

Selection Criteria of Eco-Friendly Cooling Media Using MCDM for Metallurgical Operations

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Abstract

One of the biggest issues in metallurgical operations is choose of right cooling media it decides improvement of mechanical properties and grain refinement of metals and alloy. Selection of right cooling media which gives maximum cooling rate with minimal distortion of metals and alloy. In this paper the researchers observed that the Multi Criteria Decision Making (MCDM) problem with different objectives. Using this method, the criteria weights are estimated by utilizing the method entropy and the alternative rankings are calculated, by using the method TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). In this approach out of six alternatives the best cooling media for metallurgical find out. The procedure is exhibited a case study.

Keywords: Cooling Media, Entropy Weight, MCDM, TOPSIS, Eco Friendly, Heat Treatment Operations.

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INTRODUCTION

Heat treatment is a tool that allows us to alter the mechanical properties of metals and alloys to suit our requirements. After heat treatment metals cooled in media for improve the mechanical properties and improve micro structure of metals and alloys. But right selection of cooling media plays vital role to improve the properties of metals and alloys. So far nearly twenty five cooling media used for metallurgical operations. From optimization technique according to their properties like thermal and chemical properties to decide best cooling media. Conventional multi-criteria decision-making (MCDM) issue is to choose the extremely suitable content in the existence of several, usually be the incompatible basis. According to choose the finest difference for a specified implementation [1,2], a systematic efficient approach to material selection is then required. Dweiri and Al-Oqla [3] have put on the method of analytical hierarchy (AHP) for picking a substance for an uncomplicated object (a key). Within the AHP procedure, a matrix approach (GTMA) and graph theory for substance selection for a specified technical variable was presented according to control the comparable value of the investigated [4]. A 'substance suitability index' was proposed to estimate and design at different substances depending on a substance selection factor function that was secured by the substance selection factor graph. The

important problem with the GTMA substance selection factors graph was suggested to test alternative materials and rate them. The important problem with the GTMA method is nothing but if that issued question of choice of material includes higher as five or six based, it goes well with very complicated to measure the utility of the indefinite function by the digraph created. The present approach is also very complicated to understand, and involves comprehensive expertise of mathematics that hampers its use. Jee and Kang[5], Shanian and Savadogo[6,7], Rao and Davim[8], Thakker et al.[9] and Gupta[10] used sequence partiality techniques similar to the optimum solution approach (TOPSIS) to solve substance selection issues. The TOPSIS approach is dependent on the premise that the finest alternative will be very close as possible to the optimum resolution and as far as the non-optimum resolution is concerned. Thus, identification of the ideal and non-ideal solutions is essential for the implementation of the TOPSIS method. Finally, the solution exactness of the TOPSIS approach is based on the comparable value of the parameters considered and the standardization process followed in order to provide the matrix of the dimensionless and comparable decision. The better way [11] is to use MCDM methods to pick substances for tribological uses by the use of different mechanical properties. The entropy weight-based TOPSIS approach for [12] decision-making is applied to resolve the MCDM issue influenced by

uncertainty and take into account decision-maker preferences. TOPSIS analysis uses entropy weight, which is used to make the correct decision for the organization. Rao et al. [13] used different cooling media and its mechanical properties and thermal properties found and which is gives fast cooling rate and minimum distortion metals among six cooling media. Ramji. K et al. [14] In order to choose the best specimen to achieve the goal, an MCDM is used in conjunction with Analytic Hierarchical Process, Entropy, and TOPSIS approaches. Raj Nish Kumar et al. [15] selection of suitable material regarding cost and durability etc., was observed that MCDM technique found optimum condition seven number of alternatives and six criteria material section for optimum condition. Yang Li,[16] et al. Decision making is always make big problem To address this shortcoming, this study introduces RSM-TOPSIS-IN, a fresh approach for MCDM issues with interval numbers based on TOPSIS and the response surface method (RSM). Choosing the proper partner, choosing the correct investment programme, and evaluating road transportation technologies are the first three steps. There is good agreement between RSM and TOPSIS-IN. Shweta Panjwani [17] et al. Many MCDM methods are available like AHP, TOPSIS etc., helpful to resolve the problems different applications indifferent fields like energy, agriculture, Industry, construction and other sectors which is select according to problem and domain.

