Hybrid multi-criteria decision making model creation for bucket wheel excavator evaluation and selection

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Abstract

Residual tensions from manufacturing components and equipment assembly, functional job loads (fixed and dynamic loads), and the disrupted exploitation process all cause strains on bucket-wheel excavators in use (non-stationary dynamic loads). For the purpose of deciding which bucket wheel excavator (BWE) should participate in the rehabilitation and modernisation process, this study proposes a technique for assessing and rating BWEs. In this context, we use a multicriteria approache. The MCDM approach, including the Additive Ratio Assessment, is examined in this work (ARAS). The model, derived from MCDM procedures, are used to the task of assessing the primary metrics that define a BWE's performance. Each cluster of factors, together with their subparameters and potential values, will be subjected to the procedures. There are two sections to the model definitions. Using the ARAS technique, the first section identifies the parameters of most importance and defines their respective priority vectors. In the second section, options are analysed and ranked in accordance with the established criteria using a different set of techniques. The benefits were shown from two perspectives in the paper's findings. The first part is creating a framework that can be used to address other issues with the same structure. There's also the actual machine selection, which is based on a complicated examination of many different variables. In most cases, the model generalises well and may be re-used in future studies with comparable parameters.

Keywords: ARAS; MCDM; Bucket Wheel Excavator; Experts; Expert; Decision Makers

1. Introduction

The BWE is the world's most powerful exploitation equipment. In 1978, Krupp developed the biggest BWE with the marking SchRs 6600 or 288, for the Rheinbraun mine. For a decade, engineers worked to design and build this machine. At 100 million dollars, it weighs 13.500 tonnes, is 96 feet tall, and has a length of 220 feet. The daily output of 314.000 cubic yards is possible[1].

32 BWEs are operating in Serbia's surface coal mines. Nine BWE samples from the Kolubara surface coal mine will be analyzed. Researchers will focus on BWE above the age of 30 as a potential subject population for their study.

The cost of one of these devices is prohibitive. The first equipment investments were over 600 million euros (at the current market price of 32 BWE). Protecting the initial investment is a

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fundamental tenet of the equipment exploitation, rejuvenation, and modernization process. It is necessary to carry out the rejuvenation and modernization procedure to extend the equipment's life span and maintain (or enhance) the starting machinery efficiency.

BWEs are put through their paces throughout the manufacturing process (residual stress) when executing functional duties (fixed load, dynamic load), and during the erratic process of exploitation (disruption stress) (non-stationary dynamic loads). There are several significant elements and internal structures of BWE that can't be conveyed as simple mathematical functions, so a model in which factors or variables modify uniformly during exploitation conditions can't fully represent them because a model predicts an approximation, which depends on real development of the productive forces and exploitation.

Performing operational tests on bucket-wheel excavators allows for a full assessment of their situation and the collection of data needed for quality comparison and analysis of engineering components, for the evaluation of single component and element process in terms of load-bearing capacity, as well as the perseverance of the potential of mutual operation between drive components and constructions [2]–[8]

Many of the components and parts of BWE's important structures are exposed to complicated dynamic stresses that rely on the circumstances of exploitation (barrier to digging and one's oscillation) in static and non-stationary operating regimes throughout service[9], [10]. The excavator's components may potentially be unstable due to oscillations[11], [12].

The calculation of the outer pressure on the BWE caused by excavation resistance is critical throughout the design and utilization of the bucket wheel. Rock mass characteristics, geometrical digging specifications, and the excavator's constructive kinetic characteristics are the three main categories of factors that determine excavation resistance.

Similar parameters may be found in various circumstances when the investigation is needed (primarily technical and technological). In this circumstance, the decision-work maker's becomes much more difficult. Motivated by achieving requisite objectivity, we are now trying to overcome this challenge.

The previous study [13] found that major technological systems hadn't been thoroughly analyzed by such serious and exhaustive researchers. Smaller devices at a smaller scale were used for these types of analyses[14], [15]. Data from huge systems could only be obtained via combinations of MCDMs in this scenario (BWE). The ranking/selection system (BWE) was generated using a mathematical apparatus utilizing the specified techniques for revitalization using a huge quantity of data for each unique observation system (working variables, maintenance criteria, realized delays, and realized expenses). In the end, the objective is to maintain the product's quality and production forecasts. The utilization of expert evaluations of the existing status of the system is another criteria that also indicates an effective contribution. Additionally, this survey serves as a way to determine the greatest possible mix of MCDMs. This new hybrid method to system selection (BWE) provides a significant improvement over earlier research and analyses. Such analyses may be improved by including objective characteristics into subjective evaluations, and the other way around. Researchers interested in solving problems of this kind would benefit from this method since it allows them to build on their current knowledge base. Numerous publications in recent years have dealt with mining selection of materials, technology choice, and related tasks in mineral processing, using MCDM approaches. This is the first research to use MCDM to choose the revival technique. The experienced judgment of the maintenance crew demonstrates the optimum way for this sort of study.

