



*Research Article*

## **Evaluation of Concatenation Planning of Crushing Plant Production System Using Analytic Hierarchy Process (AHP) Method at PT Buana Eltra Coal Processing Unit, South Sumatra**

Endarto<sup>1</sup>, Restu Juniah<sup>1</sup> and Weny Herlina<sup>3</sup>

<sup>1</sup>Department of Mining Engineering, Faculty of Engineering, University of Sriwijaya, Roadway of Palembang-Prabumulih KM.32 Inderalaya, South Sumatera, 30662, Indonesia

### **ABSTRACT**

Coal processing activity conducted at the Coal Processing Unit (Stockpile) Martapura PT. Buana Eltra aims to reduce the size of coal to a smaller size in accordance with market demand of 5-10 cm. Processing is done with a combination of crushing plant and excavator called concatenation of production system. Concatenation of the current production system is a concatenation between Komatsu PC300 excavator and 10 cm roll crusher dimension which produces 145,6701 tons/hour and takes 20,59 hours and is considered inefficient and ineffective to reach production target of 3000 tons/day. Based on the above, it is necessary to evaluate the concatenation of crushing plant production system so that the processing process will be optimally. The method used in this concatenation evaluation is the Analytic Hierarchy Process (AHP) method. The alternative is the concatenation between, Komatsu PC200 excavator - 10 cm roll crusher dimension, Komatsu PC200 excavator - 5 cm roll crusher dimension and Komatsu PC300 excavator - 5 cm roll crusher dimension. The selection of these alternatives is based on qualitative data (criteria from experts) and quantitative data so as to produce optimal choice. Based on the evaluation and analysis of the two types of data then selected concatenation excavator Komatsu PC200 - dimension roll crusher 10 cm which has a productivity of 207,8468 tons/hour and the time required to reach 300 tons/day for 14.43 hours.

*Keywords: Concatenation, Production System, AHP.*

### **1. INTRODUCTION**

Coal is one of the energy sources utilized in various industries such as steam power plant (PLTU), metallurgy processing, cement making mixture, paper industry, textile industry, briquette making and others.

Based on Domestic Market Obligation (DMO) data released by the Ministry of Energy and Mineral Resources, national coal demand will continue to increase in 2017 with estimates reaching 133.61 million tons, up 3.19 percent or 3.86 million tons higher than the target set in the 2015-2019 National Medium Term Development Plan (RPJMN) of the original DMO target of 124.85 million tons from production of 413 million tons and will be expected to increase further in the following year by 151.86 million tons. The coal requirement for next year's power plant is estimated to reach 86 million tons, up from this year's projection of 74 million tons. Coal needs for power plants will reach 119 million tons in 2019, while for 2016 metallurgical activities by PT Krakatau Steel Tbk (KRAS) is estimated to reach 4.65 million tons. The demand for supplies to PT Krakatau Steel is 968 thousand tons, PT Krakatau Posco Rp 2,195 million tons and PT Meratus Jaya Iron & Steel 400 thousand tons. Other supplies for two metallic mineral companies, PT Aneka Tambang Tbk (ANTAM) and PT Vale Indonesia Tbk (INCO) require different coal in 2017. Antam raised its coal requirement to 885 thousand tons from this year's projection of 565 thousand tons. Vale tends to be stagnant, which is 200 thousand tons equals this year, while for the fertilizer industry, next year's demand is estimated at 1.98 million tons which will be supplied to PT Pupuk Sriwijaya with

705 thousand tons, PT Petrokimia Gresik 475,200 tons and PT Pupuk Kaltim 800 thousand tons, while for cement industry requires a coal increase to 10.88 million tons from this year's 10.54 million tons. Coal supply for PT Semen Indonesia Tbk (SMRG) increased by 6.189 million tons from this year's 5.99 million tons. The rest is allocated 1.85 million tons for PT Holcim Indonesia Tbk and other cement 2.84 million tons.

