Criteria analysis in the selection method of mud pumping in coal mining project

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Abstract. The process of discharging water from the pit is one of the stages prior to the continued excavation of coal deposits. Due to the increase of coal price, several areas that were not economically valuable became visible to re-mined. In some mine ponds that are considered economically viable, are necessary to pump the mud before carried out the water before further digging. This requirement needs decision-making for the determination of sludge pumping methods. A large number of criterion variables for selecting the best mud pumping method drives this study. The distance of three mine ponds under the company is quite far each other. Some steps were executed to have the best method to cater to the problem. The results indicate that there are six criteria that suitable to be considered in selecting a method for mud pumping. Those are the productivity of pump, man power, mobilization, supporting facilities, flexibilities, and operational cost.

1. Introduction

Coal become one source of energy resources. Most of the power plants in Indonesia requires coal as the source of energy. Coal mining becomes an attractive business for some mining companies. The mining cycle starts from the clearing, top soil, overburden excavation, mining material excavation, and the transportation of minerals. [1]. Pumping, both mud and water are carried out when there are puddles generated from rain that cover the surface of the area to be excavated.

There is a coal mining company in South Kalimantan which is a government contractor based on Law No. 4 of 2009 having the permission of PKP2B (Coal Working Agreement of Coal Mining) of generation 1. After the world energy climate is gradually improving and coal prices are rising again, a company plans to do redeployment (cutback) at locations that were previously not economically valuable. The temporarily abandoned location is currently covered by rainwater and there is mud in its basin as a result of the sedimentation process. To continue the mining sequence in the area that is considered economical, this water and mud must be removed from the mine by pumping. Because muds have different densities or densities with water, special pumps are required to remove the mud material because the specifications of conventional water pumps are not capable of pumping. From the new mine economic analysis, there are several sumps or voids in the three work sites that are still economically

viable. Therefore, water and mud pumping are required to extend the life of the mine and to keep the company sustain.

From the initial meeting session, the top management of the company decided that the method for the pumping option would only choose one of three alternatives. Based on Article 7 paragraph (2) the letter "o" of Law Number 1 of 2004 on State Governance all asset purchases are state-owned. Therefore, this dives this research to focus on the best method of mud pumping where the main component of the drum pump (drag-flow) will be held through the rental method.

The three alternatives proposed are pumping by installing a mud pump (drag-flow) on the excavator (excavator) which is then transported to the dumping site by means of a haulage dump truck (HD). The second alternative is pumping by installing a mud pump on a pontoon vessel, where pumped mud is flowed through a pipe from the ship directly to the dump. The third alternative is pumping by installing a drag-flow pump on the excavator (excavator) and the tool is raised to the pontoon then where the pumped mud is flowed through the pipe from the ship directly to the dump. The explanation of these three alternatives is briefly shown in Table 1. The selection of these three alternatives is based on several things such as the availability of supporting tools (excavator/haulage dump truck, and sewer pipe) and the method of pumping sludge as mentioned above has been applied to many other companies.

Due to the demand from the top management for pumping mud is not only in job location Y allocations, but it can also be used in location X and Z. Job location, where the three locations are located far apart from each other, there are several variables that can influence the outcome of the decision. The criteria for selecting the mud pumping method are not based solely on operational cost calculation variables. This is caused by the designation of the mud pumping method to be used on three different job sites so that other criteria (non-cost) variables appear that must be considered in the decision-making process.

Because of the many criteria considered, and each of these criteria is considered to have no relationship with each other, the determination of decision making will be appropriate when using the Analytical Hierarchy Process (AHP) method introduced by Saaty [2].

According to Ghazinoory [3], AHP is a method that is well known in solving decision-making problems. In this method, paired comparisons are carried out by decision makers to determine the parameters weight in a problem. This weighting helps decision-makers in choosing the most superior alternatives. In this study involves many criteria variables as a basis for choosing the best alternative pumping method. With AHP estimated, it can facilitate decision makers with well-organized perceptions and assessments that will influence decision making. Saaty [4] in Kursunoglu & Onder [5] also said that the strength of this AHP is to make the basis of elections that were previously general and poorly controlled to be detailed and can be controlled. Likewise, this method can make decision makers make comparisons between each of the criteria and alternatives so that there is a reciprocal ratio between each criterion and the alternatives compared. This is in accordance with this study where the basis for the assessment and weighting of criteria and alternative pumping methods can be controlled and consistent.

