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Experimental Investigation and Optimization of Machining Parameters in Turning of Aluminum Alloy 075-T651

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Abstract
Aluminum alloy 7075-T651 is a widely used material in the aviation, marine, and automobile sectors. The wide application marks the importance of this material's research in the manufacturing field. This research focuses on optimizing input process parameters of the turning process in the machining of Aluminum 7075-T651 with a tungsten carbide insert. The input machining parameters are cutting speed, feed, and depth of cut for the output response parameters cutting force, feed force, radial force, material removal , and surface roughness of the workpiece. For optimization of process parameters, the Taguchi method, with standard L9 orthogonal array, is used. ANOVA is applied to obtain significant factors and optimal combinations of process parameters.

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List of Abbreviations

Abbreviations	Meaning	Unit
MRR	Material removal rate	mm^3/s
Ra	Surface roughness	µm
DoC	Depth of a cut	mm
N	Cutting speed	rpm
f	Feed	mm/rev
Feed Force	Forces in machining	Newton
Radial Force	Forces in machining	Newton
Cutting forces	Forces in machining	Newton

1. Introduction

The turning process is most extensively used in thefield of conventional machining. In turning, material removal takes place through the cutting tool from the rotating workpiece. In simple straight turning, the feed of the cutting tool is provided in a parallel direction to the rotation axis of the workpiece. In a turning operation, the lathe machine produces the power for rotation of the workpiece with a particular speed, and provides feed and depth of cut to the cutting tool. Thus, these input parameters of machining, cutting speed, feed, and depth of cut are important during theturning. It becomes crucial for a manufacturer to know the effect of these parameters on the product's characteristics after turning. Turning can be carried either on the manual lathe or a CNC lathe .

Aluminum Alloy 7075-T651 has several applications in almost every field, namely, aviation, marine and automobile.

Mali et al. (2020); experimented with investigating the effect of parameters such as speed and depth of a cut on machining forces in turning of Al-7075. Researchers verified experimental results of the dry turning process of Aluminum 7075 with a Finite Element-based numerical-approach. The results indicated that both the cutting and feed force increase with enhance in feed and depth of a cut. However, the spindle speed showed the least influence on the forces.

Das et al. (2018); investigated the effect of parameters such as speed, and depth of a cut on material removal rate in turning T6 tempered Al 7075 alloy with uncoated tungsten carbide inserts in a dry environment. The results indicated that spindle speed was the most significant parameter taken after the feed, and the influence of depth of cut was insignificant.

Ajith kumar et al.(2019); experimented with dry turning of three hybrid composites, viz. (i) Al7075-10%SiC-0.1% B4C, (ii) Al7075-10%SiC-0.1% Graphene, and (iii) Al7075-10%SiC-0.1% CNT using uncoated and Diamond-Like Carbon (DLC) coated carbide tool. The results indicated that the feed rate is the most dominant factor influencing the surface roughness.

Junge et al. (2020) investigated the surface properties of Aluminum alloy EN AW-2017 workpiece during the machining operation. Researchers used Seebeck effect-based thermocouples to predict the temperature and cutting tool wear during the machining. They reported that an increase in temperature caused a rise of voltage and current.

Cagen et al.(2020) performed work on the type of chip formation and surface quality of Al7075-T6 alloy workpiece under dry and MQL conditions. Results indicated the better surface quality of a workpiece with a long segment of chips reported under the MQL compared to dry machining.

Singh et al. (2020) studied the milling operation on Al6061 alloy with MQL condition. To obtain significant input parameters to produce a better surface finish of workpiece, ANOVA was used. Results indicated that the feed has a major contribution in determining a better surface finish compared to coolant flow rate and cutting speed.

Schindler et al. (2014) investigated the thermo-elastic deformation of the aluminum alloy under dry machining conditions with help of a finite element model. The authors concluded that the workpiece temperature depended upon heat flux produced due to cutting forces and heat dissipation towards the surrounding.

Sahithi et al. (2019) investigated and optimized parameters during the turning operation on Aluminum alloy 6061, Aluminum alloy 6063, and Aluminum alloy 6082 through the Tauchi technique. Researchers observed that a better surface finish was found on Aluminum 6063 than Aluminum 6061 at cutting speed 500 rpm, feed 0.10mm/min, and depth of cut 0.5 mm.

