ISSN No:-2456-2165

How to Select Appropriate Dewatering Pump Engine: A Case Study

[1]Muhamad Sarifudin
Department of Industrial Engineering,
Indonesian IslamicUniversity

[2]Elisa Kusrini
Department of Industrial Engineering,
Indonesian Islamic University

Abstract:- Mining business is growing rapidly, especially coal, gold, and nickel by using an open pit system, one of the critical aspects are the dewatering and mine drainage system because open pit mines are increasingly wider and deeper to accommodate a lot of water, therefore with a dewatering system and proper drainage of water can dispose effectively and efficiently.

PT. XWZ is a rental company that provides rental equipment to support mines, oil gas and geothermal. One of the equipment to rent is a dewatering pump. Like many companies providing rental services, PT. XWZ must provide a more competitive rental price to compete in the business by obtaining the appropriate machine specification as a major component in building a dewatering pump. HL260 pump type is a medium head pump type maximum head of 147 meters and a maximum flow of 350 liters per second. The 4 types of machine products or brand researched and observed were CAT, Volvo, Cummin and Perkins using AHP method with criteria agreed by expert team are quality, price, delivery time, after sales service and product warranty, can assist management to decide what appropriate of machine to use for building a dewatering pump.

Based on AHP method calculation the prioritized criterions are quality with a weight of 48%, service after sales 23% and delivery time with a weight of 15%, and choice of the best machine is Caterpillar (CAT) brand with a weight of 37%.

Keywords:- *Dewatering, Pump, Mine, AHP, Rental, Machine*

I. INTRODUCTION

The mining sector is an activity that has potential to generate profits as well as a negative impact on the surrounding environmental (Listiyani, N., 2017)

In general, the type of mining in Indonesia's is open pit, either gold, coal or nickel mining. As open pit mines grow of size, water evaluation and management become increasingly important, dewatering is one of the important mining activities to run as planned. Dewatering is an engineering technique to solve the problem that occurs at different construction and mining sites (Mansour et al., 2020). This practice is designed optimally to avoid mining operations being interrupted by excessive volume and pouring into pit, particularly during the rainy season (Gautama, 2019).

The dewatering system design includes the determination of the number of wells, their patterns, and spacing, as well as the pumping rates and the method of handling discharges. The total quantity of water that must be pumped to accomplish the required purpose, i.e., drying out a construction site/reducing artesian pressure, is the main objective of any dewatering system that is evaluated using either analytical or numerical approaches (Mansour et al., 2020).

The optimization of a pump application by identifying a suitable wetend and engine specification. As engine is one of major components of pump set then by appropriate engine selection has high impact to performance and to minimize total cost of production in mining sector. On the market place many various brands with equivalents specification.

PT. XYZ is a well-known and respected equipment support rental company in East Kalimantan, established in Indonesia in 1992 and commenced full equipment hire operations in Indonesia in 1993 in response to the ever-increasing demands for construction and mining services throughout the archipelago.

Throughout the years we have established 6 main branches each in Balikpapan, Sangatta, Jakarta, Surabaya, Pekanbaru and Sorowako. We have also established several services points in various locations as part of our commitment to service and excellence to our clients. On any given day, we have personnel working and living with our customers anywhere from Papua and East Indonesia to Sumatra and overseas.

One of the equipment that rented is pumps. It offers an extensive range of pumps from low head and high head to extra head specification pumps for a wide range of applications such as mining, construction, oil gas and geothermal.

The above sectors are growing rapidly so that competition in the pump rental sector is getting tougher. Therefore, PT XWZ needs to evaluate the main components with various criteria to make the right choice in building a pump so that in terms of cost and performance it can compete in the market and the business continues to run well. Based on this issue, the goal of this study is to identify what the best brand of engine with equivalent specification based on criteria of quality, cost / price, delivery service after sales and warranty using the analytic hierarchy process (AHP) approach.

II. LITERATURE REVIEW

➢ *Analytic Hierarchy Process (AHP)*

Analytic hierarchy process (AHP) is a decision-making tool which helps in breaking the complex problem in simple criteria. AHP is based upon three principles i.e., decomposition of problem, comparative judgment and synthesis of relative importance or rankings (Saaty 2008). In AHP, the problem is broken in hierarchical criteria. These criteria are compared to each other. This process of relative comparison is called pair-wise comparison. The Eigen vector method is used to calculate the rankings and after that consistency of the solution is also checked by using consistency ratio (Saaty 2008). Table 2 shows the scale of pairwise comparison given by Saaty.

