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Engineering assessment of maintenance policy decision problem: a combination of rough set theory and EDAS approach

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ABSTRACT

One of the key component of a maintenance system is maintenance policy selection because the task, determine the most effective policy for each component of a machinery system for improved overall system safety and reliability at minimum cost. In this sagacity, this paper aim to develop an effective and simple tool for selection of optimum maintenance policy for machinery system. A combined multi-criteria decision making (MCDM) tool which integrate Rough Set Theory and Evaluation based on Distance from Average Solution (EDAS) method is proposed for ordering maintenance policy. The Rough Set theory is for analyzing rough weights for decision criteria while the Rough EDAS is utilized for the ranking of alternative maintenance policy. The proposed technique

produces same result with an approach in existing literature without need of an additional tool for both decision criteria weights evaluation and final ranking of alternative maintenance policy which is the bane of most approaches in the literature.

Keywords: Maintenance policy, Rough Set Theory, Rough EDAS, decision criteria, Sea water pump

1. INTRODUCTION

For sustainable industrial development, there must be an effective maintenance scheme in place for maintaining industrial machinery. This will guarantee daily safe and reliable operation of the assets for greater productivity and profitability. British Standard define maintenance as (BS 1993) "the combination of all technical and administrative actions, intended to retain an item in, or restore it to, a state in which it can perform a required action". In this present-day, the complexity of the machinery system is geometrical increasing which also had resulted to maintenance activities complexity increment (Arab et al., 2013). There are majorly three maintenance strategies; Corrective maintenance (A1), Preventive Maintenance (PM) and Condition Based maintenance (CBM). However, Rausand and Vatn (1998)categorize maintenance as corrective maintenance (A1), scheduled overhaul (A2), scheduled replacement (A3), scheduled on-condition task (A4) and continuous on-condition task (A5) and are described in Table 1. However, not all the maintenance policy is appropriate for the different components of the machinery system. The optimum policy for each components of the system has to be selected in order to achieve greater overall machinery system safety and reliability at minimum cost. These make the task of maintenance strategy selection important and worth studying. The maintenance policy is generally selected on the basis of decision criteria and some are briefly explain in Table 2.

In the literature, different techniques have been developed for solving maintenance policy selection problem. Reliability Centered Maintenance (RCM) logic tree have been used for analyzing best fit maintenance policy for machinery system.(Conachey, 2005). However, the technique is very time consuming exercise (Waeyenbergh and Pintelon, 2004) and this is as a result of the difficulty by the RCM team in reaching a consensus solution (Emovon, 2016). Different Multi-Criteria Decision Making (MCDM) tools have also been applied in analyzing optimum maintenance policy. One of such application, is the use of Analytical Hierarchy Process (AHP) by Goossens and Basten (2015) in analyzing best maintenance policy for naval ship systems. However, the shortcoming of the approach is the configuration of the decision problem which made the assessment process very difficult due to numerous pair wise judgments from experts. Emovon, (2016) utilised a combined Delphi-AHP-Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) methods in analyzing five different maintenance policy; A1, A2, A3, A4 and A5with respect to twelve decision criteria. Nevertheless, the AHP method used by the author in evaluating weights of decision criteria is computationally challenging to analyze and implement especially with decision problem containing more than 15 decision criteria, a situation that may require an additional tool for the reduction of the number of decision criteria (Vidal et al, 2011).

From the literature survey it is very clear; there is the need for a more systematic approach that is devoid of the shortcomings of the previous methodology. In this regard, this paper proposed a hybrid MCDM technique which combines Rough Set theory and EDAS method for the ranking of alternative maintenance policy. The Rough Set theory is applied in evaluating rough interval weights for decision criteria by handling effectually opinions of experts which are subjective and uncertain. The Rough Set Theory is also use for the aggregation of multiple experts' opinions which are then applied as input data into the EDAS technique for the final classification of alternative maintenance policy.

Table 1 Maintenance policy types (Emovon, 2016)

Maintenance strategies	Description
Corrective maintenance (A1)	Maintenance technique in which machinery system or component items are allow to fail before corrective action is performed.
Scheduled overhaul (A2)	In this policy type, machinery system or component items are overhaul at a definite interval. This policy is appropriate for machinery system where rework is capable of restoring it to perform intended functions
Scheduled replacement (A3)	This is a maintenance policy in which machinery system or a unit of it is replaced at definite time interval. The approach is ideal for machinery exposed to critical failure and great number of its units must survive to the

	time of replacement.
Scheduled on-condition task (A4)	In this maintenance methodology, the condition of machinery system are monitored periodically. The check performed on machinery are carried out by maintenance personnel with or without the use of diagnostic tools.
Continuous on-condition task (A5)	In this approach, the machinery or components performance condition are monitored uninterruptedly usually with diagnostics devices.