Deepak et al. (2015); experimented with and without coolant on AL6061. Researchers reported that the feed-rate was the most significant factor which affects metal removal rate during machining of Al6061, followed by the depth of cutting and cutting speed.

Gangopadhyay et al. (2010); studied the two cutting tools; chemical vapour deposited diamond and polycrystalline diamond cutting tools, and reported that polycrystalline diamond cutting tools were an excellent tool for aluminum alloys in machining under dry environment because of high thermal conductivity, low coefficient of friction and elevated temperature. The main problem in aluminum alloys machining with an uncoated carbide cemented insert is forming of a built-up layer on the rake surface.

Viramgama et al. (2016); investigated that the quality of the machined work surface depended on the shape and size of the chips.

Srivastava et al. (2015) observed the effect of input machining parameters on heat generation during machining of Inconel 718. A high depth of a cut produces a greater value of cutting forces and causes more heat generation. If the workpiece material has lower thermal conductivity, the dissipation of heat from the machining zone becomes a challenge.

Mishra et al. (2018) experimented and optimized machining input parameters in turning of Inconel 718. The authors observed that the most significant factor was the cutting speed, followed by the depth of cut and feed in the machining of Inconel 718.

Reddy et al. (2017) investigated machining issues and optimized machining parameters in the turning operation of 7075 Aluminum alloy with Taguchi L27 orthogonal array. The result demonstrated that temperature induced in machining was most affected by the depth of a cut. Cutting force was affected the most by speed, and feed has played the most significant role in affecting surface roughness.

Gupta et al. (2015) used the Taguchi-based Grey Relation Analysis for optimizing the machining parameters, namely, speed, feed, cooling conditions during turning operation of AISI 4340 steel on a Center Lathe machine. Cutting Force, tool wear rate and surface roughness were the output parameters. A tungsten carbide insert was used for machining. L9 orthogonal arrays were used for optimization purposes. For cooling, three conditions were chosen, namely wet, dry and cryogenic (using liquid nitrogen). They found the cooling need as the most significant factor, followed by speed and feed. Cryogenic cooling was chosen as the most optimal cooling condition. ANOVA confirmed the results.

Makadia et al. (2013) used Response Surface Methodology for optimization of machining parameters cutting speed, feed, depth of a cut and nose radius of cutting tool during turning of AISI 410 on CNC Lathe. They measured surface roughness as an output parameter and found the feed to be the most contributing factor, followed by nose radius. Speed was also slightly significant, while the depth of cut was hardly significant. A regression model was also developed using the RSM. ANOVA was used toconfirm the result.

Verma et al. (2018) used the Taguchi Method to optimize machining forces in turning operation of EN-8 steel on HMT NH22 lathe .They used L9 orthogonal array for study, and found that the percentage involvement of the depth of a cut on cutting force and feed force was maximum. The feed was the second major contributing factor to both cutting and feed forces. Spindle speed was the minor significant factor.

Mishra et al. (2018) optimized the cutting force, feed force, and MRR in turning of Inconel 718 with coated (TiAlN and TiN) carbide insert. They used the Taguchi method to optimize the machining force. The study proposes that the cutting speed is the most influencing factor among input process parameters.

Dabhi et al. (2016) investigated optimizing the cutting parameters for the lowest surface roughness gained during the turning of stainless steel SS410 grade workpiece. Machining experiments were performed at the CNC machine using carbide cutting tools on SS410 materials. The analysis of variance estimated the effects of the cutting conditions and cutting tool materials on the surface roughness of a workpiece. The statistical analysis showed that the machining parameters with a significant impact on surface roughness were the cutting speed trailed by the depth of a cut and feed correspondingly.

Pandey and Yadav (2020) demonstrated optimization of process parameters during low-frequency vibration-assisted electric discharge machining of Ti-6Al-4V and Al-TiB2. They have presented the effects of vibration of tool electrodes on process parameters.

Macek et al. (2020) studied variation in fracture surface and crack profile in loading environments. The authors concluded that prime crack lengths were found at those conditions, which was other than B=T. Macek et al. (2021) performed a study on fracture surfaces of S355J2 steel workpiece at non-proportional bending with torsion with 3 D profilometer to investigate surface quantities. The authors promoted this method as a measurement methodology as well as the technique of surface evaluation.