The consistency of the weights for relative importance assigned during the pairwise comparison can be checked using the equation given below.

$$\text{Consistency Ratio (CR)} = \frac{CI}{RI}$$

Here, CI is consistency index while RI is randomness index.

CI is calculated as follows:

$$\text{Consistency Index (CI)} = \frac{\lambda max - n}{n - 1}$$

Here, λmax = Major Eigen value and n = order of matrix

Randomness index values are given by Saaty which depends on the value of n. RI is the result of extensive experimentation on the large sample of dataset. Table 1 shows the randomness index (RI) for different values of n. If CR values are less than 10%, the pairwise comparison is considered as consistent. If the CR value is more than 10%, the solution is considered inconsistent, and weights are reassigned in pairwise comparison matrix.

Table 1 Randomness Index (R.I.) Table

n	RI	n	RI
1	0.00	9	1.45
2	0.00	10	1.49
3	0.58	11	1.51
4	1.90	12	1.48
5	1.12	13	1.56
6	1.24	14	1.57
7	1.32	15	1.59
8	1.41		

Table 2 Scale of Analytic Hierarchy Process (AHP)

Degree of Preference	Definition	Explanation
1	Equally Important	Both elements are equally important
3	Moderately Important	One element is slightly more important
5	Highly Important	One element is more important than the other elements
7	Very Highly Important	One element is clearly more important than the other elements
9	Extremely Important	One element is absolutely important than the other elements
2,4,6,8	Intermediate Values	The values between the value of adjacent consideration

III. METHODOLOGY

Research was done at Workshop Department PT. XWZ in Balikpapan. The workshop department was building new pump set with specification maximum head 147 meters and maximum flow 350 liter / second. Besides wetend, engine is major component to be decided what the appropriate brand to use based on criteria considered. The researcher utilizes primary and secondary data sources. Observations made on the field or data gathered directly from sources such as interviews with workshop and supply chain department, also obtain questioner from and discussion with experts.

Numbers of sources of literature review that are utilized as references while processing relevant data are considered secondary data in this study.

The flow/stages in this research are identifying the specification requirement, direct observation and interviews with the workshop and supply chain to get quotation based on criteria, process calculation with AHP method, analyzing the results of data processing and drawing conclusions based on the ending result.

ISSN No:-2456-2165

Table 3 Research Positions

No	Researcher	Topic	Method	Object
1	Sandeep Panchal & Amit Kr. Shrivastava (2021)	Landslide hazard assessment using analytic hierarchy process (AHP): A case study of National Highway 5 in India	AHP	National Highway 5 in India
2	Jasmina Ćetković *et al* (2023)	Selection of Wastewater Treatment Technology: AHP Method in Multi-Criteria Decision Making	AHP	Dojran Lake
3	Zhenming Sun *et al* (2022)	Comprehensive Water Inrush Risk Assessment Method for Coal Seam Roof	AHP-EM	Dahaize Coal Mine, Tulin City, China
4	Jielin Li *et al* (2023)	Safety Risk Assessment and Management of Panzhihua Open Pit (OP)-Underground (UG) Iron Mine	AHP-FCE	Sichuan Province, China
5	Claudio de Rocha *et al* (2022)	Selection of interns for startups: an approach based on the AHP-TOPSIS-2N method and the 3DM computational platform	AHP -TOPSIS -2N	Startup Riverdata

IV. RESULT AND DISCUSSION

➢ *Criteria Determination*

In the AHP method there are criteria needed for the calculation process later. In this case there are five criteria that will be used for the decision-making process to determine which machine or brand to use as follows:

- *Quality* refers to anything that can be offered to the market for consideration, acquisition, use, or consumption and meets the desires and requirements of customers, thereby being considered of high quality (Kotler and Armstrong, 2019).
- *Price* can be defined as what is given up or sacrificed to receive a product and also in general is the external cue used by customers to determine the quality of a product or service (Selim *et al*., 2022).
- *Delivery time* is the amount of time from receiving an order from customers to supplying the goods or services.
- *A.4 Service after sales* is mainly used to provide an overview of the services provided after the goods are received to facilitate the use of the product by the customer throughout the product's life cycle or during the product's use (Mehta & Balakumar, 2021).
- *Warranty* is extra promises that a business makes about the quality of a product or how it will fix any problems with a product or services (Tian *et al*., 2022).