Table 2 Decision criteria types (Emovon, 2016)

Decision criteria	Description
Spare parts inventories cost (B1)	The cost of keeping spare parts inventories for each maintenance policy.
Maintenance cost (B2)	Each maintenance policy cost varies in terms of cost of equipment, materials and labour. The policy with the lowest cost is generally preferred.
Machinery safety(B3)	The safety level of machinery system depends on the maintenance policy for safeguarding it. The approach that guarantee the highest safety level is the best approach.
Machinery reliability(B4)	Reliability of machinery system depends on the maintenance policy applied for preserving it. The best policy is the one that yield the highest reliability.

2. METHODOLOGY

2.1. Rough Set Theory

As a result of the vagueness in human reasoning, it is generally challenging for expert to assign precise numerical value for decision criteria. One of the practicable methodology for overcoming this uncertainty in decision making is the Rough Set Theory (RST) (Stevic et al., 2017). The RST was developed by Pawlak (Pawlak, 1982) and has the capability of managing information that maybe subjective and uncertain without use of any assumption and further modification (Song et al. 2014). In RST any imprecise concept can be denoted as a pair of precise concepts established on the lower and upper approximation (Song et al. 2014; Pawlak, 1991) as indicated in Figure 1.

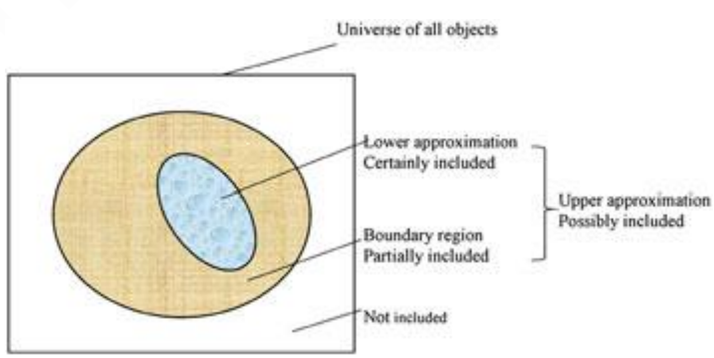

Figure 1 Basic notion of RST, duplicated from (Song et al. 2014)

In Figure 1, the lower approximation of set X are the items that can be stated with certainty belong to X, while those elements that cannot be depict with confidence whether they belong to X or not are the upper approximation (Song et al. 2014).Suppose the universal set consisting of all the items or elements is denoted with U, the boundary region of X in U consist of those items that can neither be categorized as X nor as not-X (Pawlak, 1982).

If we assumed R to be a class of set defined as R = (C1, C2... Cn) and are ordered as C1< C2... < Cn, while Y is denoted as arandom elements of U. The lower approximation, upper approximation and boundary region are described as follows (Song et al. 2014):

Lower Approximation:

$$\underline{APR}(C_i) = U\left\{Y \in \frac{U}{R(Y)} \leq C_i\right\} \quad (1)$$

Upper approximation:

$$\overline{APR}(C_i) = U\left\{Y \in \frac{U}{R(Y)} \geq C_i\right\} \quad (2)$$

Boundary region:

$$BND(C_i) = U\left\{Y \in \frac{U}{R(Y)} \neq C_i\right\} = \left\{Y \in \frac{U}{R(Y)} > C_i\right\} \cup \left\{Y \in \frac{U}{R(Y)} < C_i\right\} \quad (3)$$

Rough number can be used to indicate Ci and is defined as it lower and upper limits using the following Eq. 4 and 5(Zhai et al., 2009).