There follows a logical progression of events in the following sections: A literature review is presented in Section 2, followed by an explanation of the methodology and results, followed by a discussion of the findings in Section 4, and finally, the conclusions of the paper are presented in Section 5.

2. Related Work

In the fields of mining and mineral processing, MCDM approaches have been used in a slew of articles published in recent years. In operational research, MCDM approaches are utilized to solve

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multi-conflicting criteria. Mining equipment selection, technology selection, and comparable activities in mineral processing are all addressed in papers from international literature that have been chosen for inclusion in this collection. The literature evaluation also includes studies on the upgrading and revitalization of the investigated machinery. '

Analysis Hierarchy Process (AHP) was the most often used technique[15]. Excavation, transportation, and loading equipment selection using the MCDM were the subject of studies by authors [16] and [17]. As a result, they decided that it would be very difficult to come up with the right selection criteria for mining equipment that met all the mine's requirements. Selection between upgrading and purchasing a new piece of equipment. An excavator selection method is based on the kind of work environment, essential technical and technological criteria, and economic considerations. [18] used AHP in the selection of loading and hauling systems at the open pit coal mining "Orhanell" in western Turkey. An open-pit mine's loading-hauling equipment was selected in a case study using AHP and FTOPSIS [19]. Using a combination of the AHP approach and the coefficient of technological level, the authors [20] demonstrated a way of selecting specific equipment (CTL). An open-pit mine in western Turkey's Orhanell region was selected as the best place to produce coal using the AHP technique and Yager [21] as a comparison. For the Gole Gohar iron mine's equipment selection, a TOPSIS and AHP model is presented by [22]. Heavy equipment and truck flats were found to be the most cost-effective method of loading and transporting materials.

The finite element approach is utilized to analyze BWE in these studies [23] to do a numerical study [24]. A refurbishment and rejuvenation procedure has already been chosen for these excavators.
Using the AHP approach, the quality of metal processing was evaluated and found to be dependable (Bang & Chang, 2013). In supply chain management, risk is everywhere. Fuzzy AHP and Fuzzy TOPSIS algorithms combine measurable risk values to provide an overall risk index [25].
The iron mine in Nigeria uses a combination of AHP and FTOPSIS methodologies for the selection of equipment [26]. The biggest and most automated coal mine in Iran used the FAHP (Fuzzy-AHP) approach for equipment selection. An appropriate mining equipment system was evaluated and selected using FAHP and FTOPSIS in conjunction with other data collected by the author [27].
In underground mining, multi-criteria approaches are applied as well.
For the selection of underground coal mine equipment, the author [28] used the AHP technique. Multi-attribute fuzzy coding is used in the maintenance of equipment for underground longwall mining, FAHP, and PGP [29]. The Aegean lignite mine uses AHP and Yager for the selection of a loader [30].
It is common to see results of testing on the underlying steel structure in the majority of published publications addressing the challenges of modernizing and revitalizing this equipment [31]. On huge open-pit mines, BWE is an essential piece of equipment.
They're designed and built to be used on an ongoing basis (24 h per day).
Due to unanticipated downtime caused by malfunctions on these devices, huge losses are incurred [32].

Huge open-pit mines use the aforementioned techniques to maintain both the primary and secondary machinery. To choose the hydraulic excavators for the mine's enormous lignite deposits, several MCDM approaches were applied. Bulldozer availability and partial indicators were calculated by combining AHP and Fuzzy logic by the same researchers [33]. Bucket-wheel excavators' risk assessment model was created using the AHP and TOPSIS methods in Fuzzy inference [33].
The author uses the AHP approach to pick the best alternative from a variety of samples based on a variety of morphological or mechanical parameters based on sensitivity studies [34].
Entropy/VIKOR-based MCDM analysis was used to pick the best biomass, and the results were given in the author's work [35].
The author used the Taguchi/AHP/TOPSIS triple technique to solve a multi-objective optimization problem for a power production system [35]. In the study, the author [36] used the response surface technique and TOPSIS approach to investigate and optimize the gratifier for waste polymer foams. This article offers a fresh perspective on how excavators should be chosen as part of a rehabilitation and modernization effort. Input data are obtained via exploitation in this MCDM model. The novel of this paper used the ARAS method for the first time for this kind of problem.