3. Experimental Details

The turning operation was carried out on HMT NH22 lathe in Central Workshop at U.I.E.T CSJM University Kanpur.

3.1. Work Piece Material

The selected workpiece for the study was Aluminum Alloy 7075, which was in the form of a cylindrical bar of 300 mm length and 60mm diameter. Table 1 and Table 2 show the chemical configuration and mechanical properties of Aluminum Alloy 7075-T651, respectively.

Table1. Chemical Configuration of Aluminum Alloy-7075-T651 (ASM International, 1990)

Component	Weight%
Aluminum	87.1-91.4
Chromium	0.18-0.28
Copper	1.2-2
Iron	Max 0.5
Magnesium	2.1-2.9
Manganese	Max 0.3
Silicon	Max 0.4
Titanium	Max 0.2
Zinc	5.1-6.1
Others	Max 0.20

Table 2. Properties of Aluminum Alloy 7075-T651 (ASM International, 1990)

Property	Value
Hardness	HRB 87
Ultimate Tensile Strength	572 MPa
Tensile Yield Strength	503 MPa
Elongation at Break	11%
Density	2810 kg/m^3

3.2. Cutting Insert

For the entire experiment, the turning operation was performed using an uncoated tungsten carbide insert with specification CNMG120404, as shown in Figure 1. The aim was to study the response when an uncoated insert is used for turning of Aluminum Alloy 7075.

Fig. 1. Tungsten Carbide Insert (Uncoated)

3.3. Selection of Process Parameters

During the experiment, three process parameterswere selected along with their three levels. The preferred process parameters were cutting speed (rpm), feed rate (mm/rev), and depth of cut (mm). Table 3 shows the selected process parameters with their three-level values.

Table 3. Process Parameters and their Levels

Factors	Unit	Level-1	Level-2	Level-2
Speed	rpm	325	550	715
Feed	mm/rev	0.08	0.10	0.12
Depth ofcut	mm	0.1	0.3	0.5

3.4. Experimental Procedure

The entire experiment was performed on an HMT NH22 lathe, as shown in Figure 2. For the experimental design and run order, a commercially available software Minitab18 was used and experiments were performed accordingly. The dynamometer used for the force measurement was UIL 15Lathe Tool Dynamometer. For the surface roughness measurement Mitutoyo Surftest SJ-201 P/M Portable Surface Roughness Tester was used. Both of theseinstruments were calibrated through manual measurements. Length parameter is 3.2 mm for measuring surface roughness of workpiece.

Fig. 2. HMT NH22 Lathe

3.5. Methodology adopted for optimization

For optimization, the Taguchi Method was employed. The-Taguchi method is a statistical procedure developed to increase the product quality.Taguchi defined the product quality in terms of minimum loss to society. The method makes use of a robust design strategy by using specially designed arrays called orthogonal arrays, which make use of a few experimental trials against the full factorial design. Taguchi method makes the process insensitive to noise factors through the use of the S/N ratio, which also helps to analyze results easier. Its biggest drawbackis that it usually neglects interactions

4. Result and Discussion

4.1. For the Taguchi Method

The experimental design and analysis of experimental data for the entire experiment were done using the statistical software Minitab18. For the present work, the L9 orthogonal array (OA) of Taguchi wasused. Three sets of experiments were carried out. It helped to better predictions and accurate results. Table 4 shows the three sets of experiments. From Table 5, it is clear that all the three parameters, cutting speed, feed, and depth of a cut, are significant factors in affecting the feed Force.