The increasing demand of national coal encourages every coal company to continue its efforts to increase its productivity, as well as with various coal companies located in South Sumatra, one of them, PT Buana Eltra located in Ogan Komering Ulu district. PT Buana Eltra (BE) is a coal mining company with Mining Business License (IUP) of 1,199 Ha and SK IUP No. 08 / K / IUP / XXVII / 2009. This company is a company engaged in mining and trading with consumers such as power generation and briquette industry. PT Buana Eltra undertakes material reduction process at Martapura Coal Processing Unit with installed concatenation is Komatsu PC-300 excavator and gaperoll crusher which has been arranged with size of 10 cm. The increasing need for coal makes PT Buana Eltra's production target increase from 2,800 tons per day to 3,000 tons per day with a fixed coal demand requirement of 5-10 cm. The increase in production targets

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*\*Corresponding author email: [tato.endarto@gmail.com](mailto:tato.endarto@gmail.com)*

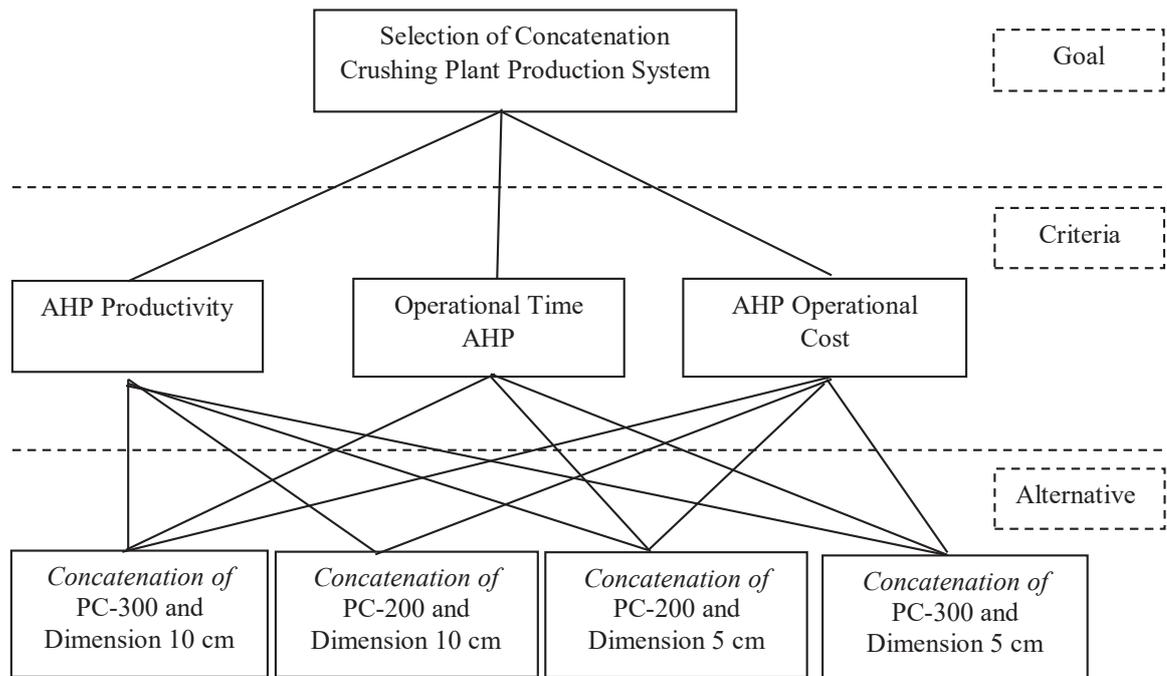


Figure 1 : AHP Flow Chart

makes the concatenation performance of crushing plant production system which is currently installed is considered less effective even though the production target is achieved, as seen from the increase of operational time and the increasing of operational cost which is not according to what is expected by the company so PT Buana Eltra needs evaluation re-concatenation of crushing plant production system.