3. MCDM ARAS Method

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By using MCDM methodologies, complicated quantitative and qualitative issues may be reduced to common components that can be mutually compared, making it easier to interpret the data.
There has been a variety of MCDMs created throughout the years, but the following approaches are the most often used in practice.

An MCDM issue is one in which it is necessary to rank a limited number of choice options, one of which is stated clearly in terms of several decision criteria that must be taken into consideration concurrently. If you use the ARAS technique, the complex efficiency of a viable alternative is determined by how much weight and importance each factor in a project has on its utility function.

To aid in ranking, Zavadskas and Turskis [37] developed ARAS, an MCDM method they developed. This approach is based on the premise that complex phenomena may be better understood by the use of analogies to everyday objects[38]. Figure 1 shows the framework of this study. Following are the stages of ARAS:

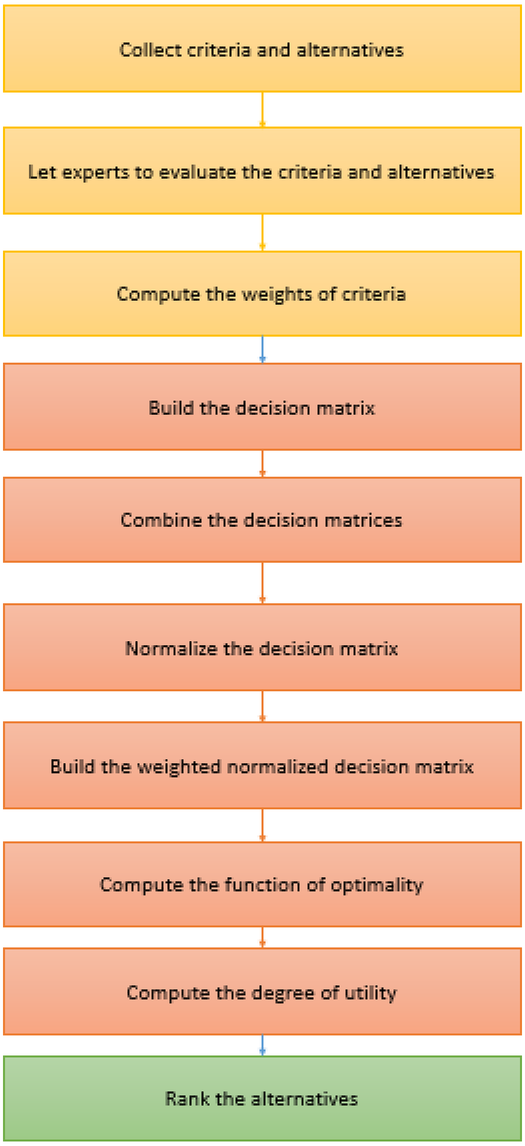

Figure 1: The steps of the proposed model.

Step 1: Create the first choice matrix in step one.
The first step is to create an initial decision matrix.

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$$X = \begin{bmatrix} x_{01} & \cdots & x_{0n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (1)$$

Where n is the number of attributes; m is the number of options.

$i = 1,2,3 \ldots m; j = 1,2 \ldots . n$

$$\max x_{ij} \ ; positive \qquad (2)$$

$$\min x_{ij} \ ; negative \qquad (3)$$

Step 2: Creating a decision matrix that has been normalized is step two.
First, each component is normalized to a consistent value.

$$N = \begin{bmatrix} n_{01} & \cdots & n_{0n} \\ \vdots & \ddots & \vdots \\ N_{m1} & \cdots & n_{mn} \end{bmatrix} \quad (4)$$

$$n_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} ; positive\ criteria \qquad (5)$$

$$n_{ij} = \frac{1/x_{ij}}{\sum_{i=0}^{m} 1/\ x_{ij}} ; negative\ criteria \qquad (6)$$

Step 3: Compute the weighted decision matrix

$$D_{ij} = n_{ij} w_j \qquad (7)$$

Step 4: Compute the function of optimality

$$s_i = \sum_{j=1}^{n} D_{ij} \qquad (8)$$

Step 5: Compute the degree of utility

$$U_i = \frac{s_i}{s_0} \ (10)$$

Step 6: Rank the alternatives by the descending order of U_i

4. Application

The MCDM approach is employed in the paperwork, as previously stated. In the ARAS technique, basic and sub-parameters are ranked based on their mutual importance. Subsequently, an alternative ranking based on rejected sub- and parameter parameters is performed using the weight coefficient previously determined by the ARAS technique employing ARAS. The expert assessment is used to validate the model.

This technique justifies itself because of the importance of BWE in the industrial process, as well as the high initial investment and maintenance expenses. The country's energy industry could not function without such equipment.

