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Multi-Response Optimization of Turning Parameters with Vikor-Entropy Method on Machining of AA6061-TiB_2 In-Situ Composites

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Abstract

In the manufacturing and metal cutting industries, the quality of the surface and strength is essential in defining the surface finish; an excellent surface finish indicates excellent quality in the product. The influence of machining parameters speed, feed and depth of cut on responses like material removal rate, surface roughness and Power consumption on turning of AA6061-TiB_2 composites is investigated using the VIKOR-ENTROPY method. The effects of changing parameters on AA6061-TiB_2 in-situ composite produced by the halide salt reaction method are explored in this paper. Twenty-seven experimental runs are carried out based on an orthogonal array. Material removal is selected as a quantitative target, and surface roughness is chosen as a qualitative target. This paper also refers to the Multi-response parameter optimization of CNC turning, such as speed, feed, and depth of cut, to improve material removal rate while simultaneously minimizing surface roughness and power consumption in turning composite. In order to handle these disparate responses, a novel entropy-VIKOR approach is used. The entropy approach calculates each response's weight, and VIKOR is employed to rank the different parameter values. The combination of 1200 rpm speed, 150 mm/min feed, and 0.6 mm depth of cut is the best setting for this technique to simultaneously minimize surface roughness, power consumption and increase material removal rate.

Keywords: In-situ composites, turning, entropy, vikor, optimization

INTRODUCTION

The in-situ method enhances mechanical properties and corrosion resistance by maintaining the homogeneous ceramic particle dispersion within a metal matrix. In the ex-situ composite manufacturing method, mechanical properties are weak due to cluster formation and poor wetting between particles and matrix [1]. The surface tension of the alloy influences the distribution of particles in liquid aluminium. Fine particles of clusters reduce their surface energy. The holding times for the melt and clump formation using quick extraction and solidification approach [2]. After a holding time of ten minutes, the exothermic reaction between the halide fluxes began and ended in 18 minutes. After 20 minutes, the formation of Ti_3B_4 was observed [3]. Aluminium composites are suited for a wide range of engineering applications due to their superior thermodynamic properties and strong bonding abilities. Chemical reactions during in-situ

