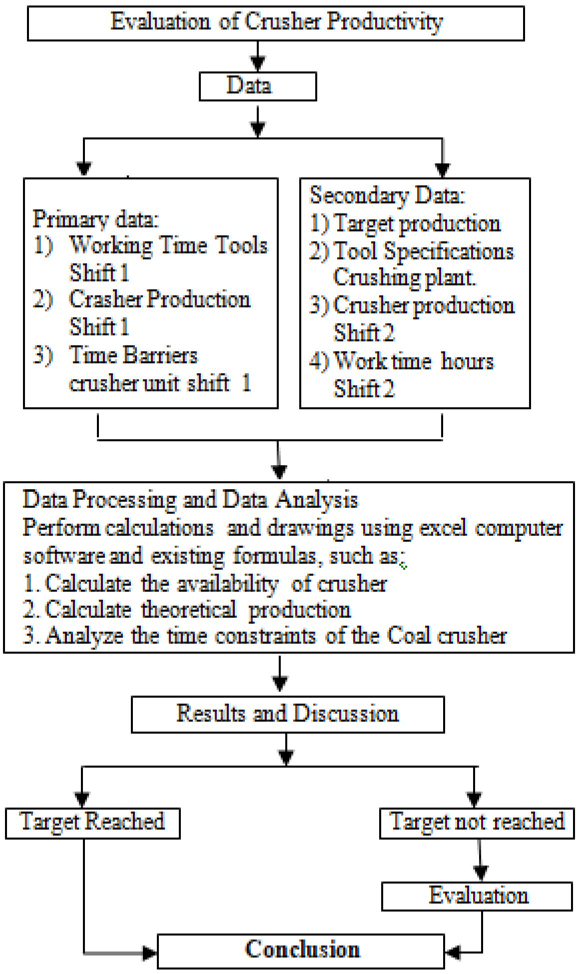
Equipment Factor

To maintain the quality of material from crushing plant, equipment used in operate must be appropriate. Equipment Selection crusher depends on the type and number ingredients to be destroyed. Parameters such as tool speed, type of tool and easy maintenance of equipment are closely related to the success rate of producing quality products.

Operating Factor

Efficient operation of the crusher has an important role in crusher productivity not only the design and layout of the equipment, but also the operating costs must be considered for achieve the best performance of a crushing plant. This process will be realized by operators who are experienced in the work. To meet production targets with a limited budget, the equipment used to destroy materials must have high operating availability, this can be achieved by maintaining maintenance needs minimal equipment (Yilmaz, 2014).

3. Research Methods



4. Results and Discussion

Following were the results and discussion obtained from research conducted at PT. Bara Tabang:

4.1 Production Targets

Each mining company has a target in an operation as well as PT. Bara Tabang which has a target. PT. Bara Tabang had a mining target in January of 1,551,000 tons and a production target in the coal processing unit in January of 806,000 tons which consists of crusher 1 and crusher 2.

4.2 Coal Crushing Process

Coal from mines is transported by using a capacity dump truck± 100 tons to run of mine (ROM), PT. Bara Tabang has 2 ROMs that have a capacity 350,000 tons and 100,000 tons. Coal which There in the run of mine is then included Into Hopper with a capacity of 400 tons with Using the help of heavy equipment in the form of excavators And Wheel Loader, then coal already Enter the hopper then move towards Crusher with feeder assistance, PT. Bara Tabang uses crusher type roll crusher with a capacity 600 tons / hour and 800 tons / hour to produce coal products measuring ± 50 mm, then coal moves through magnetic separator which aims to interesting coal impurity in the form of metal, after The coal is moving towards the tripper car aims to pour coal to a stockpile with a capacity of 75,000 tons, then coal moves to the silo with a capacity of 900 tons, then the silo will transfer coal to haul and hauling it to the jetty (see figure 4.1).

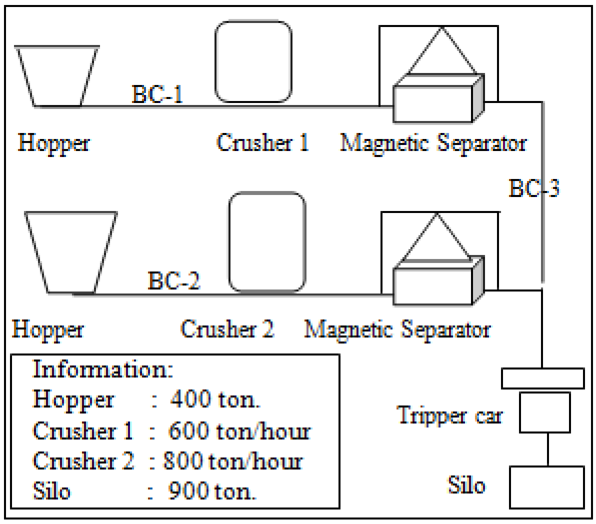


Figure 4.1: Coal Crushing Process from PT. Bara Tabang

4.3 Value of Equipment Availability

Availability of tools that indicate the state of equipment and the effectiveness of operations include the availability of tools, physical condition, willingness to use, and willingness to be effective. Following data

obtained from data sets during January 2018.