Weighting coefficients for basic and sub-parameters are calculated using the ARAS approach in the first interaction. Sub-parameter and parameter weights may be defined using subjective criteria. Because of this, the operator of the excavator may decide what aspects of the machine they are most concerned about.

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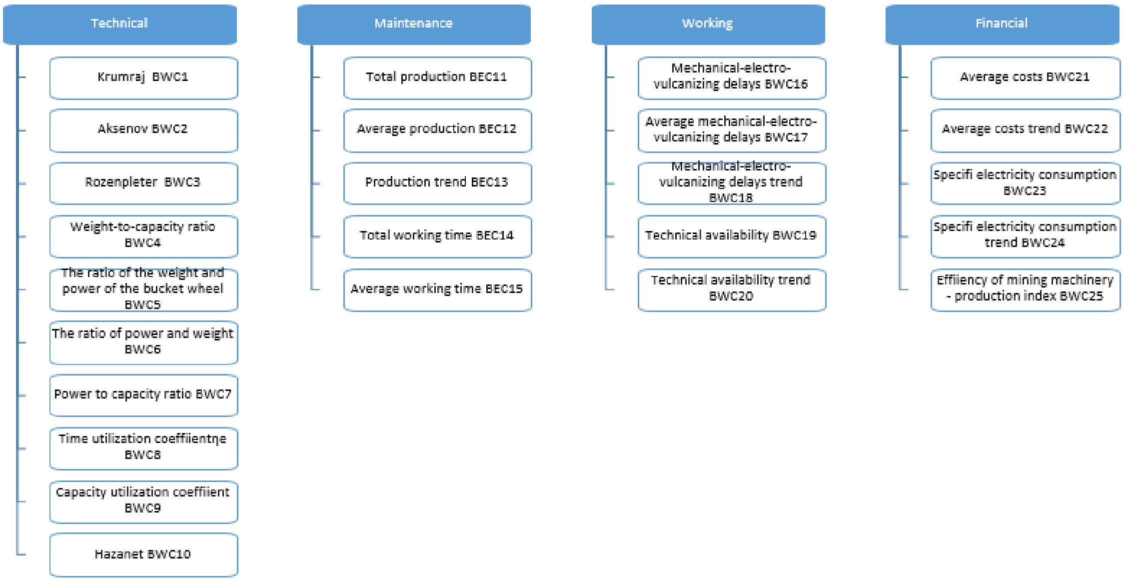
According to their features and outcomes, alternatives (BWE) are evaluated in the second phase. ARAS is employed equally in this interaction. These strategies are based on comparing alternatives to the best in a set of definable parameters.

The subjectiveness is diminished in this manner. Their technique is used to produce the BWE results and ranking: the ARAS method. The criteria are shown below:



Three experts have expertise in this field and evaluated the criteria and alternatives. Then combined their opinions as shown in table 1. Then let experts evaluate the criteria and then normalize values. Figure 2. Shows the weights of the main criteria. Then compute the global criteria as shown in figure 3.

Table 1: The decision matrix.

	BWA1	BWA2	BWA3	BWA4	BWA5	BWA6	BWA7	BWA8	BWA9
BWC1	5.666667	7.666667	5	3.666667	6.333333	4.333333	8.333333	5.666667	3
BWC1	5	7.666667	5	4.333333	5.666667	5	7.666667	5	3
BWC2	4.333333	5	3.666667	2.333333	3	2.333333	5	5	3
BWC3	4.333333	2.333333	3.666667	4.333333	3.666667	4.333333	2.333333	5	5.666667
BWC4	5	2.333333	4.333333	5	3.666667	5	2.333333	5	5.666667
BWC5	3.666667	1.666667	3.666667	5	3	4.333333	2.333333	4.333333	6.333333
BWC6	3.666667	2.333333	3.666667	4.333333	3.666667	3.666667	1.666667	3.666667	5.666667
BWC7	4.333333	1.666667	3.666667	4.333333	3.666667	3.666667	2.333333	4.333333	6.333333
BWC8	3	3	6.333333	7	5.666667	3	3	5	5.666667
BWC9	5	3	6.333333	5	4.333333	2.333333	7	7.666667	1.666667
BWC10	4.333333	3	5.666667	4.333333	4.333333	1.666667	6.333333	6.333333	3
BWC11	7	4.33333	3	3	5	5	7	3.66666	2.33333