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composite creation spread the particles evenly throughout the mold and provide uniform reinforcements [4]. The in-situ method by the salt reaction can eliminate the aggregation and variation in microstructure; ex-situ composite fabrication causes poor wetting and thermodynamic imbalance between the matrix and the reinforcement. [5]. The in-situ technique of particle enhancement in the Al matrix leads to a clean matrix particle interface, which results in superior load transfer and improves wear resistance [6]. The production of Al-MMC by varying their properties concerning the holding time of the melt in the induction field has attracted minimal investigation. The present work deals with the microstructural, mechanical, and corrosive properties of AA6061 matrix alloy reinforced with particles by the in-situ method. A study was done on the best holding times for manufacturing composites with different amounts of reinforcement. The machined work's quality, accuracy, and effectiveness are all enhanced by choosing the right machining parameters and tool conturations [7]. Measurement of surface roughness is an important parameter in the studies of machining. Surface roughness gives the grade and quality of the machined surface required for manufacturing and is acquired by measuring surface roughness. Setting proper machining conditions yields high-quality components [8]. In metal-removing operations, surface roughness and material removal rate are major manufacturing parameters; the improved production rate at a lower cost is achieved by a high rate of material removal. The rate of material removal affects the machining cost, so optimum parameter selection plays a key role in maximizing the material removal rate (MRR) [9]. A tool made of carbide was used to analyze the importance of flank buildup and Cutting speed; greater tool wear and worse surface quality were observed at less utilization of cutting fluids. [10]. Every machining operation can be performed more effectively by selecting the optimum machining settings. The best machining parameters are often chosen based on past performance and information from industry standard handbooks, most of the time, this is not the best option [11–12]. ZK60 wrought magnesium alloy was turned on in both dry and cryogenic environments, and findings reveal that in both cases, a larger feed rate causes the Ra to rise [13]. The decision-making process in manufacturing is extremely complicated because of the various interests and values of the decision-makers. To effectively resolve decision-making challenges, it is essential to identify a clear, systematic, and logical approach. Opricovic created the VIKOR technique to solve multiple-criteria decision-making situations with conflict criteria by considering compromise solution. The solution is focused on maximizing "group utility" for the majority and minimizing "individual regret" for the minimum. The 'closeness' to the 'ideal' solution is used to evaluate a VIKOR index in this approach. Furthermore, this method provides a practical solution, a close to ideal solution, and a far from unfavorable solution. The Entropy-VIKOR technique has been quite significant in handling multi-criteria decision-making problems in a wide range of technical applications. The weight of the criterion acquired from the entropy technique is combined with the VIKOR steps in this method. The area of operations research models associated with multi-criteria analysis, generally it is known as multi-criteria decision-making (MCDM) or multi-criteria decision aid methods (MCDA), it deals with the process of making decisions when there are several outcomes. These techniques, which can handle both quantitative and qualitative criteria, all have problems with designing and selecting alternatives as well as a conflict between criteria and incommensurable units [14]. There are two types of MCDM techniques: Multi-Objective Decision Making (MODM) and Multi-Attribute Decision Making (MADM). The selection of options establishes the basis of the primary differentiation between the two categories of procedures. The alternatives are not defined in MODM, sometimes referred to as multi-objective programming or a vector optimization/maximization/minimization issue. Instead, a set of objective functions is optimized under a set of restrictions. In MADM, where options are preset, a select few options must be evaluated against a set of criteria. Typically, the optimal option is chosen by comparing options for each attribute. [15]. The machining conditions and nose radius for turning composite material were optimized using GRA and the entropy measuring method. The outcomes demonstrated the effectiveness of this strategy; to establish the weight criterion of each output parameter, the entropy method was used [16]. Taguchi process, GRA, and entropy measurement combination methodologies were designed for simultaneous optimization of electric discharge machining parameters. Grey relational grade values were calculated by determining the weight of each machining parameter using the entropy approach. With the help of this integrated strategy, better machining qualities were attained [17]. Multi-objective optimization utilizing GRA and the entropy technique simultaneously. This method was used to transform multi-objective optimization into a single-objective optimization equivalent. Using the entropy observation method, Each objective function's corresponding weight factor was determined [18]. The Entropy-VIKOR technique can optimize the drilling parameters along with the reinforcement ratio for A6061-in-situ composites. This raises the material removal rate per unit time, decreases delamination, and reduces the radial overcut of the drilled hole. The validation results indicated a high correlation between the experimental results from the same run and the predicted value obtained from the VIKOR index [19]. A multiple criteria problem is hierarchically organized in AHP by being divided into smaller and smaller congruent elements. The hierarchy is organized with the objective (aim) at the top, the criteria and sub-criteria at the levels and sub-levels, and the decision choices at the bottom. Typically, the optimal solution is chosen by evaluating each alternative about each attribute. Planning with RE has made use of this method [20–21]. The TOPSIS technique includes vector normalization, and the normalized value could differ for a specific criterion's evaluation unit. The VIKOR method uses linear normalization, and the normalized values do not depend on the evaluation unit of a criterion. The VIKOR technique introduces an aggregating function that measures the deviation from the ideal solution while considering the relative weights of all criteria and finding a compromise between overall and individual satisfaction. The TOPSIS technique, in turn, introduces an aggregating function that includes the separations from the ideal point and the negative-ideal point without taking into account their relative significance. The rationale for human choice is to become as close to the ideal as possible; however, the reference point could be a significant consideration in decision-making [22]. Titanium Carbide (TiC) is added to a niobium-based metal matrix alloy using weight percentages of 2, 4, and 6 during the sintering process of powder metallurgy. After adding the TiC particle, several material characteristics are measured, including hardness, tensile strength, impact strength, and density. Analysis of variance is used to identify the variables that have the greatest impact on Surface Roughness (SR) and Material Removal Rate (MRR). The best MRR and SR values are systematically evaluated using the Taguchi technique [23–24] Based on the literature study, only a few researchers are involved in the estimation of optimum machining parameters in turning operations with the VIKOR approach. In addition, only a few studies have been published on determining weight criteria using the entropy concept in optimizing turning process parameters. The according to the authors' knowledge, there is no literature on machining parameter optimization utilizing a combined VIKOR and entropy method. As a result, more research is needed to evaluate the proposed method for selecting optimal machining settings in AA6061-machining. As a reason, this research study focuses on estimating the optimal machining conditions that minimize surface roughness and power consumption while maximizing MRR using a combined VIKOR and entropy approach.

EXPERIMENTAL WORK

The matrix was composed of AA6061, while the ceramic wasTiB_2. The ceramic phase was created in situ by reacting aluminium melt with the halide salts K_2TiF_6 and KBF_4. Our previous study described the fabrication and characterization of an AA6061-TiB_2 in-situ composite [25, 26]. The composite was shaped into a ϕ25 mm rod, and turning operations were conducted on a 120 mm length. The Cutting tool material is a multi-layer coated CVD turning insert. Three layers (TiN/TiCN/Al_2O_3) constitute this coated tool; Al_2O_3 provides wear resistance at high hardness, TiN offers wear resistance and thermal stability, and TiN offers heat resistance and decreases the coefficient of friction. A CNC system (at Sri Vasavi Engineering College at Tadepalligudem) was used throughout the experimental work, and the machining setup is represented in Figure 1 and AA6061-machined component shown in Figure 2. For the experiments, Taguchi's L_{27} orthogonal array is used. The Cutting speed, feed rate, and depth of cut are employed as input parameters in this study, whereas MRR, SF, and power consumption are used as responses in the turning process. The level of input parameters and their values are shown in Table 1. The surface roughness of the machined component is measured using a Mitutoyo Surftest SJ 301 roughness measurement equipment. For machined samples, surface roughness is measured in three locations, with the average value used for analysis. The responses are shown in Table 2.