The criteria used in selecting this pumping option were obtained from the FGD led by Operation General Manager PT ABC. In relation to the mud pumping application plan, it will be applied in three different locations, in the next session FGD, weights will be obtained for each criterion and alternative, and the final results will be obtained in determining the rankings that make up the decision of the pumping method.

The method of selecting the pumping method is one of the most important factors of mining engineering activity [6]. Dewatering is one of the most important activities in mining operations which goal is to continue the mining sequence, maximize recovery from reserves and provide a safe environment. According to Bitarafan & Ataei [6], no single method is sure to be used for mining. There are two or more methods worth applying, so is the pumping methods, both water, and sludge pumping. Each method has each different problem with each other. Some of the factors highlighted by Bitarafan & Ataei [6] include economic factors such as capital cost, operating cost and productivity factors such as efficiency, tool productivity, and environmental considerations.

For applications in the mining world, there are studies in which to make decisions using multiple applications of multi-criteria decision making (MCDM) such as fuzzy applications in open mine modeling [7], fuzzy applications to determine optimum underground mining methods [8]; non-linear fuzzy in safety evaluation at mine [9]; analytical hierarchy process (AHP) for selecting fan in tunnel [5], selection of mining equipment [10], crusher selection [11]. For more details of the considered variables can be seen in Table 1.

Table 1. The considered variables

No	Variable	Title	MCDM Tools	Author	Year
1	Productivity	Application of analytical hierarchy process to selection of primary crusher	AHP	Rahimdel	2014
		The application of fuzzy analytic hierarchy process (FAHP) approach to the selection of optimum underground mining method for Jajarm Bauxite Mine, Iran	Fuzzy AHP	Naghadehi, et al	2009
		ADecision Support System for Optimal Equipment Selection in Open Pit Mining: Analytical Hierarchy Process	AHP	Bascetin	2013
		Determining proper strategies for Iran's dimensional stone mines: a SWOT–AHP analysis	SWOT - AHP	Tahernejad, et al	2013
		Selection of an appropriate fan for an underground coal mine using the Analytic Hierarchy Process	AHP	Kursunoglu, et al	2014
2	Personel / Manpower	An application of nonlinear fuzzy analytic hierarchy process in safety evaluation of coal mine	AHP	Qiaoxiu, et al	2016
		Determining proper strategies for Iran's dimensional stone mines: a SWOT–AHP analysis	SWOT - AHP	Tahernejad, et al	2013
3	Mobility	A Decision Support System for Optimal Equipment Selection in Open Pit Mining: Analytical Hierarchy Process	AHP	Bascetin	2013
4	Support	A Decision Support System for Optimal Equipment Selection in Open Pit Mining: Analytical Hierarchy Process	AHP	Bascetin	2013
		Determining proper strategies for Iran's dimensional stone mines: a SWOT–AHP analysis	SWOT - AHP	Tahernejad, et al	2013
5	Flexibility	A Decision Support System for Optimal Equipment Selection in Open Pit Mining: Analytical Hierarchy Process	AHP	Bascetin	2013
		Selection of an appropriate fan for an underground coal mine using the Analytic Hierarchy Process	AHP	Kursunoglu, et al	2014
		Selection of material handling equipment system for surface mines by using a combination of fuzzy MCDM models	Fuzzy MCDM	Yazdani-Chamzini, et al	2013
6	Operating Cost	Selection of an appropriate fan for an underground coal mine using the Analytic Hierarchy Process	AHP	Kursunoglu, et al	2014
		Selection of material handling equipment system for surface mines by using a combination of fuzzy MCDM models	Fuzzy MCDM	Yazdani-Chamzini, et al	2013

This research is similar to some previous researchers who intended to find or choose the best alternative compiled by many existing criteria. Reference to previous research is in the scope of the mining project, such as the selection of tools and methods, but the object is different, namely the mud pumping project located in the former void of the mine.