In January crusher 1, the total available working hours is 744 hours and the actual available working time is 558.46, the repair time is 8.55 and the amount of stand by for 176.19 hours. (See table 4.1)

Licensed Under Creative Commons Attribution CC BY

Table 4.1: Working hours of crusher units 1

Month	Crusher Unit 1			
	Work hours	Repairs hours	Standby hours	Total hours
January	558,46	8,55	176,19	744

Information:
W = Total Working Hours including time Productive.
R = Number of Working Hours, i.e. time repair and maintenance.
S = Number of equipment working hours no operation, the tool is ready.
T = Total time hours worked (W + R + S).

Table 4.2: Value of Crusher Availability 1

Month	%			
	MA	PA	UA	EU
January	98,43	98,80	76,01	75,10

In January crusher 2 total working hours available at 744 hours and obtained the actual available work time of 498.47, repair time of 25.07 and the amount of the amount stand by amounted to 220.06 hours. (Table 4.3)

Table 4.3: Working hours of crusher units 2

Month	Crusher Unit 2			
	Work hours	Repairs hours	Standby hours	Total hours
January	498,47	25,07	220,06	744

Table 4.4: Value OD Crusher Availability 2

Month	%			
	MA	PA	UA	EU
January	95,21	96,62	69,38	67,04

4.4 Productivity of the Coal Crusher Unit

In general, work productivity is the result of comparison or percentage between output and input.

4.4.1 Target Crusher Production

Production target for January crusher 1amounting to 341,000 and crusher 2 amounting to 465,000 has become a provision by the company.

4.4.2 Crusher Plant Productivity

Table 4.5: Productivity of Crusher plant

Crusher	Target Production Crusher/ton	Production Time Plant (hours)	Productivity Crusher Plant (ton/hour).
1	341.000	620	550
2	465.000	620	750
Total	806.000		

4.4.3 Actual Crusher Productivity

Table 4.6: Actual crusher productivity

Crusher	Actual production (ton)	Production time actual (hour)	Productivity The actual crusher (ton / hour)
1	334.236	558,46	598,50
2	394,680	498,47	791,78
Total	728,916		

4.4.4 Corrected Production Time

Table 4.7: Difference between actual production times and corrected production time

Crusher	Target Production (ton)	Time Production actual (hour)	Time Corrected (hour)	Difference (hour)	%
1	341.000	558,46	569,76	11,30	98,02
2	465.000	498,47	587,28	88,81	84,88

It can be seen from (table 4.7) that in crusher 1 to be able to reach the production target of 341,000 tons in a month with an actual productivity of 598.50 tons / hour it takes equipment working time for production of 596.76 hours, while in crusher 2 to reach the target production of 465,000 tons a month with an actual productivity of 791.78 tons / hour requires working time of the tool for production of 587.28 hours.

4.5 Efforts to Increase Crusher Productivity by way of reducing time Obstacles in Crushing Plant Unit

To increase effective production time in the coal crushing unit is to reduce the obstacles that occur in the operation of crusher units (crusher) daily. These obstacles can be reduced because there are some time barriers that can be reduced / removed with good planning. The magnitude of the time value of obstacles and the percentage of obstacles of the coal crushing unit January in crusher 1 and 2 can be seen in Table 4.8 and Table 4.9 For more complete results. It can be seen from the data in Tables 4.8 and 4.9 that the total resistance time after repair is 155.42 hours crusher 1 and 168.37 hours on crusher 2. Increased supervision in the field, good time management and working professionally can increase production time of 29.32 hours in crusher 1 and 76.36 hours at crusher 2, so the effective working time and production increased to:

Crusher 1

- Actual productivity: 598.50 tons / hour
- Repair time: 29.32 hours
- Actual production: 334,236 tons

Total production (Q) = 598.50 tons / hour x 29.32 hours = 17,548.02 tons So that total production of 351,784.02 tons was obtained in January/ can be reached..