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		3						7	3
BWC12	4.333333	6.333333	3.666667	3.666667	5	7	2.333333	2.333333	6.333333
BWC13	5	7	3.666667	4.333333	5	8.333333	2.333333	2.333333	6.333333
BWC14	3.666667	5.666667	3	3.666667	4.333333	6.333333	3	3	7.666667
BWC15	5	5.666667	3.666667	4.333333	5	6.333333	3	2.333333	5.666667
BWC167	4.333333	5.666667	3.666667	4.333333	4.333333	7	2.333333	3	6.333333
BWC18	5	6.333333	7	3.666667	4.333333	5	3.666667	5	7.666667
BWC19	5	5	6.333333	5.666667	5	4.333333	27.66667	5	6.333333
BWC20	4.333333	5	6.333333	4.333333	3.666667	3	5	5	5.666667
BWC21	3	5	3.666667	6.333333	3.666667	5	2.333333	1.666667	5.666667
BWC22	3.666667	5	3.666667	4.333333	4.333333	5.666667	4.333333	4.333333	3.666667
BWC23	4.333333	5	3.666667	5	5.666667	6.333333	5	4.333333	3.666667
BWC24	3.666667	3.666667	3	3.666667	3.666667	4.333333	5	5	3
BWC25	4.333333	4.333333	3	4.333333	4.333333	5.666667	3	3.666667	3.666667