Based on the above, it is necessary to evaluate the concatenation planning of production system in Martapura Coal Processing Unit which then conducted the study using Analytic Hierarchy Process (AHP) method. This method is a simple method of analysis to make decision of concatenation of production system based on qualitative and quantitative data to get more optimal result [1].

## 2. EXPERIMENTAL SECTION

### 2.1. Study of Literature

The literature study was conducted by looking for literature studies related to crushing plant productivity issues, feeding tools (excavators), journals related to Analytic Hierarchy Process (AHP) methods to assist in solving problems in this regard to determine appropriate concatenation of production systems. Literature is a library materials, then from the library at the Department of Mining Engineering Sriwijaya University in the form of previous research reports, as well as from books - books related to mining science.

The productivity of the excavator can be calculated using the following formula [2].

$$TP = \frac{KB \times BF \times 3600 \times FK}{CT} \quad (1)$$

Where:

TP = Estimated Production (BCM/hour)

KB = Bucket Capacity (m<sup>3</sup>)

BF = Bucket Factor

SF = Swell Factor

FK = Correction Factor

FK = efficiency of tools × work efficiency × operator efficiency  
 CT = Cycle Time (seconds)

The feeder is a material feeder tool from the hopper to the crusher unit at a constant speed [3]. The feeder capacity for feeding material to the crushing plant can be calculated using the formula: [4]

$$Q = V \times T \times L \times d \times 60 \quad (2)$$

Where:

Q = Feeder capacity (ton hour)

V = Hauling speed of feeder (m/min)

T = Height of material above feeder (m)

L = Feeder width (m)

d = Density of Loos Material (ton/m<sup>3</sup>)

The evaluation using the Analytic Hierarchy Process (AHP) method is a superior method for choosing competing activities or many alternatives based on specific or specific criteria [1]. These criteria can be qualitative or quantitative by using a tree model. This decision support model will describe complex multi-factor or multi-criteria problems into a hierarchy [5].

### 2.2 Field Orientation

Field orientation activities are conducted by directly observing the coal reduction activities in the Martapura Coal Processing Unit of PT Buana Eltra as well as seeking supporting information and related to the issues discussed.

### 2.3 Data Collection

The data collection in this research is divided into two types, namely primary data and secondary data. The data are as follows:  
 Primary data

Primary data obtained by observing the actual conditions in the field, interviews with supervisors and other employees. The primary data required are as follows :

Table 1 : List of Experts' Inquiries

No	Question	Priority Scale									Answer
		1	2	3	4	5	6	7	8	9	
1	Which is more important between										
	productivity and operational time ?										
2	Which is more important between										
	productivity and operational cost ?										
3	Which is more important between										
	operational time and operational cost ?										

- a. The number of material entered in the hooper.
- b. Cycle time excavator.
- c. Fragmentation of dust (dust) on material.
- d. Interview with experts on concatenation of production systems to meet AHP data.

Secondary data

Secondary data obtained from the literature or reference of previous research, secondary data required are as follows:

- e. Specification of the tool used is from CAT handbook and Grobal DCA Three Generating Set.
- f. Variables used as a correction factor in the calculation of productivity gained from reference books for mechanical soil removal as well as processing of resources and energy.
- g. The operational needs of existing equipment in the Martapura Coal Processing Unit.

2.4 Processing and analysis of data

The obtained data is then sorted, then calculated and presented in the form of AHP flow chart and table (Figure 1). Flow chart that has been made further filled with the desired criteria such as productivity, operational time, operational costs and then create alternative concatenation production system to be evaluated in this case excavator and dimension roll crusher. The desired criteria can be obtained by interviewing the experts by asking questions of the priority scale required for the AHP method (Table 1) and determining the priority scale (Table 2).

The next step is calculates the cycle time data of each machine obtained by direct observation and then combines it into the AHP matrix calculation which can then be drawn the conclusion of the desired tools.