Crusher 2

- Actual productivity: 791.78 tons / hour
- Repair time: 76.36 hours
- Actual production: 394,680 tons

Total Production (Q) = 791.78 tons / hour x 76.36 hours = 60,460.32 tons.So that total production of 455,140.32 tons in january and if total production crusher 1 with production of crusher 2 to be 806,924.34 ton , so it can be said that target of production in january 806,000 ton reached / can be reached or targetable.

Licensed Under Creative Commons Attribution CC BY

Table 4.8: Large Repair Time for Barriers Crusher 1

No.	Type Resistance (The Kind of handicap)	Total Time Resistance (Hour)	Resistance Which can Removed (Hour)	Information
1	Initial Preparation	2,55	2,55	-
2	Stop working before Time	17,41	-	repairment
3	Change Shift	19,22	9,02	repairment
4	Preparation after Change Shift	1,24	1,24	-
5	Silo Full	6,14	6,14	-
6	Conveyance/dump truck Late Come and rain	82,13	8213	-
7	Material	2,49	-	repairment
8	No Coal	35,55	35,55	-
9	Jumat Praying	7,46	7,46	-
10	Breakdown and Maintenance	8,55	8,55	-
Total		185,14	155,42	29,32

Table 4.9: Large Repair Time for barriers Crusher 2

No.	Type Resistance (The Kind of handicap)	Total Time Resistance (Hour)	Resistance Which can Removed (Hour)	Information
1	Initial Preparation	3,09	3,09	-
2	Stop working before time	28,03		repairment
3	Change Shift	26,29	16,09	repairment
4	Preparation after Change Shift	2,03	2,03	-
5	Silo Full	1,02	1,02	-
6	Conveyance/dump truck Late Come and rain	78,28	78,28	-
7	Material	32,24	-	repairment
8	No Coal	40,28	40,28	-
9	Jumat Praying	8,00	8,00	-
10	Breakdown and Maintenance	25,07	25,07	-
Total			245,13	168,37

5.1 Conclusions

From the research conducted, several conclusions can be drawn, as follows:

1) **The productive work time of each** Crusher, which is as follows:
   a) Crusher 1: 558.46 hours
   b) Crusher 2: 498.47 hours
2) **The amount of productivity of each** Crusher, which is as follows:
   a) Crusher 1: 598.50 tons / hour
   b) Crusher 2: 791.78 tons / hour
3) **Barriers that influence crusher production is as follows:**
   a) Get started
   b) Stop the work before due time
   c) Change shift
   d) Preparation after changing shifts
   e) Full silo
   f) Late transportation or rain
   g) Material
   h) No coal
   i) Friday praying
   j) Breakdown and Maintenance

5.2 Suggestions

There are several things that need to be considered in the processing of minerals in the crushing plant at PT. Bara Tabang includes:

- Working time is still productive today less than the planned target, therefore it is necessary to improve working time tools with time management well.
- Crusher productivity is now achieve the predetermined target, to ensure that production does not decline, the need for regular monitoring and maintenance against coal crushing equipment.
- Need for supervision and professional work so that obstacles that can affect crusher production can minimized.

References

[1] Arif, Irwandy, Indonesian coal. Gramedia Pustaka Jakarta, 2014
[2] Indonesianto, Yanto. , Pemindahan Tanah Mekanis. Teknik Pertambangan. UPN: Yogyakarta , 2011
[3] Langgu, Y, Work Organization of Crusher tools Achieve Coal Production Target at PT. Tanjung Alam Jaya Pengaron District Banjar Regency, South Kalimantan Province, 2011., seen 22 July 2017, https:/id.scribd.com/doc/82471619/thesis.
[4] Muchjidin, Pengendalian Mutu Dalam Industri batubara, ITB, Bandung, 2016
[5] Nugroho, W, Diktat Subjects for Processing Mineral Materials, Study Programs Mining Engineering at Mulawarman University, Samarinda, Indonesien, 2016.
[6] Rochmanhadi, Heavy Equipment and Its use, YBPPU. Jakarta, 199, 2018.
[7] Rostiyanti, S.F., Heavy Equipment For Projects Second Edition Construction, Rineka Cipta, Jakarta, 2008
[8] Wigroho, H.Y., & Suryadharma, H.,T ools Heavy, Publishing at Attma Jaya University Yogyakarta, Indonesien, 2010.
[9] Wilopo, D, Construction Methods and Tools Heavy equipment, UI-Press: Jakarta, 2011
[10] Yilmaz, Ero, "Physicochemical Problems of Mineral Processing". Field Monitoring and Performance Evaluation Of Crushing Plant Operation HI, 4-11, 2014.

Licensed Under Creative Commons Attribution CC BY