Figure 1. CNC machine Set-Up.

Figure 2. Component.

Table 1. Machining Parameters

Parameters	Units	Level 1	Level 2	Level 3
Speed	rpm	1000	1200	1400
Feed	mm/min	50	100	150
Depth of Cut	mm	0.2	0.4	0.6

Table 2. Design of Experiments and measured responses

S.N.	SPEED	FEED	DC	W1 (gm)	W2 (gm)	Time (S)	MRR=(W1-W2)/T (gm/sec)	SR (Ra) (µm)	Power (kw)
1	1000	50	0.2	101.22	100.91	60.72	0.306	4.595	8.102
2	1000	50	0.4	100.91	100.28	61.81	0.612	4.508	10.515
3	1000	50	0.6	100.28	99.19	59.95	1.091	4.388	9.123
4	1000	100	0.2	99.19	98.84	29.79	0.705	6.677	9.286
5	1000	100	0.4	98.84	98.05	28.94	1.638	9.565	7.504
6	1000	100	0.6	98.05	97.13	29.8	1.852	4.305	6.496
7	1000	150	0.2	97.13	96.74	19.73	1.186	8.53	7.925
8	1000	150	0.4	96.74	95.92	19.96	2.465	7.629	6.425
9	1000	150	0.6	95.92	94.9	19.83	3.086	6.6115	4.088
10	1200	50	0.2	94.9	94.79	62.11	0.106	5.828	6.046
11	1200	50	0.4	94.79	94.21	61.19	0.569	4.4365	3.772
12	1200	50	0.6	94.21	93.23	60.2	0.977	4.895	4.933
13	1200	100	0.2	93.23	92.96	29.33	0.552	5.762	6.608
14	1200	100	0.4	92.96	92.34	29.96	1.242	4.08	5.485
15	1200	100	0.6	92.34	91.21	29.99	2.261	6.32	7.526
16	1200	150	0.2	91.21	91	19.78	0.637	6.25	4.205
17	1200	150	0.4	91	90.15	17.98	2.836	6.49	3.121

18	1200	150	0.6	90.15	88.97	20.13	3.517	7.83	3.890
19	1400	50	0.2	88.97	88.85	62.15	0.116	5.604	6.419
20	1400	50	0.4	88.85	88.44	62.43	0.394	6.811	3.731
21	1400	50	0.6	88.44	87.65	61.2	0.775	5.447	6.090
22	1400	100	0.2	87.65	87.37	30.54	0.550	7.849	2.552
23	1400	100	0.4	87.37	86.69	30.29	1.347	3.702	3.321
24	1400	100	0.6	86.69	85.89	30.39	1.579	5.751	4.137
25	1400	150	0.2	85.89	85.85	21.09	0.114	5.727	5.184
26	1400	150	0.4	85.85	85.19	25.3	1.565	8.096	4.379
27	1400	150	0.6	85.19	84.29	22.66	2.383	8.271	2.470

VIKOR-ENTROPY METHOD

Multi-criteria decision making (MCDM) or multi-criteria decision analysis is a method that is used in the VIKOR approach. Serafim Opricovic created it to address decision-making issues involving competing and incomparable (different units) criteria under the assumption that compromise is acceptable for resolving conflicts, the decision-maker seeks the best alternative, and the alternatives are assessed using all established criteria. While ranking possible solutions, VIKOR selects the one that comes the closest to the optimum compromise solution.

Rate of material removal is estimated by using the formula

$$MRR = (W1-W2)/t$$

Where

W1-Component weight before machining

W2-Component weight after machining

t-Cycle time.

In the Entropy-VIKOR method, the steps of the VIKOR technique are combined with the weights of the entropy concept's criteria. The Entropy-VIKOR approach's steps are explained below.

Entropy Method

Step 1: The entropy method is used to calculate each criterion's weight. The estimation of the projection value for each alternative, the entropy value, and the dispersion value are performed in three steps to estimate the values.

