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RELEVANT OPTIMIZATION METHOD SELECTION IN TURNING OF AISI D2 STEEL USING CRYOGENIC COOLING

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Abstract: Now a day's most of the industrial work is based upon use of newly developed techniques which makes decision making process very easy with ultimate solutions. The present paper related with experimental investigation carried out for study of hardened AISI D2 tool steel in arrangement with CVD coated inserts and cryogenic cooling to obtain optimum process parameters using novel MCDM method as EDAS and TOPSIS method. RSM analysis and multi criteria decision making (MCDM) techniques was integrated for optimization of process parameters as cutting speed, feed and depth of cut with most important consideration of quality responses i.e., surface roughness, material removal rate. Finally according to lesser error result most relevant method is presented.

***Index Terms* - AISI D2 steel, Cryogenic, RSM, MCDM, EDAS, TOPSIS.**

I. INTRODUCTION

Cryogenic cooling is one of the inventive and sustainable methods which is capable of replacing conventional oil-based cutting fluids below various conditions. The method has already proved to have a great potential in many different machining setups, performing equally or better than conventional cooling. There is availability of several cryogenic liquids but for machining operations, mostly preferable liquids for all machining operations are CO2 and LN2 [1]. The cryogenic liquid is supplied to the cutting zone through various ways and equipment. The liquid is stored in cylindrical or spherical shaped tanks including pressure control and vaporizer [2]. During spraying process the pressurized tank it forces out the coolant at the cutting zone to get the cryogenic cooling effect so additional energy not required for the application [3].To improve the productivity it is important to increase the metal removal rate with better surface finish and economical machining some other methods like use of cutting fluids, Hot machining, Cryogenic cooling, Coated tools are implemented to reduce tool wear and to increase tool life [4]. There are many parameters such as cutting speed, feed rate, and tool nose radius that are known to have a large impact on tool life and surface finish.

Multi-criteria decision making (MCDM) methods are very useful to deal with such situations. Using the MCDM methods helps decision-makers to assess and select the most desirable alternatives. Many MCDM methods and techniques which have been developed. The AHP (Analytic Hierarchy Process), ANP (Analytic Network Process), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), VIKOR (VIseKriterijumska Optimizacija I Kompromisno Resenje), COPRAS (Complex Proportional Assessment), WASPAS (Weighted Aggregated Sum Product Assessment), MOORA (Multi-Objective Optimization on the basis of Ratio Analysis) and EDAS (Evaluation Based on Distance from Average Solution) [5] are some of the MCDM methods. RSM analysis are also one of the best methods to which used to define the turning process parameters considered are cutting velocity, feed rate and depth of cut whereas responses are such as tool flank wear, surface roughness and material removal rate [6].

Das et al. have approached Taguchi as well as RSM concept for analyzing the variables. Quality of work surface highly subjected by cutting feed whereas it was improved with cutting speed till 170 m/min thereafter due to chatter it was reducing with speed [7-8]. Elbah et al. applied the desirability function methodology for the optimization of multiresponses data. RSM based empirical equations of second order and three-dimensional surface graphs were developed. Model ANOVA revealed the successful prediction of surface roughness with 95% of the confidence level [9]. Mandal et al. developed the mathematical relation based on regression of second order and its adequacy was checked by ANOVA. Point prediction optimization approach was implemented to select the optimal values of parameters [10]. Paul et al. studied experimentally the effect of the depth of cut, feed, nose 64 radius and tool geometry on simultaneous minimization of back force and specific cutting 65 energy during turning of AISI 1060 steel with uncoated carbide inserts under dry machining 66 environment [11]. Gadakh developed TOPSIS method to solve multiple criteria optimization problem and stated that it is an effective tool for complicated decision making [12]. Kumar et al (2011) compared the previous analysis based on Taguchi's robust design idea to TOPSIS method of decision making. Taguchi and TOPSIS approach used to resolve electroplating process based on plating time [13]. Parida and Routara inspected the special effects of optimum cutting condition in accordance of TOPSIS in the turning of GFRP composite material, result showed the advantage over surface roughness quality with smaller the better approach combined with Taguchi[14]. Turskis et al. worked with the EDAS method was originally defined for multi-criteria inventory classification[15]. Keshavarz Ghorabaee et al. suggested the prolonged EDAS method for selection of supplier [16]. Kahraman et al. proven the EDAS model under application of fuzzy information for solid Waste disposal site selection[17]. Manivannan and Kumar optimization of the micro-EDM drilling process using Taguchi coupled TOPSIS method in machining AISI 304 under cryogenic cooling process and result into the better-optimized process parameters [18].