A significant factor with a contribution of 83.99%. The feed is the next significant factor with a percentage contribution of 8.58%. The speed is the least significant with a percentage contribution of 3.68%. The S/N ratio is an essential characteristics of the Taguchi Method. It takes into account both the magnitude as well as variation inresponse. No matter what type of response, the highest value of the S/N ratio corresponds to a better response. Hence the factor levels correspond the to the highest S/N ratio are termed as optimal. Further S/N ratio is found higher for those responses which have the highest average value or lowest average value (whichever is applicable). Those can be easily seen from the direct effects plots. For the feed force, the lower mean value is desired and chosen, the better critera are achieved int terms of the S/N ratio. It is seen from Figures 3 and 4that the optimal combination of parameters for the feed forceis the speed at 715 rpm (main effect plot here gives a better picture), feed at 0.08 mm/rev and depth of a cut at 0.1 mm. It is seen from figure 3 that as the speed is increasing from 325 to 715 rpm, the feed force is decreasing continuously. In the entire experimental region, the heat dissipation rate is dominant over the strain hardening and the thermal softening results in a decrease in the force. Further, increasing the feed or the depth of a cut, the feed force is rising due to the increased friction of heavier chips.The delta values in Tables 6 and 7 confirm the results.

Table 4. Experimental Results for Taguchi Method

Exp. (SET 1)	**Cutting speed (rpm)**	**Feed (mm/rev)**	**Depth of cut(mm)**	**Feed Force (N)**	**Cutting Force (N)**	**Radial Force(N)**	**MRR (mm^3/s)**	**(Ra) Surface Roughness (µm)**
1	325	0.08	0.1	9.81	19.62	29.43	8.13	0.81
2	325	0.10	0.3	49.05	68.67	39.24	34.17	0.79
3	325	0.12	0.5	98.10	117.72	19.62	67.06	1.13
4	550	0.08	0.3	39.24	58.86	19.62	46.65	0.70
5	550	0.10	0.5	78.48	88.29	19.62	94.97	0.92
6	550	0.12	0.1	29.43	49.05	39.24	23.52	0.98
7	715	0.08	0.5	68.67	88.29	9.81	95.45	0.82
8	715	0.10	0.1	19.62	49.05	39.24	25.08	0.74
9	715	0.12	0.3	49.05	58.86	29.43	90.08	0.90
Exp. (SET 2)	**Cutting speed (rpm)**	**Feed (mm/rev)**	**DoC (mm)**	**Feed Force (N)**	**Cutting Force (N)**	**Radial Force(N)**	**MRR (mm^3/s)**	**(Ra) Surface Roughness (µm)**
1	325	0.08	0.1	9.81	19.62	29.43	8.06	0.97
2	325	0.10	0.3	58.86	78.48	39.24	33.97	0.92
3	325	0.12	0.5	107.91	156.96	29.43	64.88	0.95
4	550	0.08	0.3	49.05	58.86	19.62	45.79	0.94
5	550	0.10	0.5	78.48	78.48	19.62	93.16	0.89
6	550	0.12	0.1	29.43	58.86	39.24	23.09	0.87
7	715	0.08	0.5	58.86	78.48	9.81	92.89	0.79
8	715	0.10	0.1	19.62	49.05	29.43	24.26	0.83
9	715	0.12	0.3	49.05	68.67	29.43	86.94	0.80
Exp. (SET 3)	**Cutting speed (rpm)**	**Feed (mm/rev)**	**DoC (mm)**	**Feed Force (N)**	**Cutting Force (N)**	**Radial Force(N)**	**MRR (mm^3/s)**	**(Ra)Surface Roughness (µm)**
1	325	0.08	0.1	9.81	19.62	29.43	8.20	0.88
2	325	0.10	0.3	58.86	78.48	39.24	33.20	0.87
3	325	0.12	0.5	98.10	117.72	19.62	66.07	1.05
4	550	0.08	0.3	49.05	58.86	19.62	46.05	0.74

5	550	0.10	0.5	78.48	78.48	19.62	93.73	0.88
6	550	0.12	0.1	29.43	58.86	39.24	22.87	0.89
7	715	0.08	0.5	68.67	68.67	19.62	98.56	0.92
8	715	0.10	0.1	19.62	39.24	39.24	24.26	0.75
9	715	0.12	0.3	49.05	68.67	29.43	88.96	0.95

Table 5. Analysis of Variance for Feed Force

Source	DoF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	5174	3.68%	5174	2586.8	9.80	0.01
Feed	2	12054	8.58%	12054	6027.0	22.82	0.00
DoC	2	118048	83.99%	118048	59023.8	223.51	0.00
Error	20	5282	3.76%	5282	264.1		
Total	26	140	100				
		557	%				

