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"EXPERIMENTAL INVESTIGATION ON MACHINIBILITYPARAMETERS AND SURFACE ROUGHNESS OF AL-2024 ANDBASALTPOWDERBYUSINGANOVA"

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ABSTRACT

In the present experimental investigation cnc turning parameters on Aluminium 2024 and itsreinforcements of Basalt powder metal matrix composites were studied by using ANOVA.Aluminium 2024 and Basalt powder MMC were prepared using the liquid metallurgyrouteandcncturningusedformachiningthecomposites,machiningparametersandreinforcements effects the cutting speed, feed rate and depth of cut on surface roughness andmetalremovalrate.Whichperfectlyinfluencethemachinedproductsperformanceandminimizing the surface roughness of the materials by using the Three factor and Three levelTaguchiL9and ANOVAapproach.

KEY WORDS: Metal matrix composite, Al -2024, Basalt Powder, cnc turning, surfaceroughness,metal removal rate, Taguchi L9, Anova.

INTRODUCTION

Now a days aluminium alloys are mostly used in various industries of automobile, aviation,electrical, military, sports and engineering components and aerospace industries due to theirgood mechanical and physical properties. it is also low thermal expansion compared to othermetals but also better wear resistance and corrosion resistance. Metal matrix composites ofaluminium alloy to improve the mechanical properties such as impact strength and hardness,currently most of the manufacturing industries are changing the materials like monolithicmaterialstocompositesmaterialsbecausecompositematerialsarewearandcorrosionresistance and light weight.

Metalmatrixcompositesareapplicableforrequiringthermalconductivityandlow coefficient of thermal expansion with low density , by using aluminium and mmcs the mechanical properties are increasing aluminium is considered as one of the most predominantmatrixmaterialconsideringitscombinedpropertiesofductilityandtoughnessofthesoftmatrix material and strength , hardness and modulus of hard reinforcement material formmcsbasaltpowder,B4c,sic,etc…arethemostcommonpreferredparticulate reinforcements, machinabilitygreatlyimprovedduetobasaltpowderreinforcedcomposite. In the fabrication technique metalm atrixco mpos ites usingmaterialsinthisexperimentisAl-2024composit ebyusingstir casti ng. From the literatures it is observed that good machinability and surface roughness valuesmeets the demands of industries i.e quality product with lesser production time and costs .italsoobservedtha tthemetalremo valrateindi catesthehow efficiently thecu ttingofs pecimen.

M. Varma [1] Multi objective optimization of cnc turning parameters for AA 2024/sic MMCSUsing grey relational analysis observed that the machinability parameters like cutting speed,feedrate, depth ofcut influential on surface roughness. G. Srinivasa Rao [2] optimization of machinability properties on Aluminium metal matrixcomposite prepared by In-situ ceramic mixture using coconut shell ash Taguchi approach.observedthat the processof analysis of Variance.Diptikantadas[3]machiningperformancealuminium7075compositeAGreybasedTaguchiconcept,observedthat theMetalremoval rate withdifferentdiametersof thesamples.
Basim A. khidhir [4] Statical analysis (ANOVA) of machining parameters and machinabilitymodeling by fuzzy logic controller. Observed that the how the chips formation is present inthemachiningprocess.Cheng Zhu [5] effects of 2024 Al alloy insert on the grain refinement of a 2024 Al alloyprepared via Insert mold casting. we have observed that the Etching process and how thereinforcementsaddingonthe samples.H.S. Kumaraswamy [6] influence of boron fiber powder and graphite reinforcement onphysical and mechanical properties of aluminium 2024 alloy fabricated by stir casting. Wecanobserve that process of micro-Vickershardness test.

MATERIALSANDMETHODS

Al-2024 and Basalt powder was used as the matrix and reinforcement respectively, chemicalcompositionof Al-2024 is shown inTable 1.