Data that have been processed subsequently collected each tool and criteria so that it can be known difference based on aspect productivity, operational time and operational cost yangselanjutnyadihitung using matrix to know the preferred order of tools to be selected.

3. RESULTS AND DISCUSSION

The evaluation of production system planning is done to optimize the production result from the crushing plant by doing assessment between several plans from concatenation of production system which enable to be applied and then to make decision using Analytic Hierarchy Process (AHP) method to obtain the most effective technical and economical product extracting system. Concatenation is a combination of a series of production systems between excavators with crusher roll dimensions on the Crushing plant which is the equipment available in the Martapura Coal Processing Unit PT. Buana Eltra. The AHP method is used in analyzing and making the best decisions [6], including in the selection of concatenation. The main advantage of AHP methods

Table 2. Priority Scale

Scale	Importance
1	Equal Importance
3	Slightly more Importance
5	Materially more Importance
7	Significantly more Importance
9	Absolutely more Importance
2,4,6,8	Compromise values

is its ability to handle complex and ill-structured problems which cannot be usually handled by rigorous mathematical models [7]. Assessment of each concatenation crushing plant in the Martapura Coal Processing Unit is required before performing an AHP.

3.1 Concatenation of Actual Crushing Plant Production System

The processing of coal is one of the stages of mining activities. Stages of coal processing are done to reduce the size of coal in accordance with the needs of consumers. PT. Buana Eltra in this case using crushing plant with crusher type of roll crusher that is set in accordance with existing technical studies. Feeding in concatenation of its processing is done by utilizing excavator. Roll Crusher machine is suitable when used on a fragile material and moist, such as coal, gypsum, phosphate, clay, and others [8].

Based on observations made at the Martapura Coal Processing Unit of PT Buana Eltra, the concatenation used today is considered to be less efficient and effective. Concatenation is currently used using a combination of Komatsu PC-300 excavator and roller gamer roll crusher dimensions that are set to 10 cm. Concatenation has a productivity of 145,6701 tons / hour of operational time for 20.59447801 hours to get 3000 target per day and requires operational cost of Rp 6.576.946 per hour.

3.2 Alternative Concatenation of Crushing Plant Production System

The small productivity of the concatenation currently being put into consideration to evaluate concatenation planning both currently available and enabling it to be applied. The concatenation of the product system includes concatenation between Komatsu PC-300 excavator and 10 cm roll crusher excavator, Komatsu PC-200 excavator - roll crusher 10 cm dimension, Komatsu PC-200 excavator 5-cm roll crusher and Komatsu PC-300 excavator - dimensional roll crusher 5 cm.

3.2.1 Concatenation of Excavator Komatsu PC-200 and Roll

Table 3. Comparison of Any Concatenation After AHP Adjustment

No	Concatenation of Crushing Plant Production System	Criteria		
		Productivity AHP (ton / hour)	Operating Time AHP (hour / 3000 ton)	Operational Cost AHP (Rp. / hour)
1	Excavator Komatsu PC-300 and Roll Crusher Dimensions 10 cm	1,456,701	34,055	3.423.054
2	Excavator Komatsu PC-200 and Roll Crusher Dimensions 10 cm	2,078,469	95,663	6.029.093
3	Excavator Komatsu PC-200 and Roll Crusher Dimensions 5 cm	1,785,757	72,004	7.643.650
4	Excavator Komatsu PC-300 and Roll Crusher Dimensions 5 cm	1,782,378	71,685	4.624.795

Table 4. Pairwise Comparison Result of Selection Concatenation Criteria

Item	Produktivty	Operational Time	Operational Cost	Weight
Produktivty	10,000	60,000	40,000	0,7096
Operational Time	0,1667	10,000	20,000	0,1354
Operational Cost	0,2500	0,5000	10,000	0,1550

*Crusher Dimensions 10 cm*

This concatenation uses the Komatsu PC-200 excavator and is combined with the dimensions of roller guser crusher 10 cm apart. Concatenation has a productivity of 207,8468,722 tons / hour of operational time for 14.43370289 hours and requires an operational cost of Rp 3,970,907 per hour.