Table 6. Response for Means for Feed Force

Level	Speed	Feed	Depth of a cut
1	55.59	40.33	19.62
2	51.23	51.23	50.14
3	44.69	59.95	81.75
Delta	10.90	19.62	62.13
Rank	3	2	1

Table 7. Response for the S/N ratio for feed force (smaller is better)

Level	Speed	Feed	Depth of a cut
1	-31.63	-29.81	-25.02
2	-33.51	-32.89	-34.00
3	-32.00	-34.44	-38.12
Delta	1.88	4.63	13.10
Rank	3	2	1

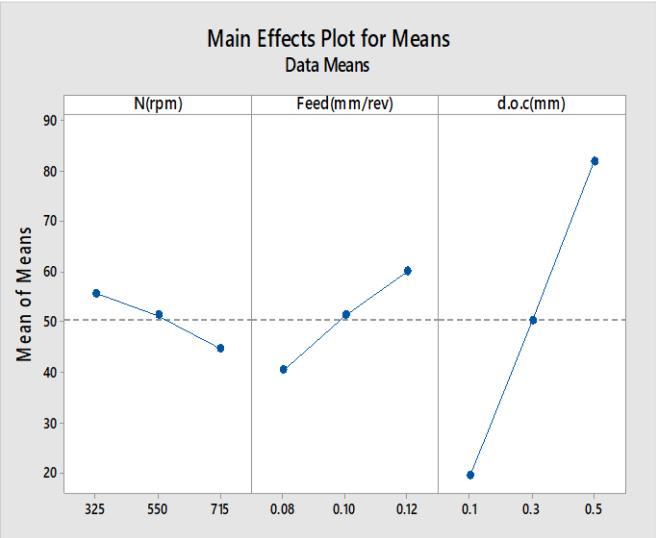

Fig. 3. Effect of Process Parameters on the feed force - raw data

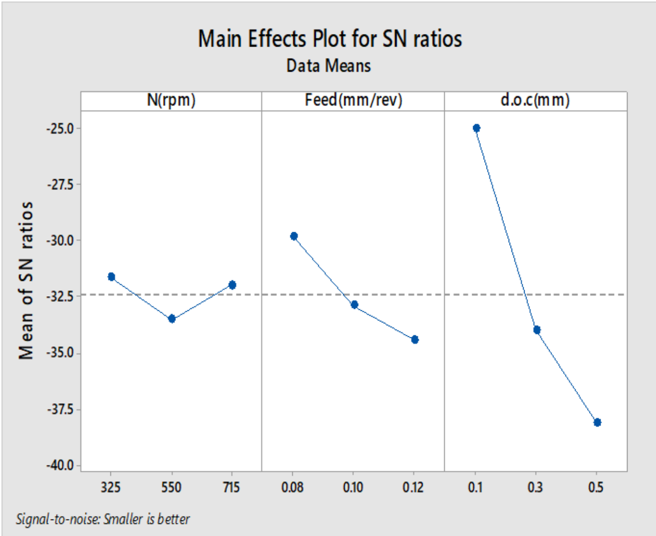

Fig. 4. Effect of Process parameters on the feed force - S/N ratio

It is clear from Table 8 that all the three process parameters are significant for the cutting force. It is seen that the depth of cut is the most significant, with a contribution of 61.22%. The feed is next significant with a contribution of 19.01% , while the speed is the least significant with a contribution of 3.10%. The behavior of Cutting force in Fig. 5 and 6 with process parameters are the same as of the feed force and are explained similarly. Further, it is seen that error contributes to about 16.66% to response which means that either interaction effect is also significant here, or that there is one or more process parameter that are not taken into account From Figure 5 and 6 it is clear that the optimal settings for the cutting force is speed at 715 rpm, feed rate at 0.08 mm/rev and depth of cut at 0.1mm.