From the literature surveyed it was observed that less research work has been performed on multiple objectives optimization of cryogenic assisted turning of AISI D2 steel. As per study, this paper aiming work to perform experiment on AISI D2 steel turning under cryogenic condition along with CVD coated carbide insert using CNC retrofitted machine. Intention of this paper is to perform multiple objective optimizations using EDAS and TOPSIS simple methods and comparing those two methods to finding out the best of them for given field.

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For this study secondary data has been collected. From the website of KSE the monthly stock prices for the sample firms are obtained from Jan 2010 to Dec 2014. And from the website of SBP the data for the macroeconomic variables are collected for the period of five years. The time series monthly data is collected on stock prices for sample firmsand relative macroeconomic variables for the period of 5 years. The data collection period is ranging from January 2010 to Dec 2014. Monthly prices of KSE -100 Index is taken from yahoo finance.

II. EXPERIMENTATION

2.1 Material

For the experimentation, the turning process was performed on AISI D2 steel which is high strength material used into industries for die and tool making applications. Chemical composition of AISI D2 steel is shown in Table 1 below. Material workpiece dimensions were rod of diameter 45 and length of 100mm turning for the length of 20 mm.

Table 1:Chemical composition of AISI D2 steel

Elements	C	Mn	Si	Co	Cr	Mo	V	P	Ni	Cu	S
Content %	1.40- 1.60	0.60	0.60	1.00	11.00-13.00	0.70 – 1.20	1.10	0.03	0.30	0.25	0.03

2.2 Experimentation setup

Figure 1 show the CNC retrofitted machining setup used for the present work along with cryogenic assisted system and cooling at machining zone during turning of AISI D2 steel shown in Figure2. Turning experiments were performed under liquid nitrogen (LN2) cryogenic cooling conditions. Different process parameters and their levels used for experiments are shown in Table 2. The experiment was designed by using MINITAB software using research surface methodology. Designed experiment contains 20 Runs RSM with central composite design. The process parameters were selected based on the preliminary experiments conducted. CVD (DNMG110408) cutting tool insert was used in machining AISI D2 steel. The cutting tool insert were placed on PDJNL 1616 H11 tool holder. Prior to machining 0.5 mm of material was removed to avoid wobbling cracks, which affects the machining results. For each experiment new cutting tip was used. The output measured was material removal rate and surface roughness.

Table 2: Process Parameters and levels

Parameters	Level 1	Level 2	Level 3
Cutting Speed(m/min)	100	140	180
Feed (mm/rev)	0.10	0.12	0.14
Depth of cut (mm)	0.4	0.6	0.8