*3.2.2 Concatenation of Excavator Komatsu PC-200 and Roll Crusher Dimensions 5 cm*

This concatenation uses the Komatsu PC-200 excavator and combined with the roller gape roll crusher dimension of 5 cm. Concatenation has a productivity of 178.5756581 ton / hour operating time for 16.7996021 hours and requires an operational cost of Rp 2,356,350.

*3.2.3 Concatenation of Excavator Komatsu PC-300 and Roll Crusher Dimensions 5 cm*

This concatenation is a combination of Komatsu PC-300 excavator and combined with the dimensions of gape roll crusher 5 cm apart. Concatenation has a productivity of 178,237,7587 tons / hour of operational time for 16.83145043 hours and requires an operational cost of Rp 5,375,205.

**3.3 Evaluation of Concatenation Selection Planning Using Analytic Hierarchy Process (AHP) Method**

The calculation of the technical and economical study of each concatenation is done to give the alternative weight value of each concatenation where the alternative weight consists of productivity, operational time and operational cost of each concatenation. The value of each concatenation must be adjusted to meet the requirements for evaluation using Analytic Hierarchy Process (AHP) .The adjustment is a reduction to the maximum availability limit value of an alternative weights value obtained. Based on the adjustment, we get the AHP weighting value from each concatenation of production system such as (Table 3).

*3.3.1 Criteria Weighting*

The criteria weighting is done by interviewing experienced ex-

perts or supervisors on the criteria used in the selection of concatenation of the production system, then assessing the specified criteria to be selected in the coal processing process. Based on interviews and processing done based on AHP method is like Table 4.

*3.3.2 Alternative Weighting*

Alternative weighting is done by distributing the value of each alternative concatenation to the total alternative value, so as to obtain a value arrangement such as hierarchy in Figure 3. Based on the stratified diagram (Figure 3), the decision can be taken by multiplying the alternative matrix with the matrix of the criterion, such decisions (Table 5)

**CONCLUSION**

Concatenation installed now is a combination of Komatsu PC-300 excavator - roll crusher dimension 10 cm with productivity of 145,6701 tons / hour, operating time for 20,5944 hours and operational cost of Rp. 6,576,946 per hour.

Based on observations at the Martapura Coal Processing Unit, several alternative concatenation production systems that can be used in crushing plant operation are Komatsu PC-200 excavator-dimensional roll crusher 10 cm, Komatsu PC-200 excavator 5 cm roll crusher and Komatsu excavator PC-300 - dimension roll crusher 5 cm..

Selection of concatenation of production system based on AHP method with criteria of productivity, operational time and