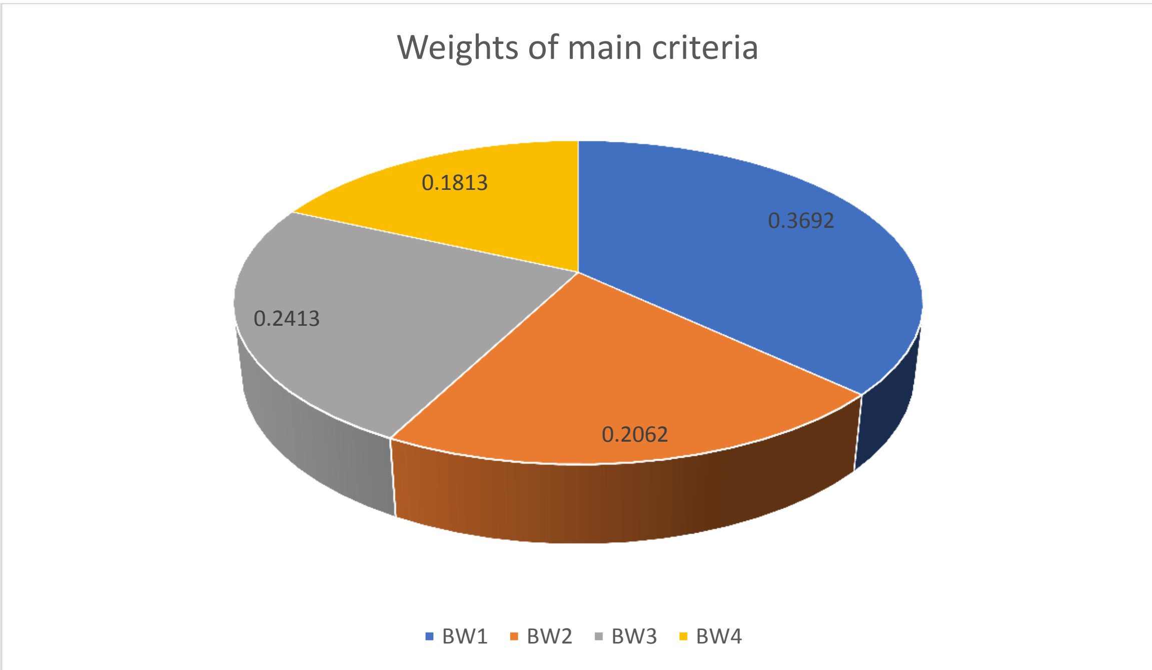

Figure 2: The weights of the main criteria

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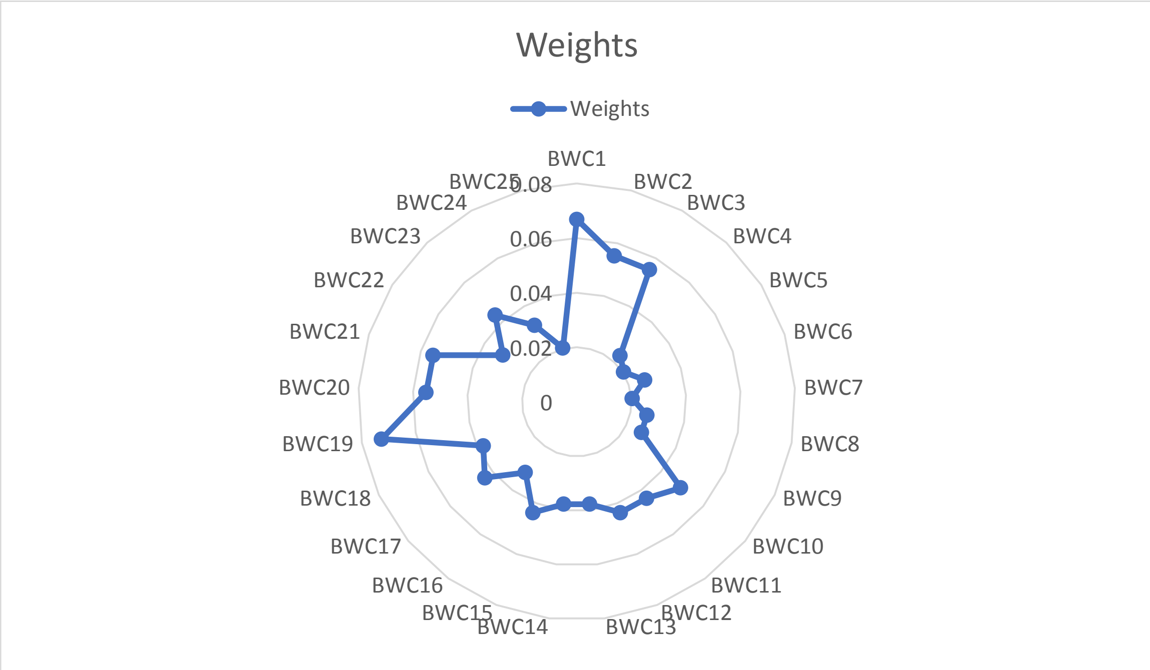

Figure 3: The weights of all criteria.

Step 2: Creating a decision matrix that has been normalized by using Eqs. (4,5,6) as shown in table 2.

Step 3: Compute the weighted decision matrix by using Eq. (7) as shown in table 3.

Step 4: Compute the function of optimality by using Eq. (8).

Step 5: Compute the degree of utility by using Eq. (9)

Step 6: Rank the alternatives by the descending order of U_i as shown in figure 4. The BWA6 is the best alternative and the BWA7 is the worst alternative.

Table 2. The normalization matrix.

	BWA1	BWA2	BWA3	BWA4	BWA5	BWA6	BWA7	BWA8	BWA9
BWC1	0.114094	0.154362	0.100671	0.073826	0.127517	0.087248	0.167785	0.114094	0.060403
BWC1	0.103448	0.158621	0.103448	0.089655	0.117241	0.103448	0.158621	0.103448	0.062069
BWC2	0.128713	0.148515	0.108911	0.069307	0.089109	0.069307	0.148515	0.148515	0.089109
BWC3	0.121495	0.065421	0.102804	0.121495	0.102804	0.121495	0.065421	0.140187	0.158879
BWC4	0.130435	0.06087	0.113043	0.130435	0.095652	0.130435	0.06087	0.130435	0.147826
BWC5	0.106796	0.048544	0.106796	0.145631	0.087379	0.126214	0.067961	0.126214	0.184466
BWC6	0.113402	0.072165	0.113402	0.134021	0.113402	0.113402	0.051546	0.113402	0.175258
BWC7	0.126214	0.048544	0.106796	0.126214	0.106796	0.106796	0.067961	0.126214	0.184466
BWC8	0.072	0.072	0.152	0.168	0.136	0.072	0.072	0.12	0.136
BWC9	0.11811	0.07086	0.14960	0.11811	0.10236	0.05511	0.16535	0.18110	0.03937

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		6	6		2	8	4	2	
BWC10	0.111111	0.076923	0.145299	0.111111	0.111111	0.042735	0.162393	0.162393	0.076923
BWC11	0.173554	0.107438	0.07438	0.07438	0.123967	0.123967	0.173554	0.090909	0.057851
BWC12	0.105691	0.154472	0.089431	0.089431	0.121951	0.170732	0.056911	0.056911	0.154472
BWC13	0.112782	0.157895	0.082707	0.097744	0.112782	0.18797	0.052632	0.052632	0.142857
BWC14	0.090909	0.140496	0.07438	0.090909	0.107438	0.157025	0.07438	0.07438	0.190083
BWC15	0.121951	0.138211	0.089431	0.105691	0.121951	0.154472	0.073171	0.056911	0.138211
BWC167	0.105691	0.138211	0.089431	0.105691	0.105691	0.170732	0.056911	0.073171	0.154472
BWC18	0.104895	0.132867	0.146853	0.076923	0.090909	0.104895	0.076923	0.104895	0.160839
BWC19	0.07109	0.07109	0.090047	0.080569	0.07109	0.061611	0.393365	0.07109	0.090047
BWC20	0.102362	0.11811	0.149606	0.102362	0.086614	0.070866	0.11811	0.11811	0.133858
BWC21	0.082569	0.137615	0.100917	0.174312	0.100917	0.137615	0.06422	0.045872	0.155963
BWC22	0.094017	0.128205	0.094017	0.111111	0.111111	0.145299	0.111111	0.111111	0.094017
BWC23	0.100775	0.116279	0.085271	0.116279	0.131783	0.147287	0.116279	0.100775	0.085271
BWC24	0.104762	0.104762	0.085714	0.104762	0.104762	0.12381	0.142857	0.142857	0.085714
BWC25	212.9524	212.9524	147.4286	212.9524	212.9524	278.4762	147.4286	180.1905	180.1905