Table 8. Analysis of Variance for the cutting force

Source	DoF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	734.2	3.10%	734.2	367.12	1.86	0.181
Feed	2	4498.1	19.01%	4498.1	2249.07	11.41	0.000
DoC	2	14485.3	61.22%	14485.3	7242.66	36.75	0.000
Error	20	3942.1	16.66%	3942.1	197.11		
Total	26	23659.8	100.00%				

Table 9. Response for Means for the cutting force

Level	Speed	Feed	DoC
1	75.21	52.32	40.33
2	65.40	67.58	66.49
3	63.22	83.93	97.01
Delta	11.99	31.61	56.68
Rank	3	2	1

Table 10. Response for the S/N ratio of the cutting force (Smaller the better)

Level	Speed	Feed	Depth of Cut
1	-29.54	-26.02	-30.81
2	-27.86	-29.64	-29.03
3	-27.80	-29.54	-25.35
Delta	1.74	3.62	5.36
Rank	3	2	1

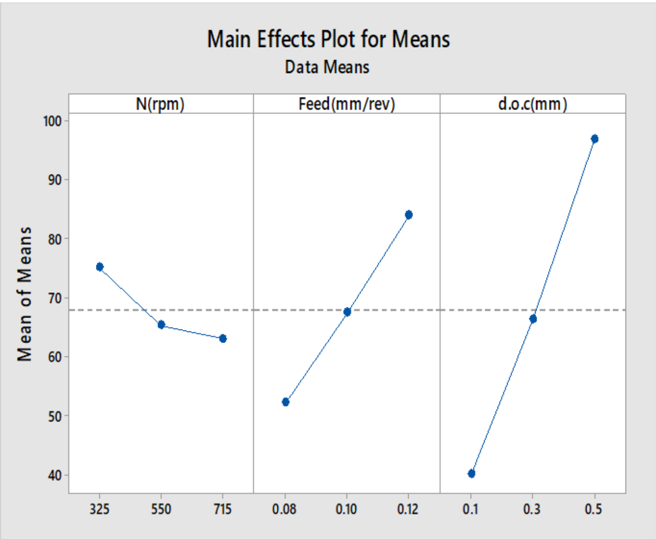

Fig. 5. Effect of process parameters on the cutting force - raw data

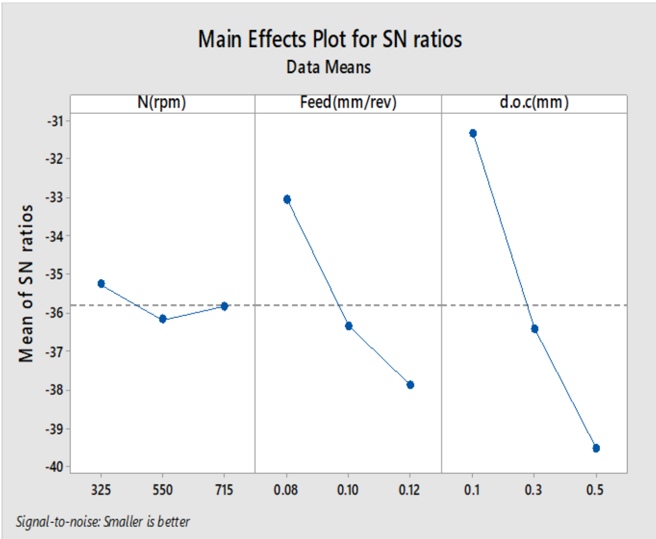

Fig. 6. Effect of process parameters on the cutting force- S/N ratio

It is clear from Table 11 that all the three process parameters are significant for the radial force. Depth of a cut is the most significant with a contribution of 53.85%. The feed is next significant factor with a contribution of 28% and the speed is next significant factor with a contribution of 4.92%. Error contributes 13.23% to the response indicating the dependence of the radial force on any other factor, which may be interaction or an unconsidered process parameter. From Figure 7, the behaviour of the radial force due to speed and is explained similarly as for the feed force and cutting force. It is seen that the feed force increases initially up to 0.10 mm/rev feed due to dominant friction in shearing the material and in chip removal.

Table 11. Analysis of Variance for the radial force

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	114.1	4.92%	114.1	57.03	3.72	0.042
Feed	2	648.7	28.00%	648.7	324.35	21.16	0.000
DoC	2	1247.5	53.85%	1247.5	623.75	40.70	0.000
Error	20	306.5	13.23%	306.5	15.33		
Total	26	2316.8	100.00%				

Beyond this, the radial force tends to decrease. Further, it is seen radial force is decreasing continuously with the depth of cut. Both these may be due to the fact that there is excess thermal softening, which is the most dominant. It is clear from Figure 7 and 8 that the optimal combination for the radial force is the speed at 715 rpm, feed rate at 0.08 mm/rev, and depth of cut at 0.5 mm.