Figure 1 Cryogenic assisted retrofitted CNC

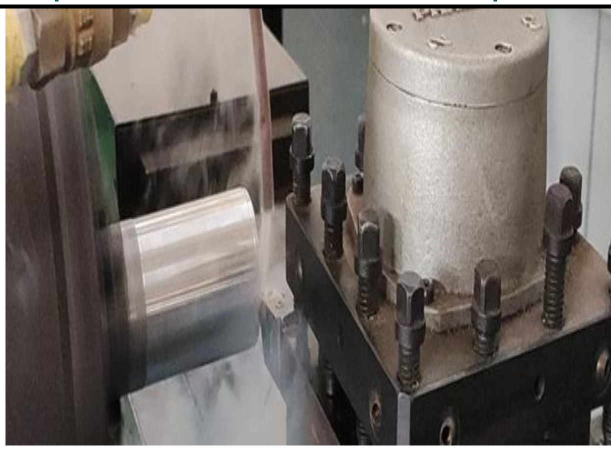

Figure 2 AISI D2 steel turning

Response parameters selected was measured as the value of MRR must be calculated by weighing the work piece before and after the experiment respectively and also noting the time required for machining. Using standard formulae MRR was calculated as weighing the work piece before machining minus weighing the work piece after machining divide by time of machining this gives accurate MRR value. The surface roughness was calculated using centre line average method. The Measurement of centre line average i.e., Ra was carried out using a portable stylus type profilometer shown in figure 3.

Figure 3 Surface Roughness measurements

2.3 Using Multi objective Optimization techniques

The ideal solution is a hypothetical solution for which all attribute values correspond to the maximum attribute values in the database comprising the satisfying solutions [19]. Most of the optimization technique used to find out the optimal solutions which gives the appropriate results or optimal solution to solve the problems accurately. In recent study two different optimization techniques was used to identify which one method gives better result of optimization. The EDAS and TOPSIS these are the two techniques compared into study.

2.3.1 Weight determination

Determination of the weight of the criteria is the most important step in optimization to know one criterion is more important than another, that which criterion should be assigned a greater weight than the other. In this work Entropy weight calculating approach was used as it is objective type weight determination method [20]. The weights calculated on the basis of responses, surface roughness and material removal rate was W1 = 0.32, W2 = 0.68. These are assigned to both optimization techniques EDAS and TOPSIS. Weighted matrix was defined using these weightages.

The Evaluation Based on Distance from Average Solution (EDAS)

EDAS was now used to determine the optimal solutions. The steps followed for calculating solution are described below.

Step1 Determine the average solution (AVj)

$$\mathrm{AVj} = \frac{\sum_{i=1}^{m} x_{ij}}{n} \qquad \dots\dots\dots\dots (1.1)$$

Step 2 Calculate the positive distance from average solution

$$\mathrm{PDAij} = \frac{\max(0, (\mathrm{Xij} - \mathrm{AVj}))}{\mathrm{AVj}} \quad \text{for maximization criteria} \qquad \dots\dots\dots\dots (1.2)$$

$$\mathrm{PDAij} = \frac{\max(0, (\mathrm{AVj} - \mathrm{Xij}))}{\mathrm{AVj}} \quad \text{for minimization criteria} \quad \dots\dots\dots\dots (1.3)$$

Step 3 Calculate negative distance from average soluti

$$\mathrm{NDAij} = \frac{\max(0, (\mathrm{AVj} - \mathrm{Xij}))}{\mathrm{AVj}} \quad \text{for maximization criteria} \quad \dots\dots\dots\dots (1.4)$$

$$\mathrm{NDAij} = \frac{\max(0, (\mathrm{Xij} - \mathrm{AVj}))}{\mathrm{AVj}} \quad \text{for minimization criteria} \quad \dots\dots\dots\dots (1.5)$$

Step 4 Calculate weighted sum of PDA and NDA

$$\mathrm{SPi} = \sum_{j=1}^{m} \mathrm{PDAij} \quad \dots\dots\dots.. (1.6)$$

$$\mathrm{SNi} = \sum_{j=1}^{m} \mathrm{NDAij} \quad \dots\dots\dots.. (1.7)$$

Step 5 calculating normalized values of SPi and SNi

$$\mathrm{NSPi} = \frac{\mathrm{SPi}}{\max \mathrm{SPi}} \quad \dots\dots\dots.. (1.8)$$

$$\mathrm{NSNi} = 1 - \frac{\mathrm{SNi}}{\max \mathrm{SNi}} \quad \dots\dots\dots.. (1.9)$$

Step 6 calculate Average of NSPi and NSNi

$$\mathrm{ASi} = \frac{1}{2}(\mathrm{NSPi} + \mathrm{NSNi}) \quad \dots\dots\dots\dots. (1.10)$$

Step 7 Rank the preference order set of alternatives can now be preference ranked according to the descending order of ASi

Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS)

The TOPSIS method used for optimizing the process parameters was broken down into steps as presented here in-under and adopted by Wang. As per the weightage determined using Entropy method, the weighted matrix was defined used for next calculation.

