Original Article

A Novel Optimization of Feed and Spindle Speed Levels for Surface Roughness and Cylindricity Tolerance of the Drilled Holes in Liquid Stir Casted Al6061 Hybrid Metal Matrix Composite Reinforced with 15% Weight Fraction of B_4C+Fly ash and Comparing with that of As-Cast Al6061

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Abstract

Aim: Our main aim of the research is to Optimization of feed and spindle speed levels for surface roughness and cylindricity tolerance of the drilled holes in liquid stir casted Al6061 hybrid metal matrix composite reinforced with 15% weight fraction of B_4C+Fly ash and comparing with that of as-cast Al6061.
Materials and Methods: In this study, Al6061 aluminum casting plate with a thickness of 10 mm was used. Al6061 aluminum was normalized at 750 degrees Celsius using a muffle furnace.and optimized with different spindle speed and feed rate. And taking the surface roughness and cylindricity tolerance. .Test samples (N = 20) were taken from each plate of experimental group (B4C,Fly ash) and control group (Al6061) G-Power:82%.
Results: To measure the surface roughness and cylindricity tolerance of the drilled holes at different spindle speed and various feed rate and to optimize with the output values.with insignificance value of 0.4485 ($p>0.05$).
Conclusion: The surface roughness and cylindricity tolerance tolerance will be compared between the control and experimental groups based on spindle speed and feed rate, as well as knowing the material properties.

Keywords: Novel Aluminum, B_4C, Fly ash, Drilling, Surface roughness, Cylindricity tolerance, Optimization

DOI: 10.47750/pnr.2022.13.S03.048

INTRODUCTION

The main goal of this study is to investigate the effects of feed and spindle speed on surface roughness and cylindricity tolerance of drilled holes in Al6061 hybrid metal matrix composite reinforced with 15% weight fraction of B_4C,Fly ash,(Paulo Davim 2011) comparing the results to as-cast Aluminum 6061 and comparing the results between the control and experimental groups.(Kwon, Saarna, and Leparoux 2020) The goal of the study is to optimize the surface roughness and cylindricity tolerance of drilled holes at various spindle speeds and feed rates.(Zaidi 2016) Taking three surface roughness measurements for a single hole and calculating the mean value, measure surface roughness for 13 holes at various spindle speeds and feed rates.(Kareem et al. 2021)and measure the cylindricity tolerance for all 13 holes and optimize the output using the spss software..and nowadays the composite materials were used moreover in the automobile based industries.

Around 410 research articles were reported on experimental work on different spindle speed and feed rate on google scholar and 153 out of it were published in science directly.(Susac and Stan 2020) in this study an experimental investigation on the aluminum 6061 to optimize of the circularity,cylindricity and the surface roughness of the drilling done with different spindle speed and feed rate.and observe at which speed the surface roughness and cylindricity tolerance are optimize with the nearest values.(Zaidi 2016) this research is about knowing the physical properties of the aluminum 6061chips using the hot extrusion process.how the metal chips are removed during the drilling process.based on the spindle speed.(Kwon, Saarna, and Leparoux 2020)aluminum 6061 alloy matrix composites were fabricated by high energy ball milling and hot pressing values that are pure aluminum alloy bulk.(Kareem et al. 2021)so to know the properties of aluminum 6061 of the mechanical properties of the silicon and boron carbide.(Kwon, Saarna, and Leparoux 2020)has the best study based on the survey. The parameters on the mechanical behavior of matrix composite materials.(Kareem et al. 2021)has the best study based on the survey.Our team has extensive knowledge and research experience that has translate into high quality publications(Bhansali et al. 2021; Jayanth et al. 2021; Sudhakar, Ravel, and Perumal 2021; Sathiyamoorthi et al. 2021; Deepanraj et al. 2021; Raju et al. 2021; Arun Prakash et al. 2020;

Kamath et al. 2020; Shanmugam et al. 2021; Rajasekaran et al. 2020; Adhinarayanan et al. 2020; Rajesh et al. 2020; Aurtherson et al. 2021)

Many studies have been conducted in this field, but only a few have been successful in developing a composite with the requisite features of varied spindle speeds and feed rates for specific applications. aerospace, automotive, and chemical sectors, to name a few.our aim is to optimize the surface roughness and cylindricity tolerance of drilled holes at various spindle speeds and feed rates. measure surface roughness for 13 holes at various spindle speeds and feed rates.and measure the cylindricity tolerance for all 13 holes and know the optimization at which spindle speed and feed rate are less tolerant.