Formula for the projection value:

$$\phi_{ab} = \frac{z_{ab}}{\sum_{a=1}^{m} z_{ab}} \tag{1}$$

Formula for the entropy measure:

$$\beta_b = -\eta \sum_{b=1}^{n} \phi_{ab} \ln\left(\phi_{ab}\right) \tag{2}$$

Where η is constant and is calculated as

$$\eta = \frac{1}{\ln(m)} \tag{3}$$

Formula for the dispersion value $\theta_b = 1 -$ entropy value (4)

Formula for calculating the weight of each criterion $\delta_b = \dfrac{\theta_b}{\sum_{b=1}^{n} \theta_b}$ (5)

VIKOR-Method

Step 2: Development of the relative decision matrix using several criteria (n) and alternatives (m). The decision matrix is represented as

$$Z_{mxn} = \begin{pmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{m1} & \cdots & z_{mn} \end{pmatrix}$$

Where zab (a = 1,2,3…m; b= 1,2…n), which denotes the real value of the ath alternative and bth criterion.

Step 3: Estimating the utility, regret measures and VIKOR index for each alternative and ranking of the alternatives.

Formula for utility measure: k+a= $\sum_{b=1}^{n} \dfrac{\delta_b \left[\left(z_{ab} \right)_{\max} - z_{ab} \right]}{\left[\left(z_{ab} \right)_{\max} - \left(z_{ab} \right)_{\min} \right]}$ (6)

if b is the benefit criteria for

b =1,2,3...m

Formula for utility measure k-a = $\sum_{b=1}^{n} \dfrac{\delta_b \left[z_{ab} - \left(z_{ab} \right)_{\min} \right]}{\left[\left(z_{ab} \right)_{\max} - \left(z_{ab} \right)_{\min} \right]}$ (7)

if j is the cost criteria.

Formula for regret measure $\mu_a = Max \left\{ \dfrac{\delta_b \left[\left(z_{ab} \right)_{\max} - z_{ab} \right]}{\left[\left(z_{ab} \right)_{\max} - \left(z_{ab} \right)_{\min} \right]} \right\}$ (8)

for b =1,2...n

Formula for VIKOR index $\tau = \chi \left[\dfrac{\left(k_a - k^-{}_a \right)}{\left(k^+{}_a - k^-{}_a \right)} \right] + \left(1 - \chi \right) \left[\dfrac{\mu_{a-} \mu_a^-}{\mu_a^+ - \mu_a^-} \right]$ [9]

Where χ is the weight of the utility. The utility measure component has a weight of 0.5, while the regret measure component has a weight of 1- χ . The VIKOR index value determines the order of the possibilities. The best option from the selection of possibilities is the one with the lowest VIKOR index.

RESULTS AND DISCUSSION

Speed, feed, and depth of cut are the three variables having alternatives (A-1 to A-27), the criteria's are the rate of material removal, surface roughness, and power consumption. The rate of material removal is benefit criteria that should be maximized. Power consumption and surface roughness are cost criteria that should be minimized. The following steps use the Entropy-VIKOR method to optimize the results obtained from experimental work under various sets of alternates.

Step 1: Applying the entropy approach to determine each criterion's weights

The measurement of projection value, entropy value, and dispersion value comprise the calculation of weight for each criterion. Equation 1 is used to get the projection value for each alternate, and it is displayed in Table 2. Utilizing equations 2, 3, 4, and 5, the entropy value, dispersion value, and weight for each criterion are determined and shown in Table 3.

Table 3. Projection Values for the alternates

S.N.	Speed	Feed	DC	W1	W2	Time (S)	MRR=(W1-W2)/T	SR	Projection value for MRR	Projection value for SF	Projection value for power
1	1000	50	0.2	101.22	100.91	60.72	0.005105402	4.595	0.009	0.025	0.061
2	1000	50	0.4	100.91	100.28	61.81	0.010192525	4.508	0.018	0.024	0.085
3	1000	50	0.6	100.28	99.19	59.95	0.018181818	4.388	0.032	0.024	0.072
4	1000	100	0.2	99.19	98.84	29.79	0.011748909	6.677	0.020	0.041	0.073
5	1000	100	0.4	98.84	98.05	28.94	0.027297858	9.565	0.048	0.063	0.055
6	1000	100	0.6	98.05	97.13	29.8	0.030872483	4.305	0.054	0.023	0.045
7	1000	150	0.2	97.13	96.74	19.73	0.019766853	8.53	0.034	0.055	0.060
8	1000	150	0.4	96.74	95.92	19.96	0.041082164	7.629	0.072	0.048	0.045
9	1000	150	0.6	95.92	94.9	19.83	0.051437216	6.6115	0.090	0.041	0.021
10	1200	50	0.2	94.9	94.79	62.11	0.001771051	5.828	0.003	0.035	0.041
11	1200	50	0.4	94.79	94.21	61.19	0.009478673	4.4365	0.017	0.024	0.018
12	1200	50	0.6	94.21	93.23	60.2	0.01627907	4.8955	0.028	0.027	0.030
13	1200	100	0.2	93.23	92.96	29.33	0.009205592	5.762	0.016	0.034	0.046
14	1200	100	0.4	92.96	92.34	29.96	0.020694259	4.08	0.036	0.021	0.035
15	1200	100	0.6	92.34	91.21	29.99	0.037679226	6.32	0.066	0.038	0.056
16	1200	150	0.2	91.21	91	19.78	0.010616785	6.25	0.018	0.038	0.022
17	1200	150	0.4	91	90.15	17.98	0.04727475	6.49	0.082	0.040	0.011
18	1200	150	0.6	90.15	88.97	20.13	0.058618977	7.83	0.102	0.050	0.019
19	1400	50	0.2	88.97	88.85	62.15	0.001930813	5.6045	0.003	0.033	0.044
20	1400	50	0.4	88.85	88.44	62.43	0.006567355	6.8115	0.011	0.042	0.018
21	1400	50	0.6	88.44	87.65	61.2	0.012908497	5.4471	0.022	0.032	0.041
22	1400	100	0.2	87.65	87.37	30.54	0.009168304	7.8495	0.016	0.050	0.006
23	1400	100	0.4	87.37	86.69	30.29	0.022449653	3.7025	0.039	0.018	0.013
24	1400	100	0.6	86.69	85.89	30.39	0.026324449	5.751	0.046	0.034	0.022
25	1400	150	0.2	85.89	85.85	21.09	0.001896633	5.727	0.003	0.034	0.032
26	1400	150	0.4	85.85	85.19	25.3	0.026086957	8.0965	0.045	0.052	0.024
27	1400	150	0.6	85.19	84.29	22.66	0.039717564	8.271	0.069	0.053	0.005