Step 1: Calculating positive A+ and Negative A- ideal solutions

To calculate the optimal value from the weighted matrix no Positive-Ideal solution (A+) and Negative-Ideal solution (A−) for each parameter of the weighted normalized matrix calculated using the below expressions

$$A^+ = \begin{cases} (\tilde{v}_1^+, \tilde{v}_2^+, \dots\dots, \tilde{v}_n^+) = \{(\mathrm{Max}_i\ v_{ij} \mid i = 1 \dots m, j = 1 \dots n)\} = \text{maximization} \\ (\tilde{v}_1^-, \tilde{v}_2^-, \dots\dots, \tilde{v}_n^-) = \{(\mathrm{Max}_i\ v_{ij} \mid i = 1 \dots m, j = 1 \dots n)\} = \text{minimization} \end{cases} \quad (1.11)$$

$$A^- = \begin{cases} (\tilde{v}_1^+, \tilde{v}_2^+, \dots\dots, \tilde{v}_n^+) = \{(\mathrm{Max}_I\ v_{ij} \mid i = 1 \dots m, j = 1 \dots n)\} = \text{maximization} \\ (\tilde{v}_1^-, \tilde{v}_2^-, \dots\dots, \tilde{v}_n^-) = \{(\mathrm{Max}_I\ v_{ij} \mid i = 1 \dots m, j = 1 \dots n)\} = \text{minimization} \end{cases} \quad (1.12)$$

Step 2: Calculating differences for each alternative from A+ and A- and closeness coefficient CCi using following formulas and applied TOPSIS

$$\text{Distance from } A+ \quad si^+ = \sqrt{\textstyle\sum_{j=1}^{m} (v_{ij} - v_i^+)^2} \quad , i = 1 \dots. n \quad \dots\dots\dots. (1.13)$$

$$\text{Distance from } A- \quad si^- = \sqrt{\textstyle\sum_{j=1}^{m} (v_{ij} - v_i^-)^2} \quad , i = 1 \dots. n \quad \dots\dots\dots(1.14)$$

$$\text{The similarities or closeness coefficient } CC_i = \frac{s_i^-}{s_i^+ - s_i^-} \quad \dots\dots\dots(1.15)$$

Step-3 Rank the preference order set of alternatives can now be preference ranked according to the descending order of CCi

III. Result

After performing the experiments the respected methodology was applied to calculate the optimum solution. In this section Table 3 defines the RSM based design and the responses measured. ANOVA was carried out to get the single process parameters performance P value which was lesser than 0.05 and model was fitted accurately. Analysis of method optimization done in this section the Table 4 shows the weighted normalized matrix for responses where the weightages used was calculated by Entropy method.

Table 3 Experimental results of response parameters

Run Order	W/P Order	Cutting Speed	Feed	DOC	Surface Roughness	MRR
1	A1	140	0.12	0.6	0.908	9.1533
2	A2	140	0.12	0.4	0.825	6.111
3	A3	100	0.12	0.6	1.2865	7.17
4	A4	180	0.1	0.4	0.833	5.111
5	B1	140	0.12	0.6	0.8485	8.365
6	B2	180	0.14	0.4	0.7575	6.469
7	B3	140	0.1	0.6	0.84	7.7215
8	B4	100	0.14	0.4	1.1105	5.6018
9	C1	140	0.12	0.6	0.877	9.038
10	C2	100	0.1	0.4	0.902	3.9542
11	C3	100	0.1	0.8	1.374	7.402
12	C4	140	0.14	0.6	0.8675	9.1254
13	D1	180	0.1	0.8	0.8575	13.3236
14	D2	140	0.12	0.6	0.893	8.365
15	D3	180	0.14	0.8	0.9695	11.103
16	D4	140	0.12	0.6	0.899	8.365
17	E1	100	0.14	0.8	1.339	10.249
18	E2	140	0.12	0.6	0.895	9.1254
19	E3	140	0.12	0.8	0.909	8.8824
20	E4	180	0.12	0.6	0.868	8.365