MATERIALS AND METHODS

The complete fabrication process was done at Saveetha School of Engineering,Saveetha Institute of Medical and Technical Sciences,Chennai.The 10mm hss uncoated drill bit standard length was included in the Srinivasan Power Tools materials.Pure AL6061 and metal matrix composites were also available for purchase at the mattest research center. Two groups were developed for this study: group 1 was the parent group, and group 2 was the experimental group. The experimental group material is matrix composite material, and the parent material is pure AL6061.No.of groups 2, sample size 0,and the total sample size 0. The g Power: 80% std devations is 14.17 and the mean value is 0.6272 (Kareem et al. 2021).

In this research it is needed a flat shaped raw material for study, therefore using a muffle furnace at 750°C to turn the solid state into a liquid state, and then pouring the molten metal into the die through the hollow for the appropriate dimensions. A CNC computer numerical control machine was utilized to drill with 13 different spindle speeds and feed rates to measure the surface roughness and cylindricity tolerance of each drilled hole. As a result, to optimize the surface roughness cylindricity tolerance tests were carried out for each hole, with the mean value serving as the output.

About 20 samples per group were fabricated.Omkar Steel Corporation provided the AL6061 that was used in this study. The weight fraction of pure aluminum is 85 percent, b4c is 7.5 percent, and fly ash is 7.5 percent when b4c and fly ash are combined with AL6061. The stir casting procedure was used to combine all of these ingredients. It rotates at 800rpm with 750c to mix the material, following which the liquid state metal is poured into the cavity and allowed to solidify for a period of time; the material dimensions are 150*150mm with a thickness of 10mm. And use a 10m hss uncoated drill bit to drill 13 holes, each with its different spindle speed and feed rate. Also, for each hole,optimize the surface roughness cylindricity tolerance and note the result.

In the control group, only pure aluminum 6061 is used, hence the material was bought from Omkar Steel Corporation in a square shape. Use a muffle furnace to melt the material from solid to liquid at 730°C, then pour the molten metal into the cavity to reach our desired dimensions and wait for solidification. The material is 150*150mm with a thickness of 10mm, and to optimize surface roughness the cylindricity tolerance for all 13 drilled holes was measured at various spindle speeds and feed rates.

Surface roughness obtained the result mitutoyo sj-410 These SJ-410 series model SJ-411 Surftest / SJ-412 Surftest series offer a wide-range, high-resolution detector and a drive unit that provide superior high-accuracy measurement in its class. as per ASTM D638 standard. By using the skid-less measurement function you can obtain ultra-fine steps, straightness and waviness.cylindricity tolerance tesa Micro-Hite 3D Model MH3D-F 454 Coordinate Measuring Machine 18" x 20" x 14" Range Equipped With: Tesa-Reflex Micro Hite 3-D Control Unit, Tesa Star-I Probe head with Adjustable Angle and Rotation, Additional Stylus Included, 29.5" x 22" x 3" Drilled and Tapped Granite Base, Tsunami Compressed Air Filtration System for CMM's, Manuals.

STATISTICAL ANALYSIS

For statistical analysis, the SPSS Software programme was employed in this study. independent variables are feed and speed.And the dependent variables are cylindricity tolerance and surface roughness were subjected to group statistics and independent sample t-tests, and a graph was created for the two groups under investigation.(Kareem et al. 2021).

RESULTS

In this research two groups were compared, one is pure aluminum that is the control group and another is the experimental group that is hybrid metal matrix composite material in both the groups drilling had done with different spindle speed and feed rate Fig.1. Shows the measurement of surface roughness of all the drilled holes and Fig.2. shows the measured cylindricity tolerance.(Zaidi 2016) Table 1. Is the different spindle and feed rate.Table 2. Value of surface roughness for both experimental and parent material Table 3. Shows the cylindricity tolerance for both experimental and parent material.Fig.3.