Table 1:**MATERIALSANDMETHODS**

Element	Cu	Mg	Mn	Al
Composition	4.4	1.5	0.6	Bal

(a). preparationofcomposite

At first, in this process first the pure aluminium 2024 alloy placed into graphite crucible andheated up to 450-600^{o}c in medium frequency induction furnace and the reinforcement ofbasalt powder preheated at 100^{o}c it will increase the bonding strength. Now adding thepreheatedbasaltpowderintographitecrucibleandthenheatedupto710^{o}candthestirrerat moderate speed for homogeneous distribution of reinforcement and poured the metal at 710^{o}cincast iron split Die.

Figure1:Frequencyinductionfurnace

Figure2: Stircasting

Figure3:Graphitecrucible

Figure4:castironsplitdie

Figure5:Beforemachining

Figure6:Aftermachining

MACHININGANDMEASUREMENTS

The machining experiments were performed on cnc turning with Three factors and Threelevelseachas shown in thetable.

TABLE2:MACHNINGPARAMETERSANDLEVELS

S.NO	Process parameters	units	Levels		
			1	2	3
1	SPEED	rpm	1000	1200	1400
2	FEEDRATE	Mm/rev	0.2	0.4	0.6
3	DEPTHOFCUT	mm	0.1	0.2	0.3

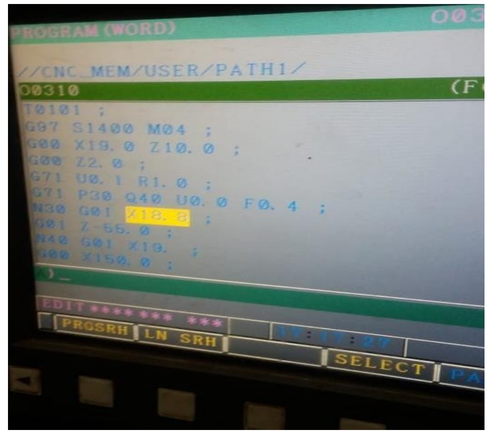

Figure7:CNC machine Figure 8: CNC
programming

METALREMOVALRATE

The metal removal rate at which the cross section of material being removed moves throughthework piece. Metalremoval rate (MRR)is measured byusingthe formula

$$MRR\ (mm3/min)=\pi/4\ (D^2–d^2)*f*n$$

Here D, d represents the composite samples of Before turning and After turning (mm), “n”represents the speed of spindle (rpm) and “f” represents the feed rate (mm).In the MRRexperiment the lowest value is 11,149 mm^3/min and it is presented at speed of 1000 rpm andfeed of 0.2 mm/rev, however it is increased to 69,091 mm^3/min at speed of 1400 rpm andfeed rate of 0.6.from this experiment we can clearly observe that at high speed and feed ratesdominatingthe metal removal rate .

TABLE3:METALREMOVALRATE

samples	speed	Feed rate	Al2024 pure		1% reinforcement		2% reinforcement		3% reinforcement.		MRR
			D	d	D	d	D	d	D	d	mm^3/min
S1	1000	0.2	21	19	20.5	18.5	20.5	18.8	20.5	19	11,149
S2	1000	0.4	22	18.5	21	18.5	21.5	18.5	20.5	18.5	34,422
S3	1000	0.6	22	18.5	21	18.5	21.5	18.5	20.5	18.2	52,929
S4	1200	0.2	21.5	19	20.5	18	21	18.5	21.5	18.5	19,605
S5	1200	0.4	22	18.5	21	18.5	20.5	18.5	21.5	18.2	42,343
S6	1200	0.6	21.5	19	21	19	21.5	18.5	21	19	53,870
S7	1400	0.2	21	18.5	20	18.5	22	18.5	21.5	18.5	22,982
S8	1400	0.4	20.5	19	22	19	21	19	20.5	19	35,332
S9	1400	0.6	22	19	21	18.5	22	18.8	20.5	18.8	69,091