Table 4 Weighted normalized matrix

Experiment no.	Weighted SR	Weighted MRR
1	0.01511	0.03834
2	0.01373	0.02560
3	0.02141	0.03003
4	0.01386	0.02141
5	0.01412	0.03504
6	0.01261	0.02710
7	0.01398	0.03234
8	0.01848	0.02346
9	0.01460	0.03786
10	0.01501	0.01656
11	0.02287	0.03101
12	0.01444	0.03822
13	0.01427	0.05581
14	0.01486	0.03504
15	0.01614	0.04651
16	0.01496	0.03504
17	0.02229	0.04293
18	0.01490	0.03822
19	0.01513	0.03721
20	0.01445	0.03504

3.1 EDAS Optimization Results

By following the steps of EDAS optimization the values of sum of positive distance from average solution, negative distance from average solution, normalized value of sum of positive and negative distance from average solution and the average of normalized value was calculated. It defines the accurate values which give tolerance values related to solution the resulted value shown in Table 5.

Table 5 Performance Values for EDAS method

Experiment no	SPi	SNi	NSPi	NSNi	ASi	Rank
1	0.17029	0.00000	0.23170	1.00000	0.61585	6
2	0.13429	0.25019	0.18271	0.53112	0.35692	14
3	0.00000	0.47023	0.00000	0.11873	0.05936	17
4	0.12590	0.37289	0.17129	0.30117	0.23623	16
5	0.13601	0.00000	0.18505	1.00000	0.59252	7
6	0.20512	0.20626	0.27908	0.61344	0.44626	13
7	0.11855	0.05258	0.16130	0.90146	0.53138	12
8	0.00000	0.47796	0.00000	0.10424	0.05212	19
9	0.18868	0.00000	0.25671	1.00000	0.62836	4
10	0.05349	0.51482	0.07278	0.03516	0.05397	18
11	0.00000	0.53358	0.00000	0.00000	0.00000	20
12	0.20937	0.00000	0.28487	1.00000	0.64243	3
13	0.73498	0.00000	1.00000	1.00000	1.00000	1
14	0.08931	0.00000	0.12152	1.00000	0.56076	10
15	0.36233	0.01734	0.49298	0.96750	0.73024	2
16	0.08302	0.00000	0.11295	1.00000	0.55647	11
17	0.25754	0.40507	0.35041	0.24084	0.29562	15
18	0.18051	0.00000	0.24560	1.00000	0.62280	5
19	0.13601	0.00000	0.18505	1.00000	0.59252	8
20	0.11554	0.00000	0.15721	1.00000	0.57860	9

3.2 TOPSIS Optimization

TOPSIS optimization steps mentioned before was done after that the positive and negative ideal solutions based on maximization of MRR and minimizations of surface roughness were found for both responses mentioned in Table 6. According to these solutions the distance from positive negative solutions was calculated and then closeness coefficient was fond and according to it ranking given as shown in Table 7.