Perturbation graph showing the comparison of desirability and deviation from reference point of optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C+ Fly ash.Fig.4. Perturbation graph showing the comparison of surface roughness and deviation from reference point of optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash. Fig. 5. Perturbation graph showing the comparison of cylindricity tolerance and deviation from reference point of optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash. Fig. 6. 3D surface graph showing the comparison of desirability and process parameters of the optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C+ Fly ash. X-axis: Feed rate (mm/rev). Y-axis: Desirability. Z-axis: Spindle speed (rpm). Fig.7. 3D surface graph showing the comparison of surface roughness and process parameters of the optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash. X-axis: Feed rate (mm/rev). Y-axis: Surface Roughness. Z-axis: Spindle speed (rpm).Fig. 8. 3D surface graph showing the comparison of cylindricity tolerance and process parameters of the optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash. X-axis: Feed rate (mm/rev). Y-axis: Cylindricity tolerance. Z-axis: Spindle speed (rpm)so in the previous research study for aluminum 6061 finding the properties of the alloy 6061 chips using the hot extrusion process so how the burs and chips are produced during the machining process and knowing the properties of the material .(Susac and Stan 2020) .

DISCUSSION

In this study optimize the circularity and measure the surface roughness and cylindricity tolerance for the drilled holes and optimize using the spss and anova software.std devations with significance value of 0.3769.

In this study, All the property values of 13 holes for AHMMC (experimental group) and for as-cast Al6061(control group) obtained in this experiment are summarized in Table 2 and Table 3 respectively and these findings are very much in correlation with the findings of (Kareem et al. 2021).. Similar findings and studies are also conducted by (Susac and Stan 2020) and (Paulo Davim 2011). Likewise, (Niranjan et al. 2017)(Kwon, Saarna, and Leparoux 2020) experimental on cylindrical rods using Taguchi method and Analysis of Variance (ANOVA) to eventually find that better quality of the surface finish is obtained with cutting speed 429 m/min, feed rate 0.05mm/min, and depth of cut 1mm.

The limitations of this research is to compare the outputs of Al6061 and hybrid metal matrix composite reinforced with 15% weight fraction of B_4C,Fly ash. With different feed and spindle speed effects on surface roughness and cylindricity toleranceof drilled holes in Al6061and hybrid metal matrix composite of B4C,Fly ash. (Kvackaj 2011) future scope is to developmental activities of the aluminum alloy has been performed and applications of the aluminum is used in the space stations.In this research, they drilled 13 holes in the parent material and 13 holes in the experimental material and measured to optimize the surface roughness and cylindricity tolerance test for all 13 holes in the parent material and experimental material.

CONCLUSION

The control and experimental groups were compared using the surface roughness and cylindricity tolerance test, and the experimental group had a smoother surface finish than the parent group. The Ra value for pure aluminum is 4.920 and for metal matrix composite material is 2.812. the cylindricity tolerance for pure aluminum is 0.069 as shown in table1 and for metal matrix composite material 0.091The experimental group outperforms the control group as a result.he surface roughness and cylindricity tolerance for the drilled holes and optimal spindle speed values using the spss and anova software.std devations with significance value of 0.3769. As a result, matrix composite materials are becoming more popular in a variety of industries.with good surface finish.

DECLARATIONS:

Conflict of Interests

The authors of this paper declare no conflict of interest

Authors Contribution

Author GV was involved in the data collection,data analysis and manuscript writing. Author GB was involved in conceptualization,data validation and critical review of the manuscript.

Acknowledgment

The authors would like to express their gratitude towards Saveetha School of Engineering, Saveetha Institute of Medical and Technical Sciences (Formerly known as Saveetha University) for providing the necessary infrastructure to carry out this research work successfully

Funding:
We thank our financial sponsors for financial support that enabled us to complete this study.
1. MRF Tyres and pre traders,vellore
2. Saveetha University
3. Saveetha Institute of Medical and Technical Sciences.
4. Saveetha School of Engineering.

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TABLES AND FIGURES

Table 1. Table for different spindle speed RPM feed rate

Run no	Feed mm/rev	speed,RPM	Feed rate,mm/min
1	0.15	1000	150
2	0.10	1000	100
3	0.10	1000	100
4	0.10	1250	125
5	0.05	1250	62.50
6	0.10	750	75
7	0.10	1000	100
8	0.10	1000	100
9	0.15	1250	187.50
10	0.05	750	37.50
11	0.05	1000	50
12	0.15	750	112.50
13	0.10	1000	100

Table 2. Surface roughness value for pure AL6061 and metal matrix composite material

SL.NO	Ra VALUE FOR PURE AL6061	Ra VALUE FOR MATRIX COMPOSITE MATERIAL
1	4.386	4.0091
2	3.474	3.806
3	3.368	3.271
4	4.962	2.290

5	4.175	2.197
6	4.058	2.098
7	4.031	2.198
8	3.464	2.622
9	6.531	3.258
10	2.019	2.275
11	2.050	1.812
12	5.001	3.922
13	4.920	2.812