Step 2: possibilities (T-1 to T-27) are coupled to create a relative decision matrix using the performance criteria of material removal, surface roughness, and power consumption

(C-1 to C-3).

$$
ZmXn = \begin{bmatrix}
0.276348 & 0.037184 & 0.1245501 \\
0.385291 & 0.074235 & 0.1212414 \\
0.322448 & 0.132422 & 0.1166777 \\
0.32982 & 0.08557 & 0.2037297 \\
0.249366 & 0.198817 & 0.3135619 \\
0.203885 & 0.224852 & 0.1135212 \\
0.268368 & 0.143967 & 0.2742003 \\
0.200674 & 0.299211 & 0.2399348 \\
0.095166 & 0.374629 & 0.2012387 \\
0.183563 & 0.012899 & 0.1714417 \\
0.080891 & 0.069035 & 0.1185222 \\
0.133299 & 0.118564 & 0.1359782 \\
0.208922 & 0.067046 & 0.1689317 \\
0.15822 & 0.150721 & 0.1049643 \\
0.250381 & 0.274427 & 0.1901528 \\
0.100456 & 0.077325 & 0.1874906 \\
0.051516 & 0.344313 & 0.196618 \\
0.086211 & 0.426936 & 0.2475789 \\
0.200394 & 0.014063 & 0.1629419 \\
0.079025 & 0.047832 & 0.2088448 \\
0.185525 & 0.094016 & 0.1569559 \\
0.025826 & 0.066775 & 0.2483205 \\
0.060551 & 0.163506 & 0.0906078 \\
0.097373 & 0.191727 & 0.1685134 \\
0.144626 & 0.013814 & 0.1676007
\end{bmatrix}
$$

Step 3: utility measure, regret measure, VIKOR index estimation, and ranking of the alternatives

Equation 6 is used to calculate the utility measure for the rate of material removal, while equation 7 is used to calculate the surface roughness and power consumption. Moreover, the equation 8 is used to estimate the regret measure. Utilizing the utility and regret measure values in equation 9 to generate the VIKOR index, and it is reported in Table 4. The utility measure component's weight is $\upsilon = 0.5$ whereas the weight for the regret measure component is $(1-\upsilon)$. The alternate with minimum value of the VIKOR index is considered to be the best alternative among the others. The alternate A-19, which can be considered the best alternate among all alternates, has the lowest value of the VIKOR index, which is evident from Table 4, 1400 speed, 50 feed, and 0.2 depth of cut are the associated cutting parameters. This level of turning parameters provides a higher rate of machining along with the least amount of power consumption and surface roughness Shown in Table 5. Using the Entropy-VIKOR technique, the choice of selecting the level of machining parameter is made by the following order of preference T-18 > T-9 > T-17 > T-27 > T-8 > T-15 > T-6 > T-24 > T-23 > T-26 > T-14 > T-5 > T-12 > T-11 > T-7 > T-22 > T-16 > T-3 > T-21 > T-20 > T-13 > T-4 > T-2 > T-25 > T-1 > T-10 > T-19.