Some previous studies only used a number of criteria in determining the best alternative, but this study used all the criteria in compiling a decision hierarchy to choose the best alternative so that it can enrich the science of dewatering project management in the mining world. For more details, Table 2 presents the summary of variables concerned in this research.

2. Research Methodology

This research was conducted based on the following steps: determination of location, data collection, and stages in selection the criterion of the mud pumping.

The research location is the coal mining project in Kintap District, Tanah Laut Regency, South Kalimantan province, where the location map is shown in Figure 1.

Table 2. Proposed variables

Item	***Variabels***						
	Produktivities	***Maintenance***	***Mobilization***	***Spareparts***	***Man Power***	***Flexibility***	***Operational Cost***
Equipment Support Selection	v	V	v				v
Mining Tools Selections	v					v	v
Material Handling Selections		V		v		v	v
Strategy / Mining Methods	v	V		v	v		v
Best Method Selections for Mud Pumping Projects	**v**	**V**	**v**	**v**	**v**	**v**	**v**

Figure 1. The location of this research

This project has three different areas in three different districts. The northernmost area goes into Kotabaru Regency, the middle area is entered into the location of Tanah Bumbu Regency and the southernmost area is in the location of Tanah Laut Regency. The southernmost area is divided into three different work/job site locations. The research location takes place in the southernmost area where the area is divided into the X-Y-Z work location.

2.1. Data Collection

In conducting the data collection process, there are two stages namely comparative study and interview to expert.

The comparative study is aimed to have some data on work conditions, equipment, human resources/manpower, equipment productivity data (excavation, hauling and pumping equipment) from the other project. These data are used for decision-makers' consideration to assign assessment weightings for each criterion and alternative. To collect this data, it is necessary to conduct a direct survey at the prospective pumping area at the coal mining site at the owner of the project, at X - Y -Z working site. Then, conducted a comparative study at the pumping area at another coal mine company in Batu Kajang, East Kalimantan. This comparative study was conducted because in that area there are three methods that become alternative candidates that have been run regularly. The result of the comparative study is to get an idea on how the three methods are implemented, the productivity and flexibility of each method, the resources needed for both human and supporting equipment such as

haulage dump truck, excavator, spare parts, pipe needs, and technical unloading assembly and mobilization.

The second stage in data collection is an interview to the experts. The selection of representative respondents is an important factor in this study. Decisions that involve many criteria require a lot of expert participation [12]. As in the optimal study of equipment selection in open-pit mining by Bascetin [10], which uses respondents who are experienced in tool selection and have the qualifications to fill out questionnaires so the results can be justified. Likewise in the crusher selection study at the Golehogar Mine, Iran by Rahimdel & Ataei [11] who used respondents who truly understood and understood the various advantages and disadvantages of each type of crusher that would be used as an alternative. Respondents here are employees and management as well as dewatering experts from contractors involved in this research, namely a). General Manager Operations, Head Office, Jakarta; b). Head of Mining Engineering Site X, Site Y, Site Z; c). Crushing Plant - Overland Conveyor - Port Subtend site Y; d). Dewatering Expert, Site Y; e). Plant - Electric & Mechanical Expert, Site Y; The 5 (five) prospective respondents were chosen because all were involved in the pumping work (a, b, c,d, e).

2.2. Forum Group Discussion.

The main purpose of the study using focus group discussion is to get respondents' attitudes, feelings, beliefs, experiences and reactions which are difficult to obtain using other methods such as observation, one-to-one interview or questionnaire. Focus group discussion is especially useful when there are different forces between participants and decision makers [12].

There are several definitions of focus group discussions (FGDs) including:

First, FGD is an individual group selected by the researcher to discuss and provide opinions on the subject of research [12] interviews involve the number of people interviewed at the same time, and the results depend on the questions and responses between the researcher and the participants. For group discussions focused on interactions within the group based on the topic presented [13].