Table 12. Response for Means for the radial force

Level	Speed	Feed	DoC
1	30.52	20.71	34.88
2	26.16	31.61	29.43
3	26.16	30.52	18.53
Delta	4.36	10.90	16.35
Rank	3	2	1

Table 13. Response for the S/N ratio for the radial force (Smaller the better)

Level	Speed	Feed	DoC
1	-29.54	-26.02	-30.81
2	-27.86	-29.64	-29.03
3	-27.80	-29.54	-25.35
Delta	1.74	3.62	5.46
Rank	3	2	1

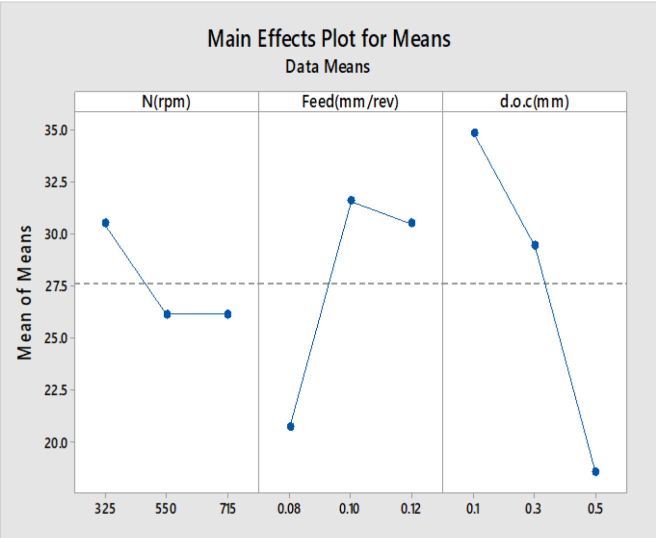

Fig. 7. Effect of process parameters on the radial force - raw data

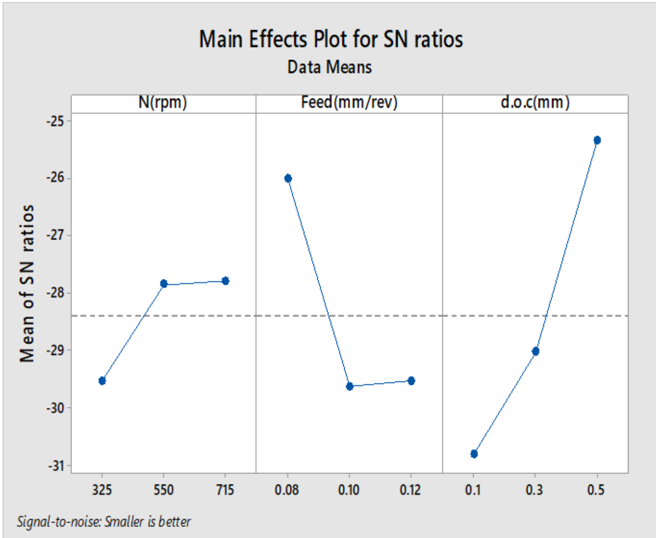

Fig. 8. Effect of process parameters on the radial force – S/N ratio

Table 12. Analysis of Variance for the MRR

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	3.1382	19.07%	3.1382	1.56909	2700.27	0.000
Feed	2	0.8909	5.41%	0.8909	0.44544	766.57	0.000
DoC	2	12.4137	75.44%	12.4137	6.20685	10681.46	0.000
Error	20	0.0116	0.07%	0.0116	0.00058		
Total	26	16.4544	100.00%				

For the MRR, it is observed that the depth of a cut is the most significant with a contribution of 75.44% followed by speed which makes a contribution of 19.07% according to table 12. The feed is the least significant with only 5.41% contribution. Error contribution is negligible indicating absence of any other factor. From Figures 9 and 10 it is clear that the MRR increases with the increment of any factor, which is the most likely because of more material being removed at the same time. It is seen that the optimal combination for MRR (which is larger the better type) is the speed at 715 rpm, feed rate at 0.12 mm/rev, and depth of cut at 0.5 mm.