Lower limits:

$$\underline{Lim}(C_i) = \frac{1}{N_L}\sum \frac{R(Y)}{(Y)} \in \underline{APR}(C_i) \quad (4)$$

Upper limits:

$$\overline{Lim}(C_i) = \frac{1}{N_U}\sum \frac{R(Y)}{(Y)} \in \overline{APR}(C_i) \quad (5)$$

However, the expert judgment can be expressed as rough number and boundary region interval and can be evaluated respectively as follows(Song et al. 2014):

Rough number:

$$RN(C_i) = \left[\overline{Lim}(C_i), \underline{Lim}(C_i)\right] \quad (6)$$

Boundary region interval:

$$BRI(C_i) = \left[\overline{Lim}(C_i) - \underline{Lim}(C_i)\right] \quad (7)$$

Arithmetic operation applicable to interval analysis can also be carried out on rough numbers. If RN(∅) and RN(γ) are two rough numbers; addition, multiplication and division are performed as follows (Zhai et al., 2009):

Addition:

$$RN(\emptyset) + RN(\gamma) = \left[\underline{Lim}(\emptyset) + \underline{Lim}(\gamma), \overline{Lim}(\emptyset) + \overline{Lim}(\gamma)\right] \quad (8)$$

Subtraction:

$$RN(\emptyset) - RN(\gamma) = \left[\underline{Lim}(\emptyset) - \underline{Lim}(\gamma), \overline{Lim}(\emptyset) - \overline{Lim}(\gamma)\right] \quad (9)$$

Multiplication:

$$RN(\emptyset) * RN(\gamma) = \left[\underline{Lim}(\emptyset) * \underline{Lim}(\gamma), \overline{Lim}(\emptyset) * \overline{Lim}(\gamma)\right] \quad (10)$$

Division:

$$RN(\emptyset) \div RN(\gamma) = \left[\underline{Lim}(\emptyset) \div \underline{Lim}(\gamma), \overline{Lim}(\emptyset) \div \overline{Lim}(\gamma)\right] \quad (11)$$

2.2. Criteria weights evaluation: Rough Set Theory Approach

The Rough Set Theory is applied in determining interval weights for decision criteria in the following steps(Song et al. 2014):

Step 1. Experts are asked to assigned weights to decision criteria using 5or 10 points likert scale. In the 5 point likert scale; 1 denotes nearly unimportant while 5 denotes very important. The assigned weights,wj, for decision criteria are shown as:

$$w_j = \left[w_j^1, w_j^2, \ldots, w_j^q, \ldots, w_j^z\right] \quad (12)$$

Where q denotes q_{th} expert and z number of experts

Step 2. Applying Eq. 1-6 the assigned weights to criteria by experts are transformed into rough number$RN\left(w_j^q\right)$expressed as:

$$RN\left(w_j^q\right) = \left[w_j^{qL}; w_j^{qU}\right] \quad (13)$$

Where $w_j^{qL}$and w_j^{qU}denotes the rough number lower and upper limits

Step 3. The criterion j rough weight is evaluated as follows:

$$RN\left(w_j\right) = \left[w_j^L; w_j^U\right] \quad (14)$$

$$w_j^L = \frac{w_j^{1L} + w_j^{2L} +, \ldots + w_j^{zL}}{z} \quad (15)$$

$$w_j^U = \frac{w_j^{1U} + w_j^{2U} +, \ldots + w_j^{zU}}{z} \quad (16)$$

Where $w_j^L$and w_j^Udenotes lower and upper limits rough criteria weights

2.3. Alternative maintenance policy ranking: Rough EDAS Approach

The Rough EDAS is a hybrid MCDM technique which combines both Rough Set Theory and EDAS method for addressing multiple criteria decision problem. The RST methodology is applied in order to overcome the challenge of uncertainty in decision makingprocess involving multiple experts (Emovon, 2018). The EDAS method utilized two index in measuring different alternatives in the maintenance policy decision problem. The positive distance from the average solution (PD) is the first index while the second index is the negative distance from the average solution (ND) (Keshavarz Ghorabaee et al. 2015).

The steps in the Rough EDAS analysis are as follows (Song et al. 2014; Stevic et al., 2017):

Step 1. Development of decision matrix, X, with m number of alternatives Ai (i =1,2,...,m) to be ranked based on n number of decision criteria, Bj (j= 1,2,...,n). Z denoting the number of experts involves in the decision making process. The decision matrix is expressed as follows:

$B_1 B_2 B_3 \quad \ldots \quad B_n$

$$X = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} x_{11}^q & x_{12}^q & x_{13}^q & \cdots & x_{1n}^q \\ x_{21}^q & x_{22}^q & x_{23}^q & \cdots & x_{2n}^q \\ x_{31}^q & x_{32}^q & x_{33}^q & \cdots & x_{3n}^q \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1}^q & x_{m2}^q & x_{m3}^q & \cdots & x_{mn}^q \end{bmatrix} \quad (17)$$

Where q = 1,2,..., z and x_{ij}^q(i= 1,2,...,m) is the assigned rating of qth expert for ith maintenance policy as regards criterion j.