MULTI CRITERIA DECISION MAKING METHODS

1. The Entropy Method

Entropy estimates the unreliability expressed in the details using probability theory. Shannon's Entropy is registered to evaluate the objective weight of our sample, which indicates that a broad classification reflects more unreliability than a strongly peaked one does. The reasoning for the entropy investigation is formally denoted as: One of the most difficult tasks in MCDM challenges is to appropriately assign weights to the criteria in connection with which options are to be evaluated. Entropy approach is utilized for this purpose. The following are the steps to estimate the weights using the entropy approach for the design matrix M.

Step 1: Decide the Decision matrix

$$M = \begin{matrix} & C_1 & C_2 & C_3 & C_4 \\ A_1 & a_{11} & a_{12} & a_{13} & \dots & a_{1n} \\ A_2 & a_{21} & a_{22} & a_{23} & \dots & a_{2n} \\ A_3 & a_{31} & a_{32} & a_{33} & \dots & a_{3n} \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\ A_m & a_{m1} & a_{m2} & a_{m3} & \dots & a_{mn} \end{matrix}$$

$$W = [W_1 \quad W_2 \quad W_3 \quad \dots \quad W_n]$$

Where A1, A2, A3,..., Am are the various alternatives that the decision-maker must rate C1, C2, C3..... The methods for evaluating the different options are Cn. Aij is the output value of alternative Ai that is based on the Cj criterion, and wj is the Cj's weight.

Step 2: Calculation of feature weight Pij for the jth criterion

$$P_{ij} = \frac{a_{ij}}{\sum_{i=1}^m a_{ij}^2}, (1 \leq i \leq m, 1 \leq j \leq n) \quad (1)$$

Step 3: The output entropy e_j of the jth factor

$$e_j = -k \sum_{i=1}^m (P_{ij} \ln P_{ij}), (1 \leq j \leq n) \quad (2)$$

$$k = 1 / (\ln m) \quad (3)$$

Step 4: Calculation of variation coefficient of jth factor g_j

$$g_j = |1 - e_j| (1 \leq j \leq n) \quad (4)$$

Step 5: Calculation of weight of the entropy w_j

$$w_j = \frac{g_j}{\sum_{i=1}^m g_j} (1 \leq j \leq n) \quad (5)$$

2. TOPSIS Method

The features between each option and the ideal alternative, which is the option with the highest score on each criterion, are calculated by allocating weights for each criterion, normalising scores for each criterion, and doing so, this compensatory aggregation approach compares a group of alternatives.

Step 1: The normalised decision matrix, please. It is obvious. The TOPSIS technique offers a number of choices for calculating normalised scores, including defining weights for each criterion and calculating normalised scores for each criterion.

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \quad j = 1, 2, \dots, n; \quad i = 1, 2, \dots, m \quad (6)$$

Step 2: Determine the relative weights of various attributes in relation to the purpose, ensuring that the sum of all weights is equal to one.

Step 3: Obtain the weighted normalized matrix.

$$V_{ij} = w_j R_{ij} \quad j = 1, 2, \dots, n; \quad i = 1, 2, \dots, m \quad (7)$$

Step 4: Determine the ideal and negative ideal solutions

$$A^+ = \{V_{ij}^+ 1, \dots, \dots, V_n^+\} = \{(max V_{ij}/i\epsilon_1'), (min V_{ij}/i\epsilon_1'')\} \quad (8)$$

$$A^- = \{V_{ij}^- 1, \dots, \dots, V_n^-\} = \{(max V_{ij}/i\epsilon_1'), (min V_{ij}/i\epsilon_1'')\} \quad (9)$$

Step 5: Calculate separation measures by below two equations

$$S_j^+ = \sqrt{\sum_{i=1}^n (v_{ij} - v_j^+)^2} \quad S_j^- = \sqrt{\sum_{i=1}^n (v_{ij} - v_j^-)^2} \quad (10)$$

Step 6: Calculate of relative closeness to the ideal solution

$$C_i^* = \frac{S_j^-}{S_j^+ - S_j^-} \quad (11)$$

3. Analysis

Table 1: List of different alternative and criteria

Cooling media	Properties	Units
Cow urine	UTS	N/mm ²
Tap water	YS	N/mm ²
Distilled water	HBN	-----
Soap nut solution	Elongation	mm
Shikakai nut solution	Thermal	W/m K
Engine oil	conductivity	
	Heart transfer coefficient	W/m ² K

Table 2: Table of decision Matrix for different alternatives (Al 2585 alloy)

UTS YS HBN	Elongation	Thermal conductivity Heat transfer coefficient
125.62 99.05	7.5	1.157 6.57
47	8.8	0.62 4.60
111.45 85.52	9.0	0.58 4.18
41	9.4	0.91 3.65
102.42 70.89	9.7	0.89 3.28
40	10	0.14 2.30
90.10 64.94 38		
86.00 62.72 36		
77.05 57.60 32		

(Source: Maruthi Rao et al, 2019)

RESULTS AND DISCUSSIONS

The grading factors shown in this paper are calculated by the entropy method and the ranking of many options is performed using TOPSIS. Table. 3 indicates the weighted average of various entropy technique criteria.