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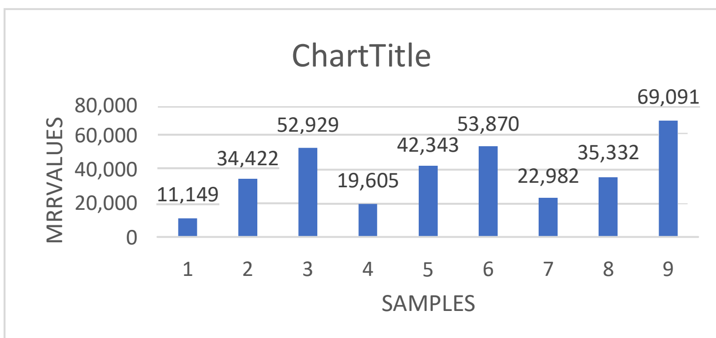
Figure9: Beforeturning diameterFigure 10: After turning diameter
Metalremoval rategraph:



CHIPFORMATION

Thetypeofchips formation inthemachinabilityprocessdependson mainlythreefactors likespeed, feed rate and depth of cut, Al -2024 and basalt powder reinforcements machinabilityprocessat differentparameters different typeofchips canbeformed,theyare Spiral continuous chips: This type of chip formation present at high speed, high feed rate andmediumdepth of cut.Long continuous chips: This type of chips formation present at low speed, high feed rate,highdepth ofcut. Asymmetrical continuous chips: This type of chips formation at medium speed, low feed rateanddepth is medium.Discontinuous chips: This type of chips formation at medium speed, high feed rate, low depthofcut.


Figure11:Spiral continuouschips Figure12:Longcontinuouschips


Figure13:AsymmetricalcontinuouschipsFigure14:Discontinuous chips

HARDNESSTEST

The hardness samples of Al 2024 and 1%,2%,3% reinforcements of basalt powder preparedon the lathe machine, the diameter of the sample is 120 mm and length of the sample is 150mm, the surface of the sample should be polished with different Sic grades of grit papers uptothe surface is having mirror finished, and then disc polishing methodis used for highersurface finish. For Al 2024 alloy killer reagent etchant is used to remove the deformed layersduringpolishing.

Hardness test is performed on using the MICRO VICKERS HARDNESS machine withapplying load of 0.1 kg with dwell time of 15 sec. Three indentations are performed on eachsample and average to be taken.The formula used to calculate the microVickers hardnesstest is

$$HV=1.854 * F / D^2$$

$$D=(D_1+D_2)/2$$

HereFisapplied loadkgandD1, D2 areareaoftheindentation.

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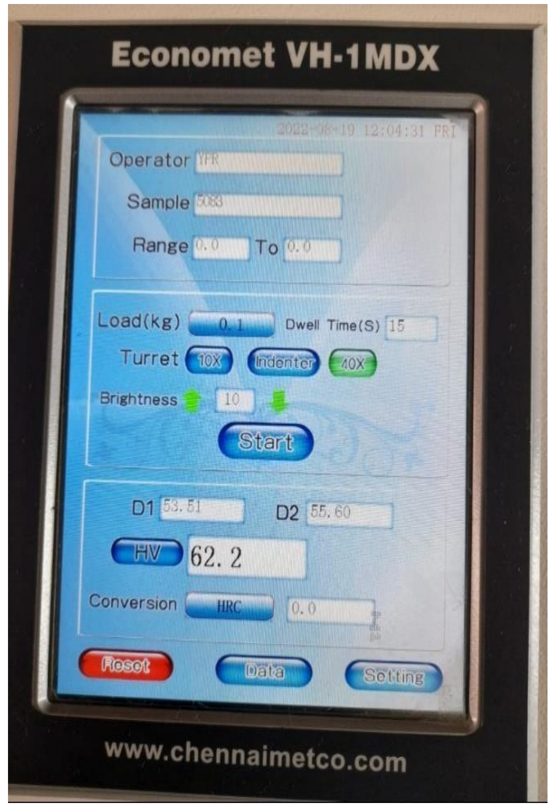

Figure 15: Micro Vickers hardnesstest

TABLE4: MICRO VICKERS HARDNESS TEST

S.no	samples	D1	D2	HV
1	Al2024	51.82	54.80	65.23
2	Al and 1%reinforce ment	38.2	37.62	129
3	Aland 2% reinforcement	47.72	46.06	84.32
4	Al and 3%reinforce ment	49.16	52.57	71.67

Thehardnesstestshowsthathardnesshavebeenincreasedin addingthereinforcement1%andthen it is decreasedtoon further 2 and 3%ofreinforcements.