Step 2. The assigned rating is converted into rough number which is used to produce rough matrix. Eq. 1-6 is used to obtain rough number expressed as:

$$RN(x_{ij}^{q}) = [x_{ij}^{qL}; x_{ij}^{qU}] \quad (18)$$

Where x_{ij}^{qL} and x_{ij}^{qU} denotes the lower and upper limits of $RN(x_{ij}^{q})$

The rough sequence is expressed as follows:

$$RN(x_{ij}) = [x_{ij}^{1L}, x_{ij}^{1U}],\ [x_{ij}^{2L}, x_{ij}^{2U}], \ldots, [x_{ij}^{zL}, x_{ij}^{zU}] \quad (19$$

The average of $RN(x_{ij})$ is then expressed as follows:

$$x_{ij}^{L} = \frac{x_{ij}^{1L} + x_{ij}^{2L} +, \ldots + x_{ij}^{zL}}{z} \quad (20)$$

$$x_{ij}^{U} = \frac{x_{ij}^{1U} + x_{ij}^{2U} +, \ldots + x_{ij}^{zU}}{z} \quad (21)$$

Where x_{ij}^{L} and x_{ij}^{U} denotes lower and upper limits of $RN(x_{ij}^{q})$ and are used to form the group rough matrix R expressed as follows:

$$R = \begin{bmatrix} [x_{11}^{L}, x_{11}^{U}] & [x_{12}^{L}, x_{12}^{U}] & \ldots & [x_{1m}^{L}, x_{1m}^{U}] \\ [x_{21}^{L}, x_{21}^{U}] & [x_{22}^{L}, x_{22}^{U}] & \ldots & [x_{2m}^{L}, x_{2m}^{U}] \\ \vdots & \vdots & \ddots & \vdots \\ [x_{n1}^{L}, x_{n1}^{U}] & [x_{n2}^{L}, x_{n2}^{U}] & \ldots & [x_{nm}^{L}, x_{nm}^{U}] \end{bmatrix} \quad (22)$$

Step 3. Evaluation of the rough average solution RN(A) as follows:

$$RN(A) = [A_j^{L}; A_j^{U}] = \frac{\sum_{i=1}^{m}[x_{11}^{L}, x_{11}^{U}]}{m} \quad (23)$$

Step 4. RN(PD) and RN(ND) evaluation depend on the type of criteria. The RN(PD) and RN(ND) calculation for benefit criteria is performed as follows:

$$RN(PD_{ij}) = \frac{max\left(0, (x_{ij}^{L} - A_j^{U}; x_{ij}^{U} - A_j^{L})\right)}{[A_j^{L}; A_j^{U}]} \quad (24)$$

$$RN(ND_{ij}) = \frac{max\left(0, (A_j^{L} - x_{ij}^{U}; A_j^{U} - x_{ij}^{L})\right)}{[A_j^{L}; A_j^{U}]} \quad (25)$$

For the non-benefit criteria, evaluation of RN(PD) and RN(ND) is carried out as follows:

$$RN(PD_{ij}) = \frac{max\left(0, (A_j^{L} - x_{ij}^{U}; A_j^{U} - x_{ij}^{L})\right)}{[A_j^{L}; A_j^{U}]} \quad (26)$$

$$RN(ND_{ij}) = \frac{max\left(0, (x_{ij}^{L} - A_j^{U}; x_{ij}^{U} - A_j^{L})\right)}{[A_j^{L}; A_j^{U}]} \quad (27)$$

Step 5. RN(PD) and RN(ND) weighted sum evaluation is performed as follows:

$$RN(EP_i) = [EP_i^{L}; EP_i^{U}] = \sum_{j=1}^{n}\left(\left[[w_j^{L} * PD_{ij}^{L}]; [w_j^{U} * PD_{ij}^{U}]\right]\right) \quad (28)$$

$$RN(EN_i) = [EN_i^L; EN_i^U] = \sum_{j=1}^{n} \left(\left[[w_j^L * ND_{ij}^L]; [w_j^U * ND_{ij}^U] \right] \right) \quad (29)$$

Where wj denotes the jth criterion weight

Step 6. Normalisation of the RN(EP) and RN(EN) values for all alternatives as follows:

$$RN(NEP_i) = \frac{[EP_i^L; EP_i^U]}{\max_i [EP_i^L; EP_i^U]} \quad (30)$$

$$RN(NEN_i) = 1 - \frac{[EN_i^L; EN_i^U]}{\max_i [EN_i^L; EN_i^U]} \quad (31)$$

Step 7. Performance grade RN(PG) determination for each alternative using Eq. 32.

$$RN(PG_i) = {}^1/_2 \, (NEP_i + NEN_i) \quad (32)$$

The alternatives are ranked with regard to RN(PG) and the alternative having the highest value of RN(PG) is the best solution.