Table 3. Cylindricity tolerance value for pure AL6061 and metal matrix composite material

SL.NO	PARAMETER	MEASURED VALUE IN MM FOR PURE AL6061	MEASURED VALUE IN MM AL+B4C*FLY ASH
1	CYLINDRICITY	0.079	0.132
2	CYLINDRICITY	0.086	0.069
3	CYLINDRICITY	0.090	0.062
4	CYLINDRICITY	0.098	0.074
5	CYLINDRICITY	0.011	0.094
6	CYLINDRICITY	0.070	0.068
7	CYLINDRICITY	0.065	0074
8	CYLINDRICITY	0.060	0.068
9	CYLINDRICITY	0.057	0.099
10	CYLINDRICITY	0.078	0079
11	CYLINDRICITY	0.089	0.074
12	CYLINDRICITY	0.076	0.098
13	CYLINDRICITY	0.069	0.091

Table 4. ANOVA (quadratic model) for surface roughness drilled holes of as- cast Aluminum 6061. It is observed that on performing ANOVA, there is a statistical significant difference between the investigated parameters and the model is significant ($p>0.05$).

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	3.14	5	0.6272	1.26	0.3769	significant
A-Feed Rate	1.73	1	1.73	3.48	0.1045	
B-Spindle Speed	0.5424	1	0.5424	1.09	0.3317	
AB	0.5543	1	0.5543	1.11	0.3268	
A^2	0.0031	1	0.0031	0.0062	0.9393	
B^2	0.2801	1	0.2801	0.5617	0.4780	
Residual	3.49	7	0.4988			
Lack of Fit	2.91	3	0.9713	6.73	0.0484	not significant
Pure Error	0.5773	4	0.1443			
Cor Total	6.63	12				

Table 5. ANOVA (quadratic model) for cylindricity tolerance drilled holes of Aluminum 6061 MMC with 15% weight fraction of B_4C + Fly ash. It is observed that on performing ANOVA, there is a statistical significant difference between the investigated parameters and the model is significant ($p>0.05$).

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	1078.06	5	215.61	0.07	0.4485	significant
A-Feed Rate	32.67	1	32.67	0.1627	0.6987	
B-Spindle Speed	150.00	1	150.00	0.7470	0.4161	
AB	20.25	1	20.25	0.1008	0.7601	

A^2	8.21	1	8.21	0.0409	0.8455	
B^2	682.88	1	682.88	3.40	0.1077	
Residual	1405.64	7	200.81			
Lack of Fit	331.64	3	110.55	0.4117	0.7541	not significant
Pure Error	1074.00	4	268.50			
Cor Total	2483.69	12				

Table 6. Optimized point prediction for drilled holes of Aluminum 6061 MMC with 15% weight fraction of SiC + Fly ash

Factor	Name	Level	Low Level	High Level	Std. Dev.	Coding
A	Feed Rate	0.0500	0.0500	0.1500	0.0000	Actual
B	Spindle Speed	968.46	750.00	1250.00	0.0000	Actual

Table 7. Point prediction for Two-sided with Confidence = 95% and Population = 99% for drilled holes of Aluminum 6061 MMC with 15% weight fraction of SiC + Fly ash

Analysis	Predicted Mean	Predicted Median	Std Dev	SE Mean	95% CI low for Mean	95% CI high for Mean	95% TI low for 99% Pop	95% TI high for 99% Pop
Surface Roughness	1.61772	1.61772	0.706223	0.49601	0.444843	2.7906	-2.59123	5.82667
Cylindricity Tolerance	64.1862	64.1862	14.1706	9.95258	40.6521	87.7203	-20.2675	148.64