Table 6 Ideal solutions of responses

Responses	Possitive Ideal solution A+	Negative Ideal solution A-
Surface Roughness	0.01261	0.02287
MRR	0.05581	0.01656

Table 7 Performance Values for TOPSIS method

Experiment no	Si+(Distance from A+)	Si (Distance from A-)	closeness coefficient (cci)	Rank
1	0.01765	0.02312	0.56709956	5
2	0.03023	0.01285	0.2982551	17
3	0.02724	0.01355	0.33218301	16
4	0.03442	0.01023	0.22901405	18
5	0.02083	0.02044	0.49534564	9
6	0.02871	0.01471	0.33869477	15
7	0.02351	0.01811	0.43518306	13
8	0.03287	0.00818	0.1991903	19
9	0.01806	0.02285	0.5584726	7
10	0.03932	0.00786	0.16652192	20
11	0.02684	0.01444	0.34981508	14
12	0.01768	0.02324	0.56797011	4
13	0.00166	0.04018	0.96022184	1
14	0.02089	0.02014	0.49077665	11
15	0.00995	0.03069	0.75521123	2
16	0.02090	0.02010	0.49015427	12
17	0.01611	0.02637	0.62079763	3
18	0.01773	0.02308	0.56551387	6
19	0.01877	0.02205	0.54008999	8
20	0.02085	0.02030	0.49335457	10

3.3 RSM analysis and ANOVA

The residual plots were generated for the indexes calculated by two different optimization methods shown in fig.4 and fig.5. The main effect plots also generated which gives each parameter and their levels effects with EDAS index and TOPSIS index shown in Fig. 6 and Fig.7. The result of analysis with response was shown in Table 8. This analysis of experimental data gives optimal solution for both methods. The Analysis of variance of both optimization method shows that the developed regression model and the R-square values found to be accurate between limits. The performed ANOVA for both methods was shown in Table 9 for EDAS index and Table 10 for TOPSIS index respectively.