Second, focus group discussion is one of the techniques used by researchers to extract the data needed by the researcher. The resulting data is accurate and has high validity because all information is the result of the agreement of all participants.

Based on two definitions mentioned, this research conduct FGD to have the criteria of the best method to pump the mud from the coal mining basin. The participants and decision makers have different rules in the projects. The characteristics of the participants are classified based on the experience in dealing with mud pumping. Table 3 presents the characteristics of the participants.

Table 3. Number of participants based on work experience

No	Work Experience (year)	Number of Respondents	Percentage	Job Description
1	0-5	1	14%	Dewatering Engineer Contractor Site Y
2	5-10	1	14%	Senior Engineer Site Y
3	10-15	2	29%	Senior Engineer Site X Engineering Superintendent Site Y
4	>15	3	43%	Project Manager of Contractor Site Y Dewatering Exper – Head Office Contractor Head of Mining Engineer Site Y

For a more succinct, the flow of the research method that shows the stages - the process at that stage - and the output to be used for the next stage is shown in Table 4. as follows:

Table 4. Summary of Research Methodology

Step	Item	Input	Process	Output
1	Identifications	Field surveys include pond conditions, number of support equipment, terrain conditions and access to conformity, candidates for alternative management proposals	Field survey, interview with dewatering expert	Data of support equipment, comparative study object
2	Survey	Data of support equipment, comparative study object	Comparative Study	Criteria and alternative variable
3	Literature Review	Criteria and alternative variable	Variabel from previous researchers	Syntesis of literature review, empirical data of alternatives proposed
4	Interview & comparative study	Syntesis of literature review, empirical data of alternatives proposed	Discussion	Criteria proposed
5	Focus Group Discussion	Criteria proposed	Discussion	Selected Criteria

3. Results

Table 2 showed the seven proposed criteria for the mud pumping method. Those criteria are productivity, maintenance, mobilization, spare parts, manpower, flexibility, and operational cost. Through the process of research as presented in Table 4, the result comes to six criteria as shown in Table 5.

4. Concluding Remark

The goals of this paper are to get what criteria are needed in determining best method priorities in implementing the mud pumping option. Step of research started with empirical identification, literature study to get proposed criteria, data collecting which is consist of both of local survey condition and comparative study, focus group discussion and get a synthesis of criteria. For the final criteria, there are six variables selected out of seven in the initial criterion because indeed these six variables are important variables in the mud pumping project. Six final criteria that have influence with method selection of pumping are: productivity, support, mobilization, manpower, flexibility, and operational cost

Table 5. The Selected Criteria

No	Main Criteria Variables	Data Source	Description and Operational Definition
1	Spare part	FGD, Comparative Study, Interview	Each alternative proposal has a spare parts type - each where there is a difference in the difficulty of spare parts for each option (Pontoon, Highway Dumptruck, Dredger, PC / Excavator have different spare parts). Pontoon: The floating vessel where the main component of the dredger is located Highway Dumptruck: A giant truck with large capacity Dredger: The main component of the mud pump PC / Excavator: Digging tool with boom / long arm
2	Manpower	FGD, Comparative Study, Interview	Since this pumping will be done by switching at several different sites, there is a need for manpower at every job site to operate this mud pump (not picking up from job site Y). Manpower could be an operator, mechanic, welder, crew sampling, where the ability and experience of each - different job sites will vary.
3	Mob-Demobilization	FGD, Comparative Study, Interview	Mobilization - demobilization is needed when going to move location. Each alternative method/option has different difficulties in unpacking the equipment when it is about to move
4	Productivity	FGD, Comparative Study, Interview	Productivity is the ability to produce production output per unit time. This variable is used in this study because the value of pump productivity in each alternative greatly determines how quickly the mud pool is dry .
5	Flexibility	FGD, Comparative Study, Interview	Each pumping method/option has different work characteristics/principles, so the degree of flexibility in the field will differ also between method
6	Operational Cost	FGD, Comparative Study, Interview	Each method has different operational costs so it will be considered in choosing the pumping method

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