Table 3: The weighted normalized matrix

	BWA1	BWA2	BWA3	BWA4	BWA5	BWA6	BWA7	BWA8	BWA9
BWC1	0.007628	0.010321	0.006731	0.004936	0.008526	0.005833	0.011218	0.007628	0.004039
BWC1	0.005714	0.008761	0.005714	0.004952	0.006476	0.005714	0.008761	0.005714	0.003428
BWC2	0.007109	0.008203	0.006015	0.003828	0.004922	0.003828	0.008203	0.008203	0.004922
BWC3	0.002825	0.001521	0.002391	0.002825	0.002391	0.002825	0.001521	0.00326	0.003695
BWC4	0.002654	0.001239	0.0023	0.002654	0.001946	0.002654	0.001239	0.002654	0.003008
BWC5	0.002794	0.00127	0.002794	0.00381	0.002286	0.003302	0.001778	0.003302	0.004826
BWC6	0.002308	0.001468	0.002308	0.002727	0.002308	0.002308	0.001049	0.002308	0.003566
BWC7	0.003302	0.00127	0.002794	0.003302	0.002794	0.002794	0.001778	0.003302	0.004826
BWC8	0.001884	0.001884	0.003977	0.004395	0.003558	0.001884	0.001884	0.00314	0.003558
BWC9	0.005837	0.003502	0.007393	0.005837	0.005059	0.002724	0.008172	0.00895	0.001946
BWC10	0.004845	0.003354	0.006336	0.004845	0.004845	0.001863	0.007081	0.007081	0.003354
BWC11	0.00756	0.00468	0.00324	0.00324	0.00540	0.00540	0.00756	0.00396	0.00252

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	8	5	3	3	6	6	8	4	3
BWC12	0.003994	0.005838	0.00338	0.00338	0.004609	0.006452	0.002151	0.002151	0.005838
BWC13	0.004262	0.005967	0.003126	0.003694	0.004262	0.007104	0.001989	0.001989	0.005399
BWC14	0.003964	0.006126	0.003243	0.003964	0.004685	0.006847	0.003243	0.003243	0.008288
BWC15	0.0039	0.00442	0.00286	0.00338	0.0039	0.004939	0.00234	0.00182	0.00442
BWC167	0.004609	0.006027	0.0039	0.004609	0.004609	0.007445	0.002482	0.003191	0.006736
BWC18	0.003964	0.005021	0.00555	0.002907	0.003436	0.003964	0.002907	0.003964	0.006078
BWC19	0.005166	0.005166	0.006544	0.005855	0.005166	0.004478	0.028588	0.005166	0.006544
BWC20	0.005654	0.006524	0.008263	0.005654	0.004784	0.003914	0.006524	0.006524	0.007393
BWC21	0.00456	0.007601	0.005574	0.009628	0.005574	0.007601	0.003547	0.002534	0.008614
BWC22	0.003006	0.0041	0.003006	0.003553	0.003553	0.004646	0.003553	0.003553	0.003006
BWC23	0.004394	0.00507	0.003718	0.00507	0.005746	0.006422	0.00507	0.004394	0.003718
BWC24	0.00335	0.00335	0.002741	0.00335	0.00335	0.003959	0.004568	0.004568	0.002741
BWC25	4.333333	4.333333	3	4.333333	4.333333	5.666667	3	3.666667	3.666667