3. CASE STUDY

In order to illustrate the fitness for use of the proposed approach for optimum maintenance policy selection, a case of sea water pump was applied. The case study was taken from the work of Emovon (2016).The sea water pump system is an integral component of the central cooling system of the main engine that power most ships. The duty of the sea water pump system is to draw water from the sea for the cooling of the fresh water in the central cooler which in-turn cools the main engine. In the work of Emovon (2016), five maintenance policy were suggested as possible strategy for safeguarding sea water pump system. The author applied Delphi-AHP-TOPSIS method in the selection of the most appropriate policy from among the five alternatives based on 12 decision criteria. However, in this paper the 12 decision criteria were carefully scrutinize and 4 were chosen as most of the decision criteria were overlapping.

Three experts, E1, E2 and E3 were used in the rating of the decision criteria based on a 5 point likert scale; with score 1 denoting nearly unimportant and rating 5 indicating very important. The assigned rating are shown in Table 3. The precise rating were also assigned to five alternative maintenance policies; A1, A2, A3, A4 and A5 with respect to 4 decision criteria; B1, B2, B3 and B4 as indicated in Table 4.

Table 3 Individual experts rating of decision criteria

	Experts (E)		
Decision criteria	E1	E2	E3
B1	3	3	2
B2	2	2	5
B3	4	5	4
B4	5	4	3

Table 4 Individual expert rating of maintenance alternatives (Emovon 2016)

	B1			B2			B3			B4		
Alternatives	E1	E2	E3	E1	E2	E3	E1	E2	E3	E1	E2	E3
A1	1	2	1	2	5	2	1	1	1	1	2	1
A2	3	3	2	3	4	2	4	3	4	2	4	4

A3	3	2	1	3	3	1	3	3	3	3	3	2
A4	5	4	5	4	4	5	5	5	5	5	5	5
A5	5	4	4	2	3	3	5	5	5	5	4	5

3.1. Rough weights evaluation for decision criteria: Rough Set Theory approach

Applying Eq. 1-6, the assigned rating to decision criteria in Table 3 by the three experts are transformed into rough number. For example the assigned rating for decision criteria, B3 [4, 5, 4] is converted to rough number as follow:

$$\underline{Lim}(4) = \frac{4+4}{2} = 4$$

$$\underline{Lim}(5) = \frac{5+4+4}{3} = 4.33$$

$$\overline{Lim}(4) = \frac{5+4+4}{3} = 4.33$$

$$\overline{Lim}(5) = 5$$

The decision criteria assigned rating by three experts for B3, can therefore be expressed as rough number interval form as:

$$RN(B3) = RN(4) = [4, 4.33]$$
$$RN(B3) = RN(5) = [4.33, 5]$$
$$RN(B3) = RN(4) = [4, 4.33]$$

Applying Eq. 14-16 the rough weight of decision criteria, B3, is evaluated as follows:

$$w_{c6}^{L} = \frac{4+4.33+4}{3} = 4.11$$

$$w_{c6}^{u} = \frac{4.33+5+4.33}{3} = 4.55$$

$$RN(w_{c6}) = [4.11, 4.55]$$

The rough weights for the other decision criteria are evaluated following the same process and the results are presented in Table 5.

Table 5 Rough interval weights for decision criteria

Decision criteria	Rough weights
B1	[2.44,2.89]
B2	[2.33,3.67]
B3	[4.11, 4.55]
B4	[3.5,4.5]

3.2. Maintenance policy ranking: Rough EDAS approach

The rating assigned by the experts to alternative maintenance policy with regards to decision criteria in Table 4 are converted to rough group matrix utilizing Eq. 18-22. The rough group matrix produced is indicated in Table 6. This is followed by the application of Eq. 24 and 25 to the data in Table 6 in order to find the RN(PD) and RN(ND) and the results generated are shown in Table 7 and 8 respectively. Applying Eq. 28 and 29 the weighted sum of RN(PD) and RN(ND) are determined to produced RN(EP) and RN(EN) and the results generated are presented in column 2 and 3 of Table 9. RN(EP) and RN(EN) were then normalized using Eq. 30 and 31 respectively to obtained RN(NEP) and RN(NEN) which are also indicated in Table 9. Finally, the performance score, RN(PG), of each alternative maintenance policy are evaluated using Eq. 32 and the results produced are presented in Table 9. The maintenance policy were rank with regards to performance grade, the rank order of each alternative are also shown in Table 9.