Table 4 Criteria

Criteria	Remarks
C1	Quality
C2	Price
C3	Delivery Time
C4	Service after Sales
C5	Warranty

➢ *Alternative Determination*

The following is an alternative table (engine specifications) shown in Table 5 containing alternative assessment variables.

Table 5 Alternative

Alternative	Specification
A1	CAT C18
A2	VOLVO TAD1643VE
A3	PERKINS 1706D
A4	CUMMIN QSX15

➢ *Pairwise Comparison*

A pairwise comparison is the process of comparing criteria in pairs to judge which of each criterion is preferred overall. The process as follows:

The first step is to pairwise comparison of alternative to quality consistency criteria. The following is a table of assessment weighting and alternative pairwise comparisons to each criterion.

The Second next step is to normalize the alternative matrix against the criteria consistency.

The third step is to measure the consistency of criteria. The eigen maximum obtained by summing up the total of each column multiplied by eigen vectors. Below the result each criterion.

➢ *Criteria Weightage*

Table 6 Weightage Matrix - Criteria

Criteria	C1	C2	C3	C4	C5
C1	1	7	3	3	7
C2	0.14	1	0.33	0.33	0.33
C3	0.33	3	1	0.33	3
C4	0.33	3	3	1	3
C5	0.14	3	0.33	0.33	1
Total	**1.94**	**17**	**7.66**	**4.99**	**14.3**

Table 7 Normalization Matrix - Criteria

Criteria	C1	C2	C3	C4	C5	EV
C1	0.52	0.41	0.39	0.6	0.49	**0.48**
C2	0.07	0.06	0.04	0.07	0.02	**0.05**
C3	0.17	0.18	0.13	0.07	0.21	**0.15**
C4	0.17	0.18	0.39	0.2	0.21	**0.23**
C5	0.07	0.18	0.04	0.07	0.07	**0.09**
Total	**1**	**1**	**1**	**1**	**1**	**1**

The result of eigen maximum (λmax) of quality is 5.35

$$CI = \frac{\lambda max\ - n}{n - 1}$$

= (5.35 – 5) / (5-1)

= 0.0469

For n = 4, RI = 0.9 (Saaty's Table)

CR = CI / RI

= 0.0884 / 1.12

= 0.0789

This result of 0.0789 states that the criteria consistency ratio of pairwise comparison is 7.89% and can be accepted due to smaller than 10% (Saaty, 2008).

➢ *Alternative Assessment Against Criteria's Consistency*

- *Quality*

Table 8 Weightage Matrix - Quality

Quality	A1	A2	A3	A4
A1	1	0.5	3	2
A2	2	1	3	2
A3	0.33	0.33	1	0.33
A4	0.5	0.5	3	1
Total	**3.83**	**2.33**	**10**	**5.33**

Table 9 Normalization Matrix - Quality

Quality	A1	A2	A3	A4	EV
A1	0.26	0.21	0.3	0.38	**0.29**
A2	0.52	0.43	0.3	0.38	**0.41**
A3	0.09	0.14	0.1	0.06	**0.10**
A4	0.13	0.21	0.3	0.19	**0.21**
Total	**1**	**1**	**1**	**1**	**1**

The result of eigen maximum (λmax) of quality is 4.14

$$CI = \frac{\lambda max - n}{n - 1}$$

= (4.14 – 4) / (4-1)

= 0.0469

For n = 4, RI = 0.9 (Saaty's Table)

CR = CI / RI

= 0.469 / 0.9

= 0.0521

This result of 0.052 states that the quality consistency ratio of pairwise comparison is 5.21% and can be accepted due to smaller than 10% (Saaty, 2008).