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Scanningelectronmicroscope(SEM)

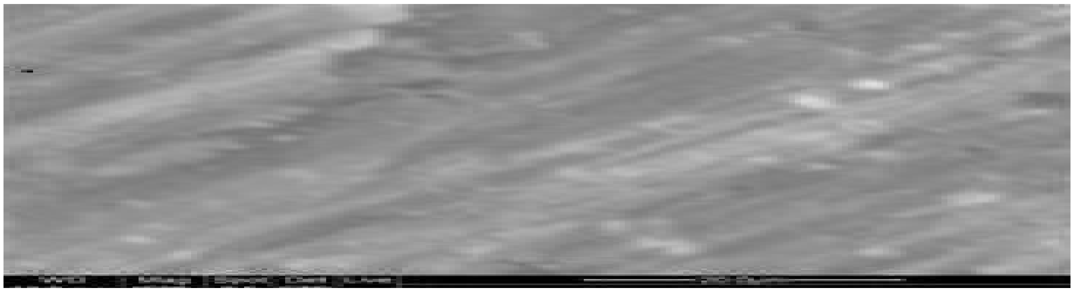


Figure16: Al 2024puresample

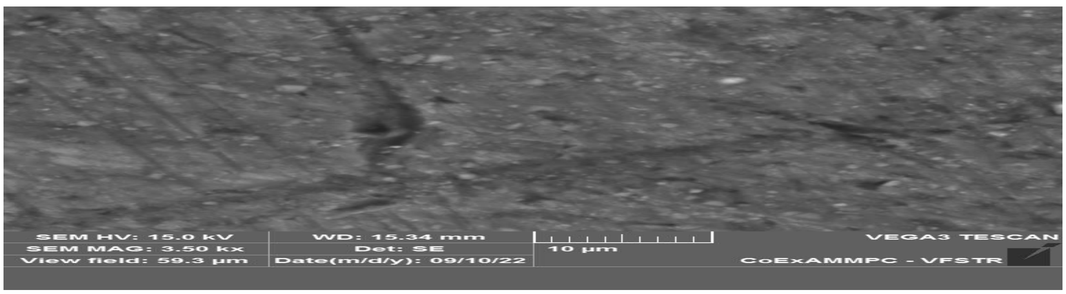
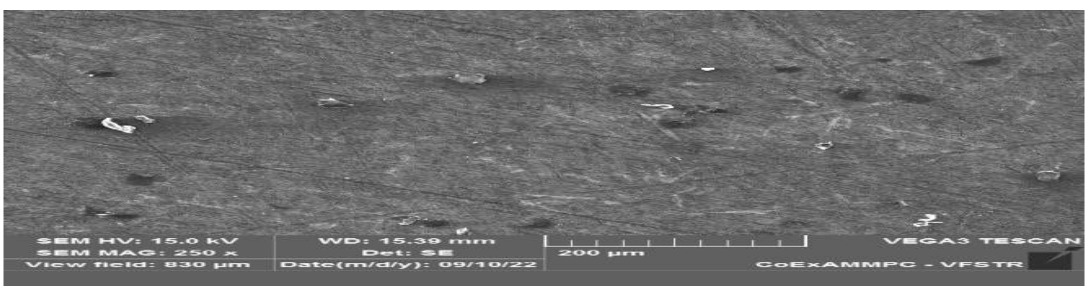