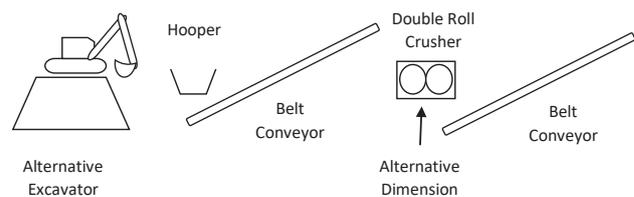


Figure 2. Concatenation Scheme of Crushing Plant Production System

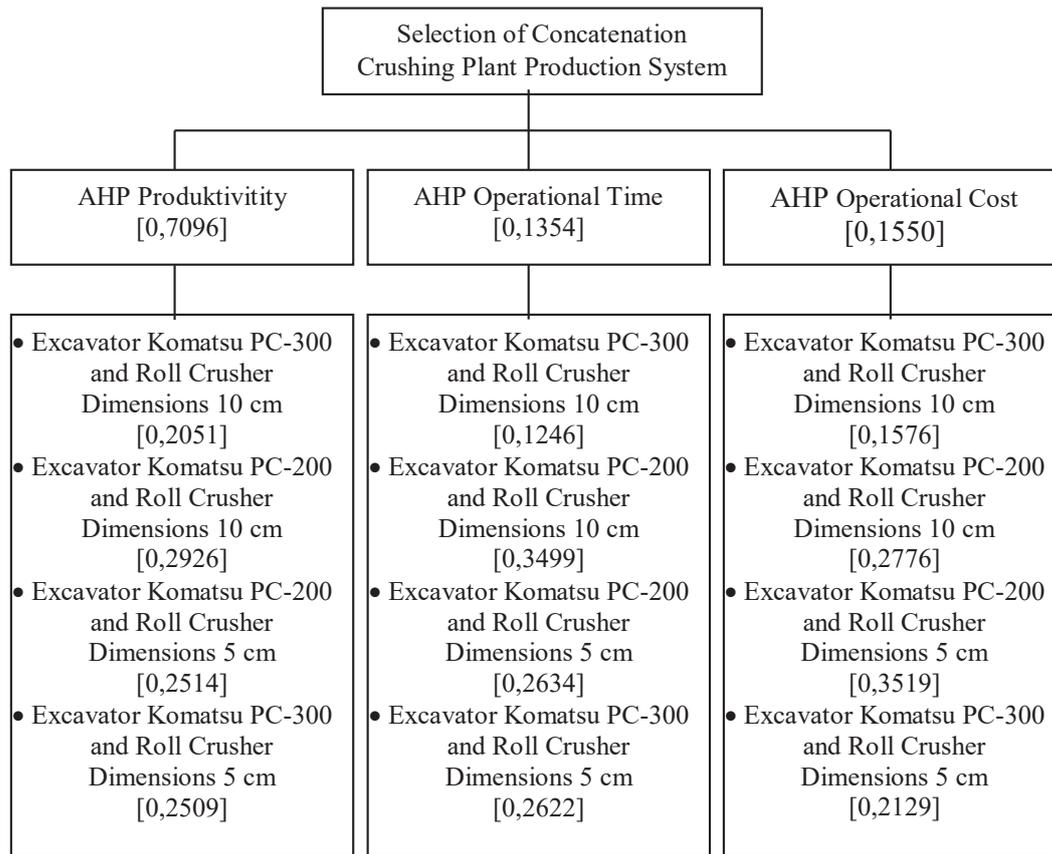


Figure 3. Final Result of All Weighting

Table 5. Decision Table

No	Alternative	Final Value	Ranking
1	Excavator Komatsu PC-300 and Roll Crusher Dimensions 10 cm	0,186814675	4
2	Excavator Komatsu PC-200 and Roll Crusher Dimensions 10 cm	0,298032151	1
3	Excavator Komatsu PC-200 and Roll Crusher Dimensions 5 cm	0,268594252	2
4	Excavator Komatsu PC-300 and Roll Crusher Dimensions 5 cm	0,246558922	3

Table 6. Comparison of Actual Concatenation with Best Concatenation based on AHP Method

Criteria	Actual Concatenation	Best Concatenation based on AHP Method
Produktivitiy (ton / hour)	1,456,701	2,078,469
Operational Time (hour)	205,944	144,337
Operational Cost (rupiah / hour)	6.576.946	3.970.907
Weigth AHP Value	0,186814675	0,298032151

operational cost resulted in optimum weight machine that is concatenation excavator Komatsu PC-200-dimension roll crusher 10 cm.

Comparison of concatenation of production system currently used is Komatsu PC-300 excavator - 10 cm roll crusher dimension with engineering selection of concatenation based on AHP far enough and feasible to be replaced such as productivity concatenation excavator Komatsu PC-300 - dimension roll crusher 10 cm for 145,6701 tons / hour while the Komatsu PC-200 - dimensional roll crusher concretation 10 cm by 207,8469 tons / hour. The concatenation time is 20.5944 hours while the selected concatenation is 14.4337 hours and the current operational cost is Rp 6,576,946, while the concatenation is Rp 3,970,907.

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