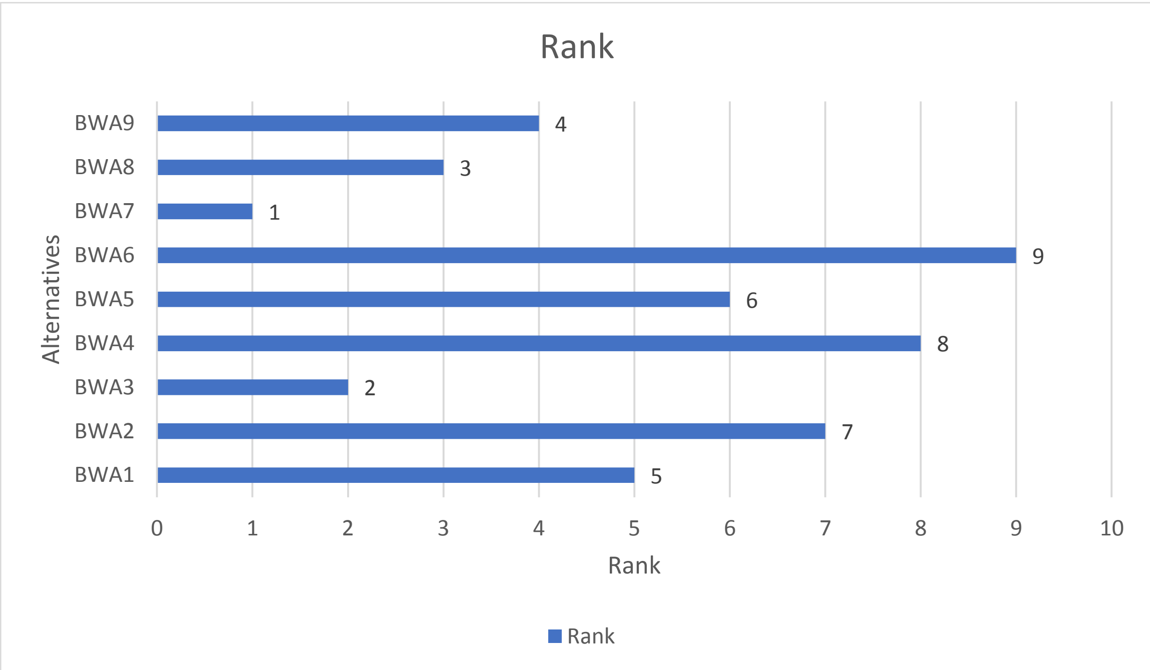

Figure 4: The rank of alternatives.

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The ARAS technique was used in the first creative process to determine how the sub-parameters interact with one another. The first connection between parameters and subparameters was defined based on the knowledge and judgement of specialists. It is the professional judgments of both the personnel working on these excavators as well as the writers of this study that provide the basis for AHP decisions. In the comparison shows iteration, all the algorithms employ the determined values of the parameterization and sub-parameters (ARAS). In the second cycle, we see how several options stack up against one another using the selected criteria. When used in conjunction with the AHP approach, all of the other methods provide somewhat independent findings that are then matched to the expert assessment.

The first step of the ARAS process is to create a matrix. The matrix represents the preference relations between the four specified parameters. Parameter weights may be calculated by solving a matrix. Each component of the excavator is given a score between 1 and 10 during the BWE evaluation process. Experts' judgments regarding the true BWE are used to assign grades to the items at the base of the hierarchy. A combined evaluation of the constituent parts is then generated by multiplying their individual ratings. Using this method, the part's value to the whole (the construction crew) may be determined. The questionnaires are established by the dissection of excavators and serve as the foundation for the assessment. Experts' evaluations of the real-world BWE informed the ratings they assigned to items at the base of the hierarchy. Answers are recorded in the forms.

The BWE expert rating is used to assess the precision and accuracy of the combined methodologies that have been used. As a result of their sophistication and high cost, BWEs are a rare and costly commodity. BWE in surface coal mines has to be revitalised and modernised to extend the equipment's life span and maintain (or enhance) initial performance levels. Huge cost reductions may be realised if the MCDM were used instead of the traditional approaches. Given the BWE's crucial role in manufacturing and the high expense of both initial investment and ongoing upkeep, this strategy is understandable. According to the work objective, the stated study material, and the files containing (part of which are subjective), the ARAS approach is applicable to the selection of a BWE in the context of modernisation and regeneration.

5. Conclusion

This paper's significance is double-edged. The first step is to pick the best hybrid technique, and the second is to rank BWE using MCDM. It's not about the sequence of the BWE that joins the modernization process, but rather the whole group of excavators.

Utility function values are directly proportional to numbers and weights of the most important project criteria, as provided by the new technique ARAS, which is based on a novel approach.
The value function utility is used to rank the relative importance of various options. As a result, this method makes it easy to analyze and rank choice options. The alternative utility may be measured by comparing an evaluated variation to an idealized benchmark. Alternative projects may be improved by using the ratio with an ideal alternative while evaluating and ranking them.

In future studies, the proposed model can be used in many MCDM problems. The other MCDM methods like the AHP, TOPSIS, VIKOR, MABAC, and WASPAS can be used in this problem and make a comparison between them. The other environment can be used to deal with uncertainty like fuzzy and neutrosophic environments.

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