Figure17: al2024 and1%basalt powder

Figure18: Al 2024and 2%basaltpowder



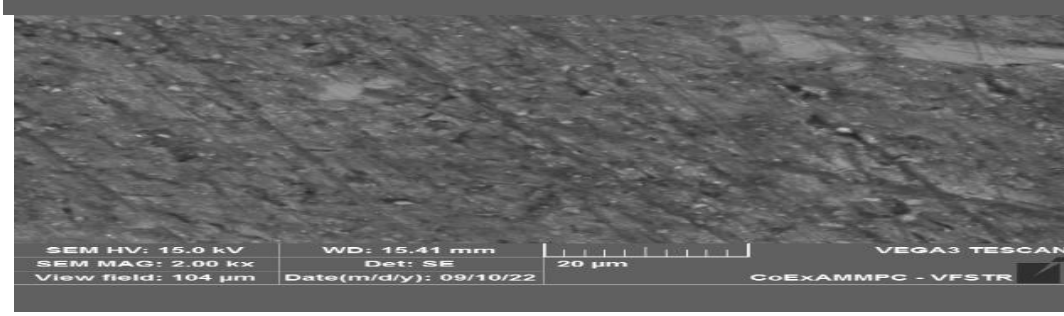


Figure19: Al2024 and 3%basaltpowder

In the al 2024 and 1% of basalt powder reinforcements images we can clearly observe the how thereinforcementscan Adding to thematrix withdifferentmagnifications, At3.50kx magnificationweclearlyobservethe basaltpowder reinforcementtothe pureal 2024sample

RESULTS AND DISCUSSIONS

Taguchitechniqueisusedforthes/nratioresults,pureAl2024and1%,2%,3%reinforcements of basalt powder was analyzed with machinability parameters such as speed(rpm),feedrate(mm/rev), depth of cut(mm) onthesurfaceroughness(Ra) in table5.

TABLE5:

Speed	Feedr ate	Depth ofcut	Pure(Ra) values	1%(Ra) values	2%(Ra) values	3%(Ra) values	S/NPU RE	S/N 1%	S/N 2%	S/N 3%
1000	0.2	0.1	3.5	2.7	3.58	3.67	-10.88	-8.62	-11.07	-11.29
1000	0.4	0.2	5.41	7.51	8.77	5.48	-14.66	-17.51	-18.85	-14.7
1000	0.6	0.3	10.45	9.74	7.47	9.61	-20.38	-19.77	-17.46	-19.65
1200	0.2	0.2	3.34	4.95	4.51	3.55	-10.47	-13.89	-13.08	-11.00
1200	0.4	0.3	4.49	5.74	6.26	6.44	-13.04	-15.17	-15.93	-16.17
1200	0.6	0.1	6.63	10.63	7.87	12.54	-16.43	-20.53	-17.91	-21.96
1400	0.2	0.3	6.11	2.96	4.72	5.71	-15.72	-9.42	-13.47	-15.13
1400	0.4	0.1	3.83	6.78	4.98	5.52	-11.66	-16.62	-13.94	-14.83
1400	0.6	0.2	8. 44	9.39	7.29	8.39	-18.52	-19.45	-17.25	-18.47

Here the surface roughness (Ra) values is measured by using the“TALYSURFINSTRUMENT”Andthe(Ra)valuespresent inmicrometer(μm).

Figure20:Talysurfinstrument

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ThemachinabilityparameterswithS/Nratiomaximumwillyieldtheoptimumqualitywithminimum variance, from the below response tables for signal to noise ratios we can clearlyobserve the FEED RATE is dominant parameter on surface roughness followed by speed anddepthofcut. Responsetables forsignalto noiseratios rankingsoftheparametersin tables6,7,8,9

TABLE6:RESPONSETABLE FORSIGNALTO NOISERATIOSFORPUREAL-2024			
Smalleris better			
LEVEL	SPEED	FEED	DEPTHOFCUT
1	-15.31	-12.36	-12.99
2	-13.32	-13.12	-14.56
3	-15.30	-18.45	-16.38
Delta	1.90	6.09	3.39
Rank	3	1	2

TABLE 7: RESPONSE TABLE FOR SIGNAL TO NOISE RATOS FOR AL 2024 AND 1% REINFORCEMENT			
Smalleris better			
LEVEL	SPEED	FEED	DEPTHOFCUT
1	-15.30	-10.65	-15.26
2	-16.53	-16.44	-16.95
3	-15.17	-19.92	-14.79
Delta	1.37	9.27	2.16
Rank	3	1	2

TABLE 8: RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS FOR AL 2024 AND 2% REINFORCEMENT			
Smalleris better			
LEVEL	SPEED	FEED	DEPTHOFCUT
1	-15.80	-12.55	-14.31
2	-15.64	-16.25	-16.40
3	-14.89	-17.55	-15.63
Delta	0.91	5.00	2.09
Rank	3	1	2