Table 4. Entropy value, dispersion value and weight for each criterion

Criteria	**C1**	**C2**	**C3**
Entropy	0.917	0.985	0.95
Dispersion value	0.083	0.015	0.05
Weight	0.554	0.100	0.346

Table 5. Utility measure, regret measure, VIKOR index and ranking

Alternatives	Machining parameters and their levels			Utility measure	Regret measure	VIKOR Index	Ranking
	Speed	***Feed***	***DC***				
T-1	1000	50	0.2	0.764962806	0.521130421	0.927772146	25
T-2	1000	50	0.4	0.817853958	0.471590564	0.915042836	23
T-3	1000	50	0.6	0.694683951	0.393788558	0.744578388	18
T-4	1000	100	0.2	0.8022001	0.456434058	0.887920436	22
T-5	1000	100	0.4	0.621818486	0.305013971	0.599450298	12
T-6	1000	100	0.6	0.456685225	0.27020325	0.442904518	7
T-7	1000	150	0.2	0.696163476	0.378353042	0.7296678	15
T-8	1000	150	0.4	0.409151891	0.170778469	0.305226406	5
T-9	1000	150	0.6	0.202106992	0.070942089	0.050739212	2
T-10	1200	50	0.2	0.745886782	0.553601275	0.947491369	26
T-11	1200	50	0.4	0.549932541	0.478542262	0.726763692	14
T-12	1200	50	0.6	0.541264092	0.412318063	0.651835546	13
T-13	1200	100	0.2	0.696573843	0.481201607	0.836510885	21
T-14	1200	100	0.4	0.508545842	0.369321694	0.583422555	11
T-15	1200	100	0.6	0.468042133	0.217636435	0.396735318	6
T-16	1200	150	0.2	0.587484183	0.467459007	0.742680639	17
T-17	1200	150	0.4	0.18780617	0.11047331	0.081256544	3
T-18	1200	150	0.6	0.132564942	0.071452022	0.000528253	1
T-19	1400	50	0.2	0.75668259	0.552045476	0.953756501	27
T-20	1400	50	0.4	0.615768895	0.506893501	0.804168989	20
T-21	1400	50	0.6	0.633000007	0.445141663	0.752770701	19
T-22	1400	100	0.2	0.556879768	0.481564725	0.734963575	16
T-23	1400	100	0.4	0.392090917	0.352227164	0.480746114	9
T-24	1400	100	0.6	0.423329646	0.314493303	0.464448939	8
T-25	1400	150	0.2	0.705870579	0.552378321	0.917027888	24
T-26	1400	150	0.4	0.474829686	0.316806071	0.504420215	10
T-27	1400	150	0.6	0.262810043	0.184067336	0.212218893	4

The conditions in order to determine whether the best alternative satisfies the compromise solution [27, 28]

Condition 1: Acceptable benefit: $= \varpi$ [A-26 (Second rank)] - ϖ [A-15 (First rank)] ≥ XY; where XY is denoted as approach value and it is calculated by

$$XY = \frac{1}{M} \tag{13}$$

Condition 2: Acceptable stability requirement: The alternate with the highest VIKOR index A-19 should also have the highest utility measure and regret measure.

The second best rank given by VIKOR index is 0.050739212 and first rank is 0.000528253. The approach value XY is $\frac{1}{27-1} = \frac{1}{26}$ = 0.0384. The acceptable advantage 0.05021 ≥ 0.0384. Hence, the condition 1 is satisfied. Figure 3 illustrates the VIKOR Index, the utility measure, and the regret measure for each alternative. The utility measure, regret measure, and VIKOR Index are follow a similar trend, as shown in Figure 3. Additionally, the A-18 is the good alternative, because the condition 2 was also satisfied.