Table 3: Weight factor of criteria by Entropy method

Criteria Wight
UTS 0.002371
YS 0.04
HBN 0.125755
Elongation 0.245952
Thermal conductivity(K) 0.304536
Heat transfer coefficient (h) 0.28

Table 4: Normalize decision matrix

UTS YS HBN	Elongation	Thermal conductivity Heat transfer coefficient
0.5122 0.5402	0.3364	0.6019 0.6231
0.4886	0.3947	0.3223 0.4363
0.4545 0.4664	0.4036	0.3015 0.3964
0.4262	0.4216	0.4730 0.3462
0.4176 0.3866	0.4350	0.4626 0.3111
0.4158	0.4485	0.0728 0.2181
0.3674 0.3542		
0.3950		
0.3507 0.3421		
0.3742		
0.3142 0.3141		
0.3326		

Table 5: Weighted Normalize decision matrix, V_{ij}

UTS YS HBN	Elongation	Thermal conductivity Heat transfer coefficient
0.0012145 0.0238552	0.0827318	0.1832967 0.1727470
0.0614410	0.0970719	0.0981381 0.1209492
0.0010775 0.0205966	0.0992781	0.0918066 0.1099060
0.0535975	0.1036905	0.1440414 0.0959706
0.0009902 0.0170731	0.1069997	0.1408757 0.0862421
0.0522902	0.1103090	0.0221062 0.0604746
0.0008711 0.0156401		
0.0496757		
0.0008315 0.0151055		
0.0470612		
0.0007449 0.0138724		
0.0418322		

Table 6: Determine the ideal and negative ideal solutions

$A^+ A^-$
0.0012145 0.0007449
0.0238552 0.0138724
0.061441 0.0418322
0.08273176 0.11030901
0.1832967 0.0221602
0.172747 0.0604746

Table 7: Calculate separation measures by using the equation (10).

$S_j^+ S_j^- C_i^*$	Rank
0 0.199537 1	1
0.101058 0.098938 0.4947	4
0.112796 0.086807 0.434898	5
0.089894 0.127371 0.586248	2
0.100772 0.121644 0.546919	3
0.199537 0 0	6

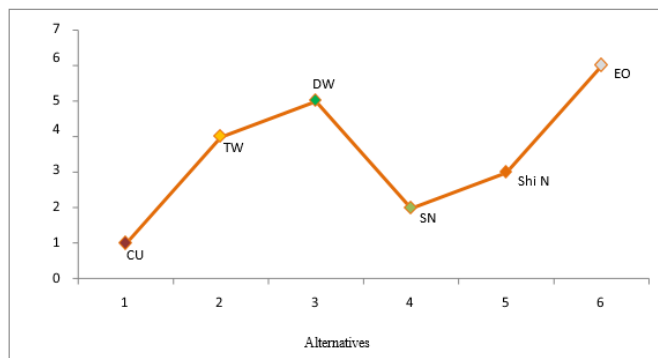


Fig. 1. Ranking of the cooling media

CONCLUSION

In this research, the author developed a novel methodology to offer a straightforward strategy for evaluating alternate cooling media and assisting decision makers in choosing the optimal one. Therefore, TOPSIS also takes into account how far an alternative is from the positive ideal solution and how far it is from the negative ideal solution. In TOPSIS modelling method of solution quality when applied to a benchmarking problem in cooling media selection for metallurgical operation on the basis of some selected criteria which enhance the mechanical and microstructure of metals, with the help of normalized decision matrix methods estimate criteria weights so that human decision may be ignored by allocating weights to several attributes. The results showed that one of the cooling medium is the most highly ranked by both techniques. Being the TOPSIS method's most frequently used option shows that it is the closest to the ideal solution, and to be as close to the ideal as is practical is what drives human decision-making. According to the TOPSIS approach, cow urine has the highest ranking index C_j^* . Quenching media selection is important for metallurgical operations, it plays a crucial role

to improve the mechanical characteristics and refine the grain structure. Above quench media cow urine got the first rank compared with other media

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