Fig. 1. During the Surface Roughness Testing

Fig. 2. During the Measurement of Cylindricity Tolerance Cylindricity Tolerance

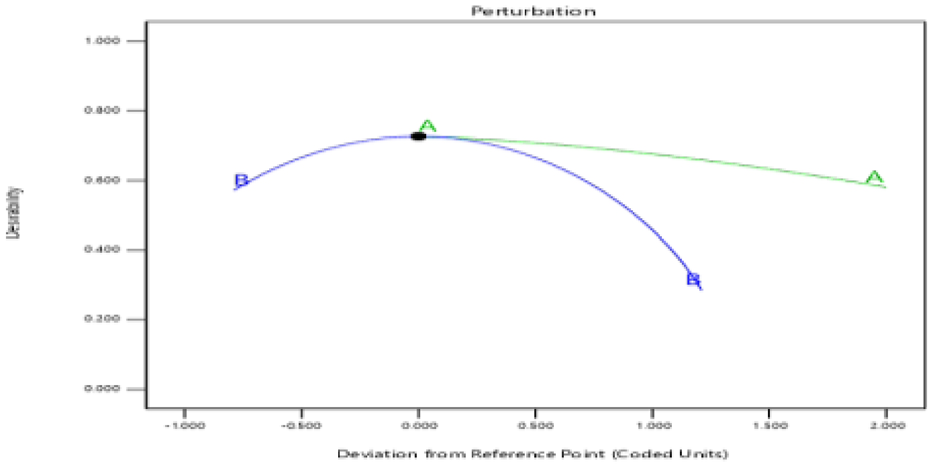

Fig. 3. Perturbation graph showing the comparison of desirability and deviation from reference point of optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C+ Fly ash

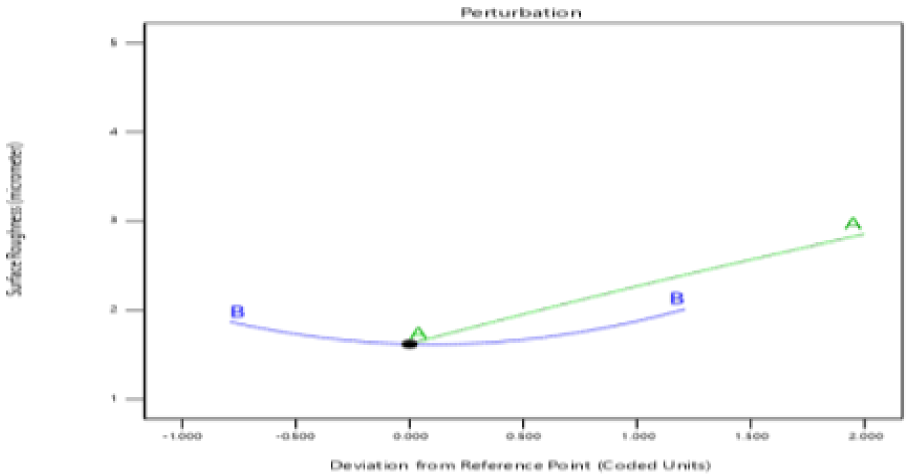

Fig. 4. Perturbation graph showing the comparison of surface roughness and deviation from reference point of optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash

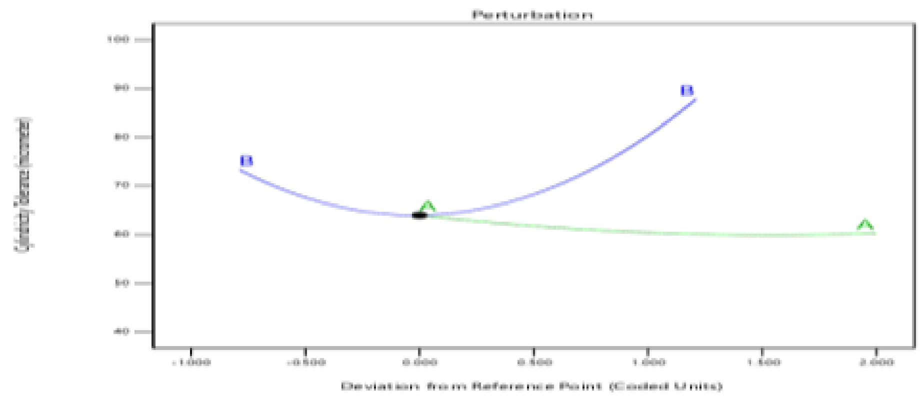

Fig. 5. Perturbation graph showing the comparison of cylindricity tolerance and deviation from reference point of optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash.