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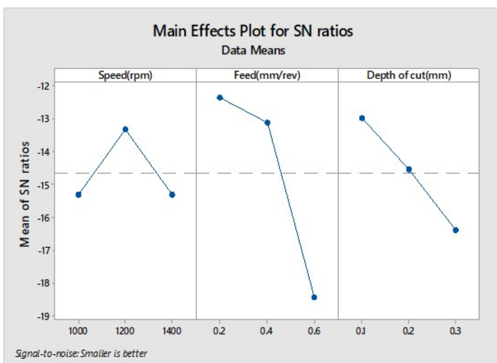
TABLE 9: RESPONSE TABLE FOR SIGNAL TO NOISE RATIOS FOR AL 2024 AND 3% REINFORCEMENT			
Smalleris better			
LEVEL	SPEED	FEED	DEPTHOFCUT
1	-15.24	-12.48	-16.03
2	-16.38	-15.26	-14.75
3	-16.15	-20.03	-16.99
Delta	1.14	7.56	2.24
Rank	3	1	2

In the means of signal noise ratio of aluminium and its reinforcements of figures(19,20,21,22) the optimum parameters are speed (1400 rpm), feed rate (0.2 mm/rev) anddepthofcut (0.1mm)



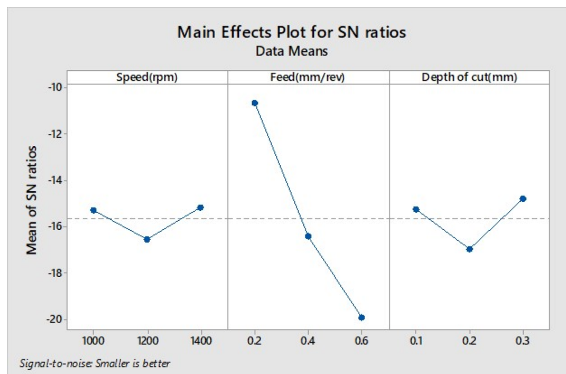
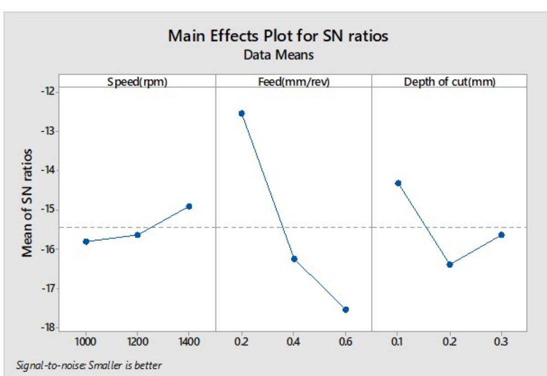


Figure21:MeansofSN ratioforAl 2024Figure22:MeansofSNratioforAland1%reinforcement



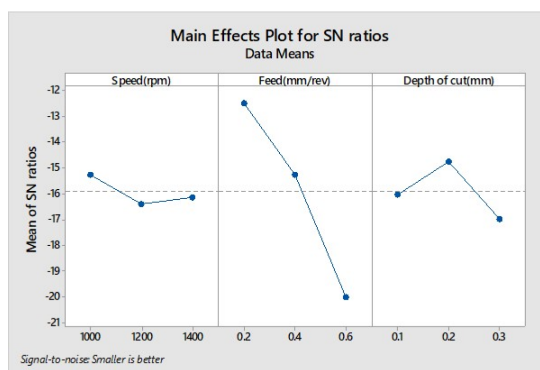


Figure23:MeansofSNratioforalandFigure24:MeansofSNratio foraland
2% reinforcement3% reinforcement

ANALYSISOFVARIANCE

Anova is used to detect the difference between the related means with the repeated measures,the procedure to perform the analysis of variance using the general linear model approach anditis used to