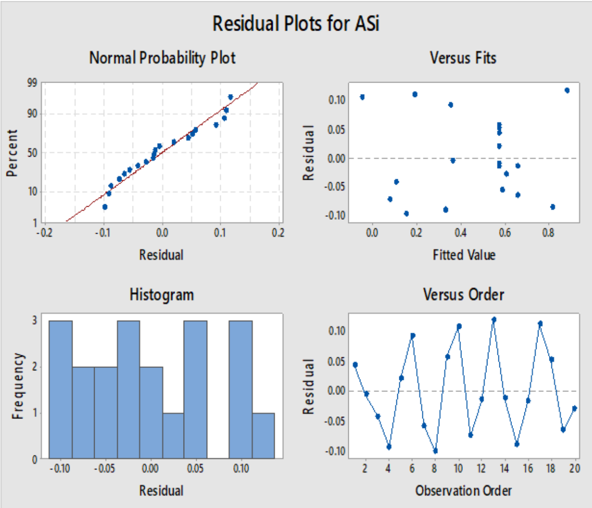

Figure 4 Residual plots for EDAS index

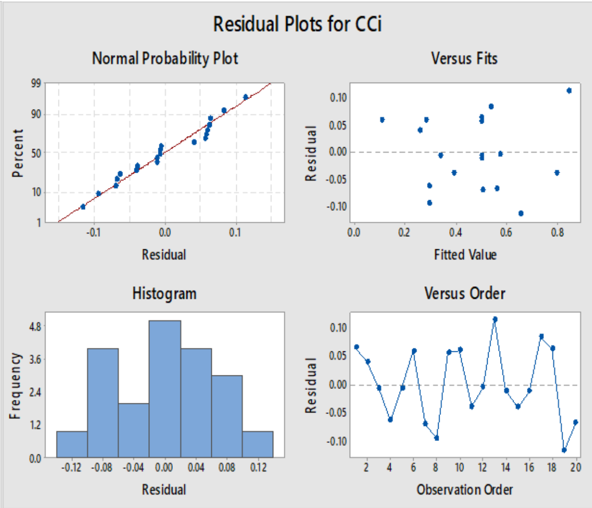

Figure 5 Residual plots for TOPSIS index

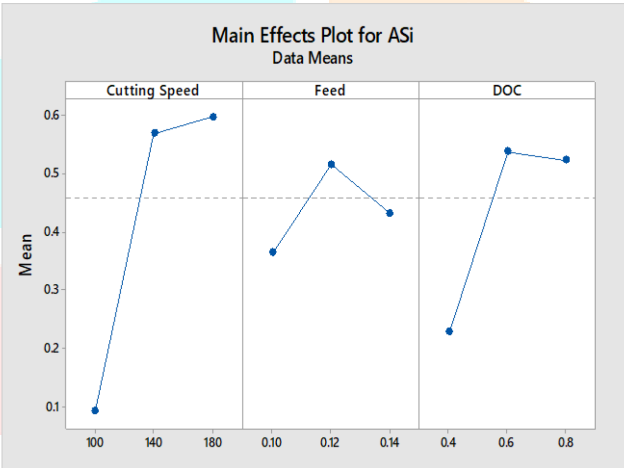

Figure 6 Main effect plot for EDAS index

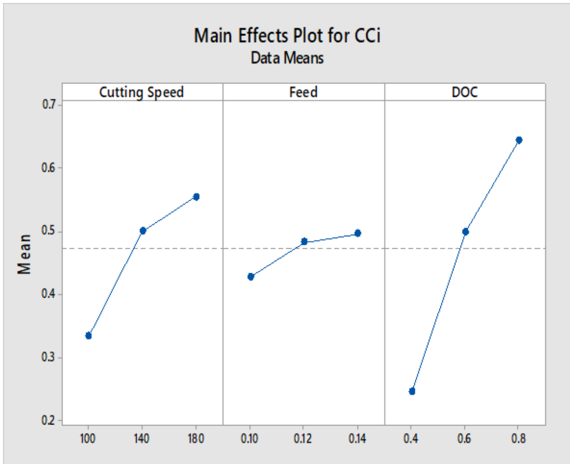

Figure 7 Main effect plot for TOPSIS index

Table 8 Response table for average values of methods

Process parameters	Average value of EDAS Method			Average value of TOPSIS Method		
	Cutting Speed	Feed	Depth of cut	Cutting Speed	Feed	Depth of cut
Level 1	0.09221	0.36432	0.2291	0.3337	0.4282	0.2463
Level 2	0.54388	0.43671	0.48158	0.4739	0.4384	0.4713
Level 3	0.59827	0.43333	0.52368	0.5553	0.4964	0.6452
max-min	0.50605	0.07239	0.29458	0.2216	0.0682	0.3989
Rank	1	3	2	2	3	1
	Optimum level = CS3F2D3			Optimum level = CS3F3D3		

Table 9 Analysis of Variance of EDAS index

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution %
Model	9	1.24639	0.138488	14.50	0.000	100
Linear	3	0.86907	0.289689	30.32	0.000	100
Cutting Speed	1	0.64022	0.640222	67.01	0.000	100
Feed	1	0.01191	0.011909	1.25	0.290	71
DOC	1	0.21694	0.216938	22.71	0.001	99.9
Square	3	0.26548	0.088492	9.26	0.003	99.7
Cutting Speed*Cutting Speed	1	0.13034	0.130342	13.64	0.004	99.6
Feed*Feed	1	0.00693	0.006935	0.73	0.414	58.6
DOC*DOC	1	0.01056	0.010560	1.11	0.318	68.2
2-Way Interaction	3	0.11184	0.037281	3.90	0.044	95.6
Cutting Speed*Feed	1	0.01562	0.015620	1.63	0.230	77
Cutting Speed*DOC	1	0.09207	0.092068	9.64	0.011	98.9
Feed*DOC	1	0.00416	0.004155	0.43	0.524	47.6
Error	10	0.09554	0.009554			
Lack-of-Fit	5	0.09056	0.018112	18.20	0.003	
Pure Error	5	0.00498	0.000995			
Total	19	1.34193				