- *Price*

Table 10 Weightage Matrix - Price

Price	**A1**	**A2**	**A3**	**A4**
A1	1	0.3	0.3	3
A2	3	1	0.5	5
A3	3	2	1	5
A4	0.3	0.2	0.2	1
Total	**7.3**	**3.5**	**2**	**14**

Table 11 Normalization Matrix - Price

Price	**A1**	**A2**	**A3**	**A4**	**EV**
A1	0.1	0.1	0.2	0.2	**0.2**
A2	0.4	0.3	0.2	0.4	**0.3**
A3	0.4	0.6	0.5	0.4	**0.5**
A4	0	0.1	0.1	0.1	**0.1**
Total	**1**	**1**	**1**	**1**	**1**

The result of eigen maximum (λmax) of price is 4.13

$$CI = \frac{\lambda max - n}{n - 1}$$

= (4.13 – 4) / (4-1)

= 0.0463

For n = 4, RI = 0.9 (Saaty's Table)

CR = CI / RI
= 0.463 / 0.9
= 0.0515

This result of 0.0515 states that the price consistency ratio of pairwise comparison is 5.15% and can be accepted due to smaller than 10% (Saaty, 2008).

- *Delivery Time*

Table 12 Weightage Matrix – Delivery Time

Delivery	A1	A2	A3	A4
A1	1	5	5	5
A2	0.2	1	2	2
A3	0.2	0.5	1	0.5
A4	0.2	0.5	2	1
Total	**1.6**	**7**	**10**	**8.5**

Table 13 Normalization Matrix – Delivery Time

Delivery	A1	A2	A3	A4	EV
A1	0.6	0.7	0.5	0.6	**0.6**
A2	0.1	0.1	0.2	0.2	**0.2**
A3	0.1	0.1	0.1	0.1	**0.1**
A4	0.1	0.1	0.2	0.1	**0.1**
Total	**1**	**1**	**1**	**1**	**1**

The result of eigen maximum (λmax) of delivery time is 4.18

$$CI = \frac{\lambda max - n}{n - 1}$$

= (4.18 – 4) / (4-1)

= 0.0606

For n = 4, RI = 0.9 (Saaty's Table)

CR = CI / RI

= 0.0606 / 0.9

= 0.0674

This result of 0.0674 states that the delivery time consistency ratio of pairwise comparison is 6.74% and can be accepted due to smaller than 10% (Saaty, 2008).

- *Service After Sales*

Table 14 Weightage Matrix – Service After Sales

SAS	A1	A2	A3	A4
A1	1	2	5	3
A2	0.5	1	3	1
A3	0.2	0.3	1	0.3
A4	0.3	1	3	1
Total	**2**	**4.3**	**12**	**5.3**

Table 15 Normalization Matrix – Service After Sales

SAS	A1	A2	A3	A4	EV
A1	0.5	0.5	0.4	0.6	**0.5**
A2	0.2	0.2	0.3	0.2	**0.2**
A3	0.1	0.1	0.1	0.1	**0.1**
A4	0.2	0.2	0.3	0.2	**0.2**
Total	**1**	**1**	**1**	**1**	**1**

The result of eigen maximum (λmax) of service after sales is 4.04.

$$CI = \frac{\lambda max - n}{n - 1}$$

= (4.04 – 4) / (4-1)

= 0.0152

For n = 4, RI = 0.9 (Saaty's Table)

CR = CI / RI

= 0.0152 / 0.9

= 0.0169

This result of 0.0169 states that the service after sales consistency ratio of pairwise comparison is 1.69% can be accepted due to smaller than 10% (Saaty, 2008).

- *Warranty*

Table 16 Weightage Matrix – Warranty

Warranty	A1	A2	A3	A4
A1	1	1	1	1
A2	1	1	1	1
A3	1	1	1	1
A4	1	1	1	1
Total	**4**	**4**	**4**	**4**

Table 17 Normalization Matrix – Warranty

Warranty	A1	A2	A3	A4	EV
A1	0.3	0.3	0.3	0.3	**0.3**
A2	0.3	0.3	0.3	0.3	**0.3**
A3	0.3	0.3	0.3	0.3	**0.3**
A4	0.3	0.3	0.3	0.3	**0.3**
Total	**1**	**1**	**1**	**1**	**1**

The result of eigen maximum (λmax) of warranty is 4.

$$CI = \frac{\lambda max - n}{n - 1}$$

= (4 – 4) / (4-1)

= 0.000

For n = 4, RI = 0.9 (Saaty's Table)

CR = CI / RI

= 0.000 / 0.9

= 0.000

This result of 0.000 states that the warranty consistency ratio of pairwise comparison is 0% can be accepted due to smaller than 10% (Saaty, 2008)

- *Total Ranking Calculation*

After analyzing the alternatives, the ranking result can be obtained by summing up of multiplication between criteria with each alternative average. It is shown on table 18.