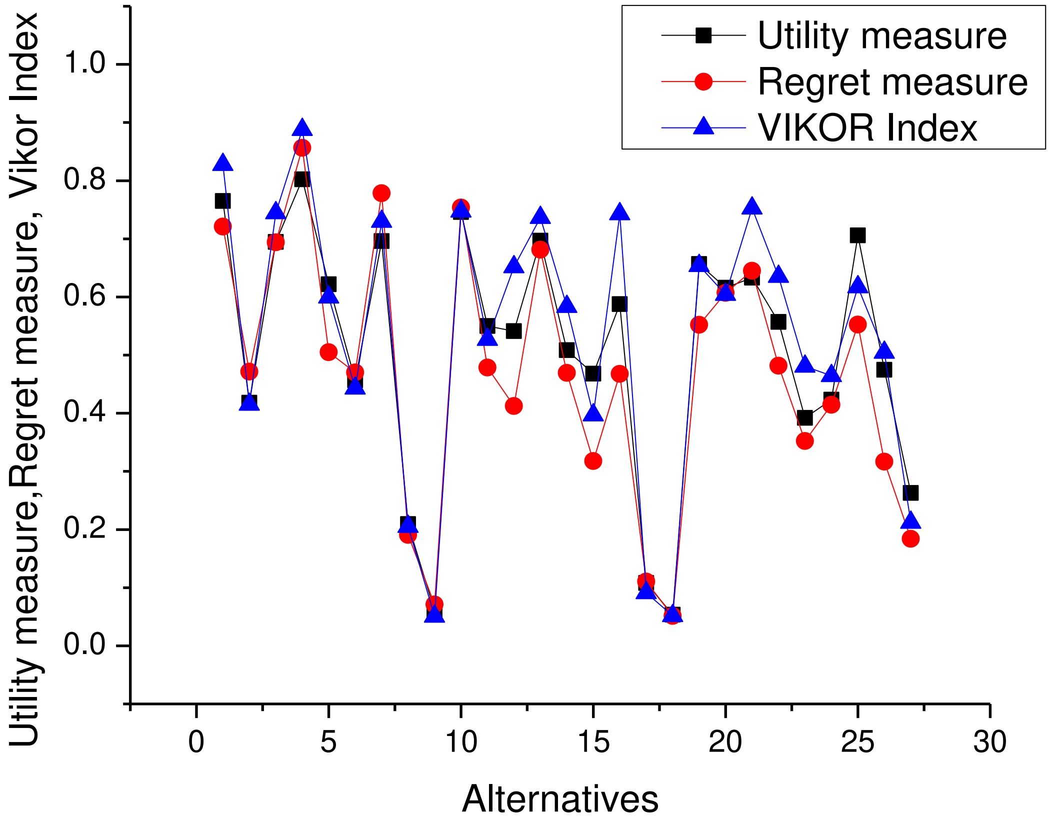

Figure 3. Utility measure, Regret measure and VIKOR Index Comparison.

The A-18 alternative satisfied the criteria for a stable and acceptable advantage. The best alternative is A-18 alternate because it simultaneously provides the highest rate of material removal, the lowest surface roughness, and the least amount of power consumption. All of the responses are combined into one response through the use of the Entropy-VIKOR approach. More advanced parameter optimization results in more effective machining.

The comparison of the material removal rate and surface roughness at various alternatives is shown in Figure 4. The alternate 18 has a higher rate of material removal, as shown in Figure 4, and the corresponding levels of machining parameters are 1200 Speed, 150 Feed, and 0.6 Depth of Cut. The alternate 23 also has the least amount of surface roughness, and the equivalent levels of the machining parameters are 1400 speed, 100 feed, and 0.4 depth of cut.

The alternate 27 has the lowest power consumption, as shown in Figure 5, and the corresponding levels of the machining parameters are 1400 speed, 150 feed, and 0.6 depth of cut. The higher value of speed within the chosen levels leading to increased rate of material removal rate from the perspective of single response optimization. Moreover, the alternative 10's lower range of speed is reducing the surface polish and power usage. The single response optimization only considers one response at a time; in contrast, the multi-response optimization deals with several responses and integrates them into a single response. The alternate 18's VIKOR index values are lower than those of the other alternatives, shown in Figure 5. The alternative 18's parameter levels are 1200 speed, 150 feed, and 0.6 depth of cut. The higher speed of computer numerical machining is an advanced method where the rate of material removal is accelerated. The power consumption and surface roughness are governed by a moderate degree of feed and depth of cut.