Table 6 Group rough matrix

Alternatives	B1	B2	B3	B4
A1	[1.33,1.53]	[2.33,3.67]	[1,1]	[1.33,1.53]
A2	[2.67,2.89]	[2.5,3.5]	[3.453.89]	[2.89,3.78]
A3	[1.5,2.5]	[3,3]	[3,3]	[2.67,2.89]
A4	[4,4.89]	[4.11,4.55]	[5,5]	[5,5]
A5	[4.11,4.55]	[2.67,2.89]	[5,5]	[4,4.89]

Table 7 Positive deviation from average solution RN(PD)

Alternatives	B1		B2		B3		B4	
A1	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
A2	0.00	0.05	0.00	0.16	0.00	0.11	0.00	0.17
A3	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
A4	0.27	0.66	0.20	0.46	0.41	0.42	0.44	0.50
A5	0.31	0.56	0.00	0.00	0.41	0.42	0.12	0.47

Table 8 Negative deviation from average solution RN(ND)

Alternatives	B1		B2		B3		B4	
A1	0.364	0.713	0	0.408	0.696	0.739	0.456	0.72
A2	0	0.221	0	0.35	0	0.037	0	0.23
A3	0.068	0.651	0	0.179	0.137	0.166	0.137	0.298
A4	0	0	0	0	0	0	0	0
A5	0	0	0.01	0.292	0	0	0	0

Table 9 Analysis result of the Rough EDAS

Alternatives	RN(EP)		RN(EN)		RN(NEP)		RN(NEN)		RN(PG)	Rank
A1	0.000	0.778	5.345	9.835	0.000	0.180	0.457	-0.840	-0.102	5
A2	0.000	1.957	0.000	3.110	0.000	0.453	1.000	0.418	0.936	3
A3	0.000	0.811	1.208	4.562	0.000	0.188	0.877	0.147	0.606	4
A4	4.315	7.614	0.000	0.000	0.567	1.765	1.000	1.000	2.166	1
A5	2.844	5.478	0.023	1.072	0.374	1.270	0.998	0.799	1.720	2

From Table 9, the rank order of the alternative maintenance policy is A4>A5 >A2>A3>A1. A4 was ranked best for having the highest RN(PG) value of 2.166 while A1 was ranked worst for having the lowest PN(PG) value of -0.102.The DELPHI-AHP-TOPSIS method utilized by Emovon, (2016) also yielded the same alternative maintenance policy rank order of A4>A5 >A2>A3>A1. The comparative analysis result is therefore an indication that the Rough EDAS method is capable of solving maintenance policy selection decision problem. The Rough Set Theory used in this paper in evaluating decision criteria weights is effective and yet simple to apply in the handling of uncertainty and subjectivity involves in group decision making. On the other hand, the AHP method used by Emovon (2016) in determining decision criteria weights is difficult to apply especially in problem involving more than 15 decision criteria and in such scenario an additional tool may be needed to reduce the number of decision criteria (Vidal et al, 2011). Furthermore, the Rough EDAS utilized in the ranking of alternative maintenance policy is capable of aggregating different opinions of experts in a group decision making process whereas, the TOPSIS method applied by Emovon (2016) in prioritizing maintenance policy options will require an additional tool for the aggregation of experts' opinions.

4. CONCLUSION

Appropriate maintenance is the key for safe and reliable daily operation of any machinery system. This makes the subject, maintenance policy selection an important task as the process applied yield the best maintenance policy for each component of the machinery system. The paper presented a hybrid MCDM methodology which combines Rough Set theory and EDAS method for ordering alternative maintenance policy. The Rough Set theory was applied in evaluating rough weights for decision criteria by manipulating effectively different subjective and uncertain opinions of experts. The Rough Set Theory was further utilized for the aggregation of three experts' opinions which was then applied as input data into the EDAS method for the ranking of the alternative maintenance policy. In the analysis, five maintenance policy: A1, A2, A3, A4 and A5 were ranked with regard to four decision criteria; B1, B2, B3 and B4. The result of the analysis indicated that A4 is the optimum policy for maintenance management of the sea water pump system. The proposed tool when compared to an alternative tool in literature yielded the same result. However, the proposed tool is more effective and simpler for analyzing appropriate maintenance policy.

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