Table 18 Ranking Result

Criteria	**C1**	**C2**	**C3**	**C4**	**C5**	**Rank**
Average	0.48	0.05	0.15	0.23	0.09	
CAT	0.29	0.15	0.61	0.48	0.25	0.37
VOLVO	0.41	0.32	0.18	0.23	0.25	0.31
PERKINS	0.1	0.46	0.09	0.08	0.25	0.12
CUMMIN	0.21	0.07	0.13	0.21	0.25	0.19

➢ *Priority List*

Lists result up from largest to smallest.

Table 19 Priority List

Priority	**Alternative (Brand)**	**Result**
1	CAT	0.37
2	VOLVO	0.31
3	CUMMIN	0.19
4	PERKINS	0.12

V. CONCLUSION

The following conclusions based on research and observation at PT. XWZ can be concluded that:

- Based on the above data calculation and analysis by using analytical hierarchy process method, the alternative that most of fit to criteria is engine CAT (Caterpillar) with a weight value of 37%.
- The main factor that is most prioritized in dewatering engine product selection is quality with a weight value of 48%, service after sales with a weight value of 23% then delivery time with a weight value of 15%.
- The management can decide what the best dewatering engine to purchase comprehensively and quicker based on the criteria agreed, because decision aspect taken from all of point of view likely engineering aspect, procurement aspect, logistic aspect, maintenance aspect and rental or sales aspect as well as.
- Decision taken can be accounted for due to support with the calculation based on Analytical Hierarchy Process (AHP) method as a model in decision support system.

REFERENCES

[1]. Listiyani, N., 2017. “Dampak Pertambangan Terhadap Lingkungan Hidup Di Kalimantan Selatan dan Implikasinya Bagi Hak-hak Warga Negara”. Al-Adl: Jurnal Hukum. Vol. 9, No. 1, Hal. 67-85

[2]. Gautama, RS., 2019. “Sistem Penyaliran Tambang”. Institut Teknologi Bandung, Bandung

[3]. Mona A. Mansour, Marwa M. Aly (2020). “A simulation-optimization approach for optimal design of dewatering systems in unconfined strata”. Alexandria Engineering Journal (2020) 59, 839–850

[4]. Saaty, T. L. (2008). “Decision making with the analytic hierarchy process”. International Journal of Services Sciences - Volume 1, Number 1/2008 - Inderscience Publishers. International Journal of Services Sciences, *1*(1), 83–98. https://doi.org/10.1504/IJSSci.2008.01759

[5]. Kotler, P. and Armstrong, G. (2019). “Principles of Marketing”. 18th Edition Harlow: Pearson Education

[6]. Selim Ahmed, Ahmed Al Asheq, Ezaz Ahmed, Ujjal Yaman Chowdhury, Tahir Sufi, Md. Golam Mostofa (2022). “The intricate relationships of consumers’ loyalty and their perceptions of service quality, price and satisfaction in restaurant service”. TQM Journal · January 2023. https://www.emerald.com/insight/1754-2731.htm

[7]. Mehta, R., & Balakumar, K. (2021). “Redesigning after-sales service: Impact on incumbent product distribution channels”. Journal of Retailing and Consumer Services, 58, 102279. https://doi.org/https://doi.org/10.1016/j.jretconser.2020.102279

[8]. Yongting Tian, Shouxu Song, Dan Zhou, Chen Wei (2022). “Configuring products using NSGA-II: warranty profits, performance–price, and environmental emissions from the contractor perspective”. Journal of Engineering Design. ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cjen20

[9]. Beheshte Nakhaie Sarvedani, Reza Jahanshahi, Amin Assari (2022). “Determining the best places for dewatering wells in the Gohar- Zamin pit mine, using geostatistical methods”. Geopersia 2022, 12(2): 287-298. DOI: 10.22059/GEOPE.2022.339672.648651

[10]. A.A Inung Arie Adnyano, Muhammad Bagaskoro (2020). “Technical Study of Mine Dewatering System In Coal Mining”. Mining Journal Exploration, Exploitation Georesources Processing and Mine Environmental. PROMINE, Juni 2020, Vol. 8 (1), Halaman 28 - 33