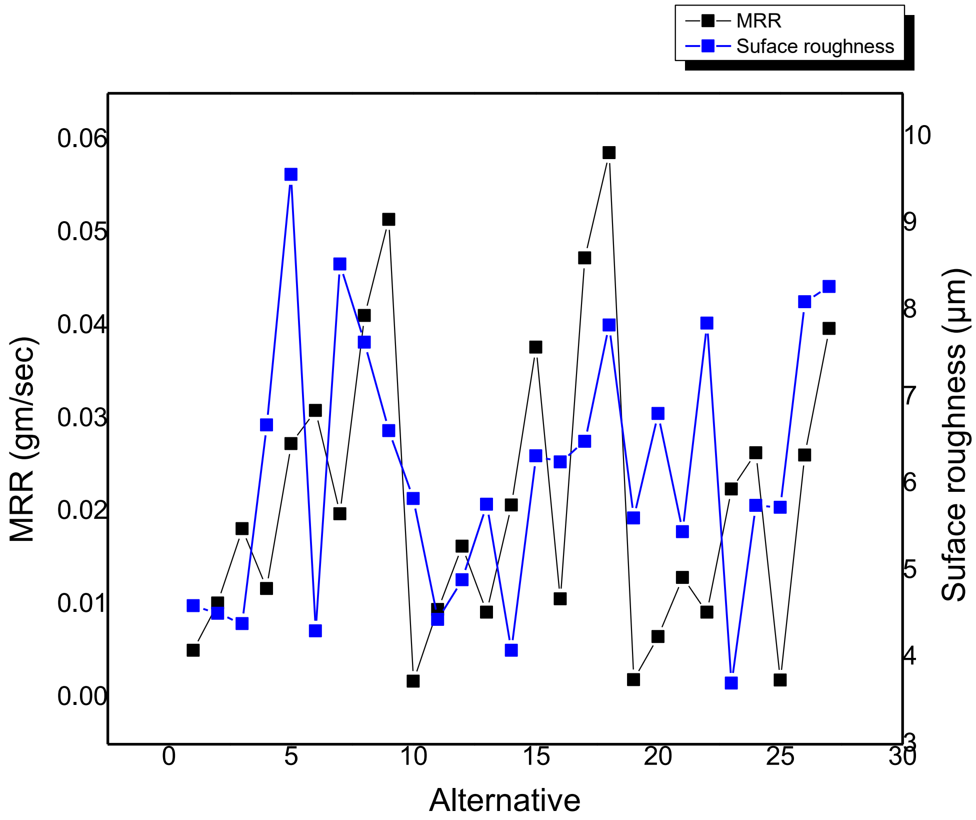

Figure 4. MRR and Surface roughness Comparison.

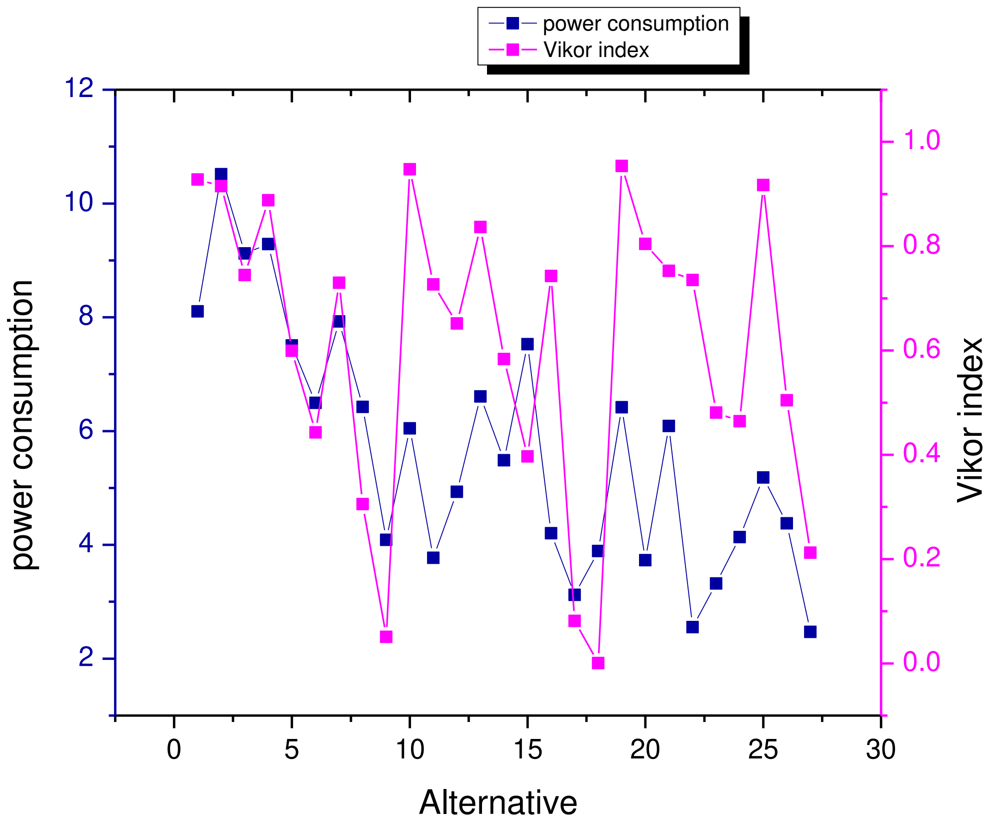

Figure 5. Power consumption and Vikor index Comparison.

CONCLUSIONS.

As the AA6061-TiB_2 in-situ composite is turned, the CNC turning operating parameters of speed, feed, and depth of cut are chosen to maximize the rate of material removal and minimizing both surface roughness and power consumption. The next conclusion is drawn in view of the experimental investigation's findings. The VIKOR entropy approach is used to determine the ideal level of the turning process regulating parameters. The optimum settings for minimizing surface roughness, power consumption, and maximizing the rate of material removal at the same time are 1200 speed, 150 feed, and 0.6 depth of cut. Also, the ideal parameters fit the requirements for a compromising solution, including an acceptable advantage and an acceptable stability condition. Vikor entropy is a useful method for resolving optimization issues in CNC turning. With regard to the importance of the process responses, the operator can select the predetermined pairings of the lathe settings.

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