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perform the calculations.In the analysis of variance table consists of Degree of freedom, Sum of squares, Meansquares, F values is for qualitative understanding, P values for probability of significance.Tables 10,11,12,13 results shows analysis of variance of aluminium 2024 and 1%,2%,3%reinforcementsforsurface roughness

TABLE10:ANALYSIS OFVARIANCEFORSNRATIOSFORAL2024					
Source	DF	AdjSS	AdjMS	F	P
SPEED	2	7.919	3.959	1.90	0.345
FEED	2	65.968	32.984	15.85	0.059
DEPTH OFCUT	2	17.281	8.641	4.15	0.194
Error	2	4.163	2.082		
Total	8	95.332			
S= 1.44275		R^2=95.63%	R^2adj=82.53 %		

TABLE 11: ANALYSIS OF VARIANCE FOR SN RATIOS FOR AL 2024 AND 1% REINFORCEMENT					
Source	DF	AdjSS	AdjMS	F	P
SPEED	2	3.396	1.698	0.41	0.711
FEED	2	131.568	65.784	15.77	0.060
DEPTH OFCUT	2	7.752	3.876	0.93	0.518
Error	2	8.342	4.171		
Total	8	151.059			
S= 2.04233		R^2=94.48%	R^2adj= 77.91%		

TABLE 12: ANALYSIS OF VARIANCE FOR SN RATIOS FOR AL 2024 AND 2% REINFORCEMENT					
Source	DF	AdjSS	AdjMS	F	P
SPEED	2	1.416	0.7080	0.18	0.844
FEED	2	40.375	20.1877	5.25	0.160
DEPTH OFCUT	2	6.668	3.3341	0.87	0.536
Error	2	7.690	3.8450		
Total	8	56.150			
S= 1.96087		R^2=86.30%	R^2adj= 45.22%		

TABLE 13: ANALYSIS OF VARIANCE FOR SN RATIOS FOR AL 2024 AND 3% REINFORCEMENT					
Source	DF	AdjSS	AdjMS	F	P
SPEED	2	2.182	1.091	0.26	0.795
FEED	2	87.579	43.789	10.37	0.088
DEPTH OFCUT	2	7.556	3.778	0.89	0.528
Error	2	8.445	4.222		
Total	8	105.761			
S= 2.05483		R^2=92.02%	R^2adj=68.06 %		

From the above results of all the tables in the machinability parameters only FEED wasmostly influenced on the surface roughness,Because of the maximum F values indicates thattheaffectingthe machiningparameter.

REGRESSIONMODEL

In the machinability parameters of speed(rpm), feed(mm/rev), depth of cut (mm) the optimalvaluesofsurfaceroughness can beestimated byfollowingregression equations.Thesurfaceroughness ofpureAl 2024regressionequation 1is asfollows

pure 2024=0.23-0.00082Speed(rpm) + 10.47Feed(mm/rev)+11.82Depth ofcut(mm)

Thesurfaceroughness of Al2024and1%reinforcementofbasalt powderregressionequation2 as follows
SurfaceRoughness(1%) =1.70-0.00068Speed(rpm)+15.96Feed(mm/rev)

-2.78Depth ofcut(mm)

From the above equations we can observe feed(mm/rev) plays a major role on surfaceroughness. The negative (-ve) signs indicates the decreasing the surface roughness andpositive(+ve)signs indicates increasingthesurfaceroughness (Ra).In the above equations 1 and 2 the speed is in negative so it indicates the decreasing thesurface roughness with increasing speed(rpm). If the feed is increased the surface roughnessalsoincreases.

CONCLUSION

Intheexperimental investigationwecanobservetheeffects ofmachiningparameterssuchasspeed (rpm,), feed rate (mm/rev), depth of cut (mm) performance on the surface roughnessandmetal removalrate.
In the surface roughness feed rate is mainly effected, it can clearly shown in the responsetablessignal to noise ratios feed ratehas rank 1.In the anova process also f values maximum at feed rate it shows the qualitativeunderstanding,In the regression model also feed rate has positive values it indicates the increasing thesurfaceroughnessIn the metal removal rate at low speeds and low feed rate metal removal rate is minimum andathigherspeedsand higher feedsthemetal removalrates aremaximum.

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