Table 10 Analysis of Variance of TOPSIS index

Source	DF	Adj SS	Adj MS	F-Value	P-Value	Contribution %
Model	9	0.612473	0.068053	8.55	0.001	99.9
Linear	3	0.532186	0.177395	22.29	0.000	100
Cutting Speed	1	0.122764	0.122764	15.42	0.003	99.7
Feed	1	0.011635	0.011635	1.46	0.254	74.6
DOC	1	0.397787	0.397787	49.97	0.000	100
Square	3	0.022827	0.007609	0.96	0.451	54.3
Cutting Speed*Cutting Speed	1	0.007321	0.007321	0.92	0.360	64
Feed*Feed	1	0.003808	0.003808	0.48	0.505	49.5
DOC*DOC	1	0.005617	0.005617	0.71	0.421	57.9
2-Way Interaction	3	0.057460	0.019153	2.41	0.128	87.2
Cutting Speed*Feed	1	0.019898	0.019898	2.50	0.145	85.5
Cutting Speed*DOC	1	0.036832	0.036832	4.63	0.057	94.3
Feed*DOC	1	0.000729	0.000729	0.09	0.768	23.2
Error	10	0.079598	0.007960			
Lack-of-Fit	5	0.071850	0.014370	9.27	0.014	
Pure Error	5	0.007749	0.001550			
Total	19	0.692071				

3.4 Verification of experiments

The objective of verification process is to validating the optimal solution by doing prediction of responses at the optimum levels. After selecting the optimal solution from average value of responses it is important to verify the improvement in response characteristics using these optimum levels of parameters. For the conformity test following equation was used.

$$\gamma = \gamma_m + \sum_{i=1}^{n} (\gamma_i - \gamma_m) \qquad \ldots\ldots\ldots(1.16)$$

Where,

γ_m = Total mean of required responses

γ_i = Mean of responses at optimum levels

n = Number of process parameters which effects response characteristics

Table 11 Result of confirmatory experiment For EDAS method

Response parameters	Initial parametric values	Optimal parameters	
		Predicted	Experimental
	CS1F1D1	CS3F2D3	CS3F2D3
Surface roughness (SR)	0.908	--	0.8745
Material removal rate(MRR)	9.1533	--	10.895
Index value	0.61585	0.7358	0.7790

Table 12 Result of confirmatory experiment for TOPSIS method

Response parameters	Initial parametric values	Optimal parameters	
		Predicted	Experimental
	CS1F1D1	CS3F3D3	CS3F3D3
Surface roughness (SR)	0.908	---	0.8925
Material removal rate(MRR)	9.1533	---	11.52
Index value	0.61585	0.7883	0.8058

Discussion

IV. Discussion

After performing the optimization the result based on ranking shows that 13th no experiment was best solution of 1st rank for both the methods. RSM and ANOVA analysis performed for EDAS and TOPSIS index to know the accuracy of process and the response table gives the average mean value observed that both indexes have the different optimal solution. Confirmatory test was carried according to that the test result of both the process shows that in EDAS method the value of index increased up to 0.7790 than predicted value 0.7358 with percentage deviation about 5.87%. Similarly TOPSIS indexed experimental value 0.8058 maximum than the predicted value 0.7883 with deviation about 2.29%. This result defines TOPSIS as multi objective optimization method with lesser error compared to the EDAS method.

V. Conclusion

In present study, two novel multi criteria decision making techniques such as EDAS (Evaluation Based on Distance from Average Solution) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) approach have been considered to attain optimal parameters in cryogenic turning of AISI D2 steel that lead to minimum SR and maximum MRR. After result obtained from analysis it can be concluded as follows:

1. The optimized parameters such as cutting speed about 180 m/min, feed rate of about 0.14 mm/rev, depth of cut 0.8 mm.
2. Through RSM and ANOVA analysis controlled parameters found along impactful factors as cutting speed, depth of cut with contribution 99.7% and then feed rate with 100%.RSM model contains lack of fit lesser than 0.05 it means both MCDM models are validated.
3. From confirmation it was found that TOPSIS give proper and closer values to predicted values. This defines that TOPSIS yielded best result as it shows lesser deviation from predicted values. Hence TOPSIS is the best suited method.

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