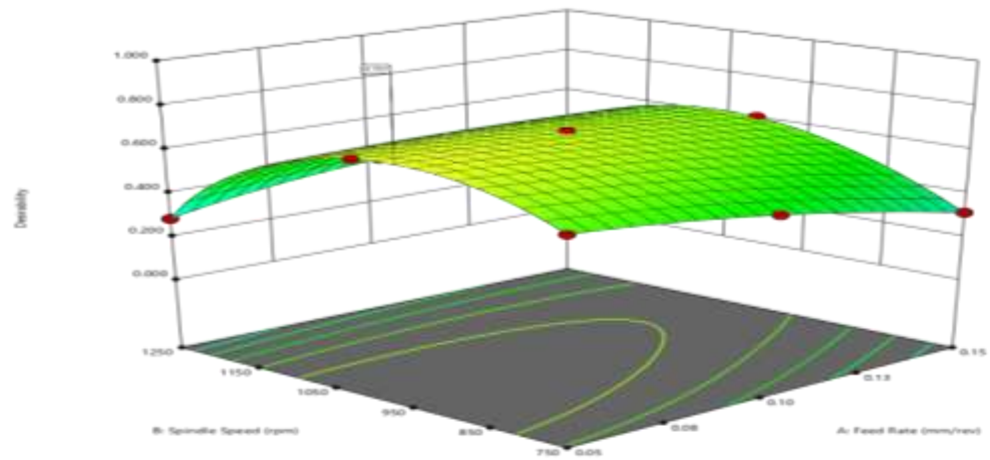

Fig. 6. 3D surface graph showing the comparison of desirability and process parameters of the optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C+ Fly ash. X-axis: Feed rate (mm/rev). Y-axis: Desirability. Z-axis: Spindle speed (rpm).

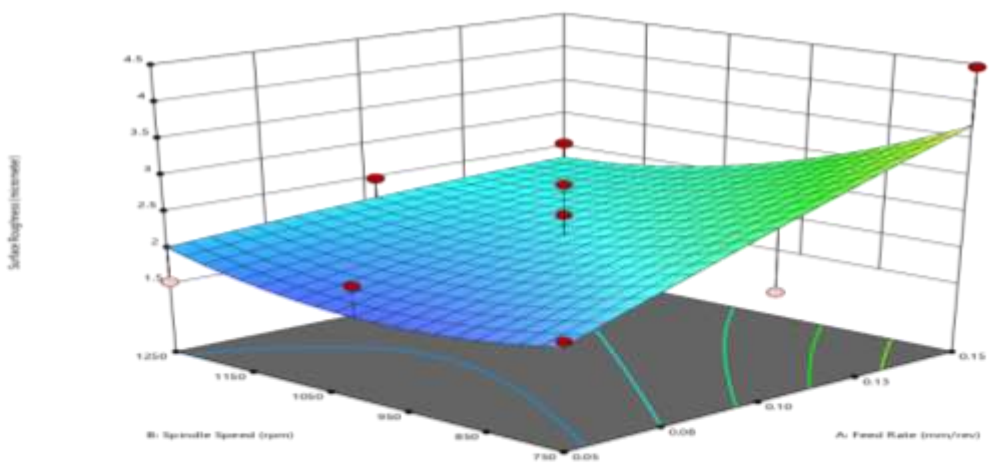

Fig. 7. 3D surface graph showing the comparison of surface roughness and process parameters of the optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash. X-axis: Feed rate (mm/rev). Y-axis: Surface Roughness. Z-axis: Spindle speed (rpm).

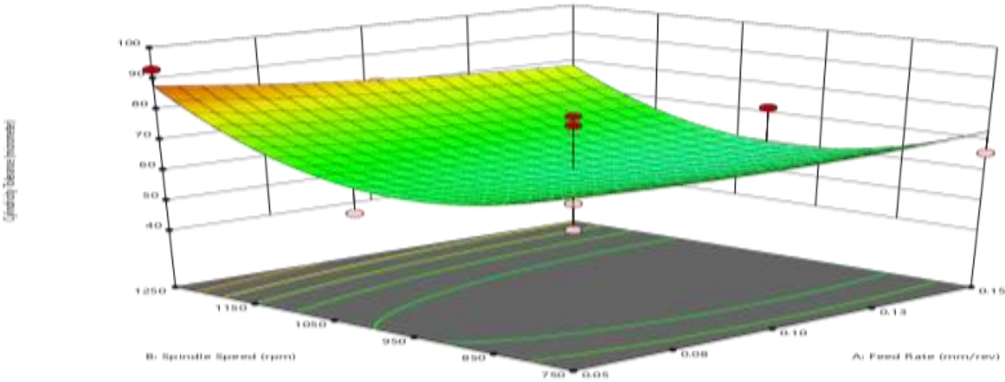

Fig. 8. 3D surface graph showing the comparison of cylindricity tolerance and process parameters of the optimized value of Surface roughness and Cylindricity tolerance of Al6061 MMC with 15% weight fraction of B_4C + Fly ash. X-axis: Feed rate (mm/rev). Y-axis: Cylindricity tolerance. Z-axis: Spindle speed (rpm).