Table 13. Response for means for the MRR

Level	Speed	Feed	DoC
1	35.97	49.98	18.61
2	54.43	50.76	56.20
3	69.61	59.27	85.20
Delta	33.64	9.30	66.59
Rank	2	3	1

Table 14. Response for the S/N ratio for the MRR (larger the better)

Level	Speed	Feed	DoC
1	28.39	30.36	24.43
2	33.35	32.61	34.27
3	35.45	34.21	38.48
Delta	7.06	3.85	14.05
Rank	2	3	1

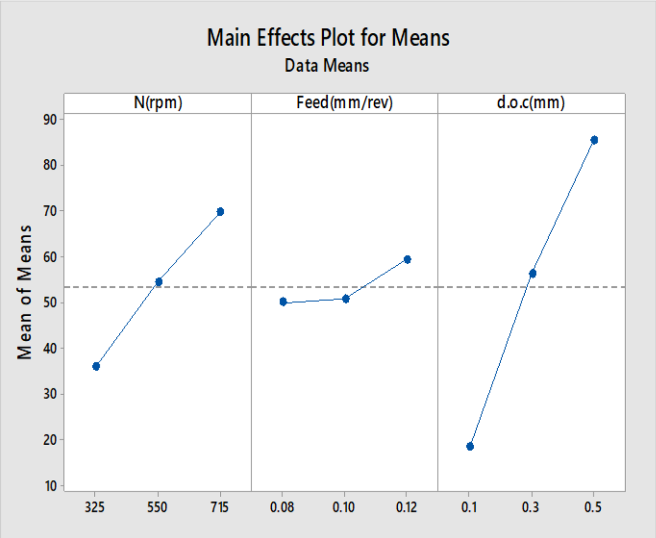

Fig. 9. Effect of process parameters on the MRR – raw data

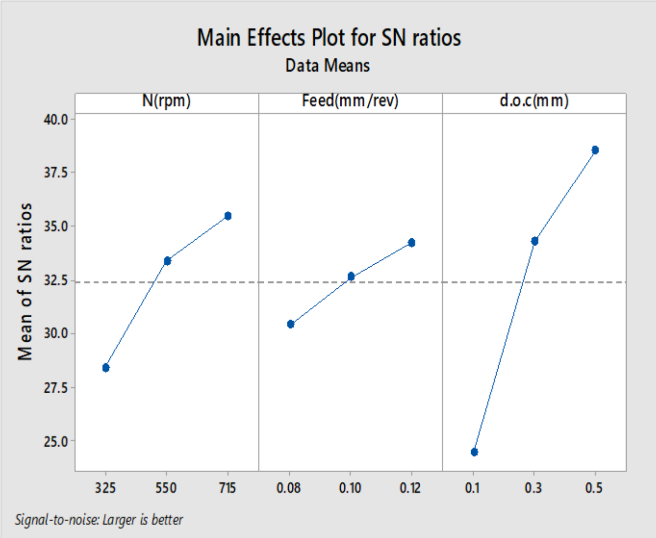

Fig. 10. Effect of process parameters on the MRR – S/N ratio

From Table 15 it is observed that all the three parameters are statistically significant. The feed is the most significant factor with 26.60% contribution;speed is the next significant factor with 17.74% contribution and depth of a cut is the next significant with a contribution of 14.41%. It is also visible that error contribution is high on surface roughness with a contribution of 41.25%, indicating that there are more significant factors that should have been taken into account. Tool nose radius can be such a factor.

Table 15. Analysis of Variance for the surface roughness

Source	DF	Seq SS	Contribution	Adj SS	Adj MS	F-Value	P-Value
Speed	2	0.12088	17.74%	0.12088	0.06044	4.30	0.028
Feed	2	0.18128	26.60%	0.18128	0.09064	6.45	0.007
DoC	2	0.09824	14.41%	0.09824	0.04912	3.49	0.050
Error	20	0.28115	41.25%	0.28115	0.01405		
Total	26	0.68156	100.00%				

Table 16. Response for means for the surface roughness

Level	Speed	Feed	DoC
1	0.9300	0.8411	0.8578
2	0.8678	0.8433	0.8456
3	0.8333	0.9467	0.9278
Delta	0.0967	0.1056	0.0822
Rank	2	1	3

Table 17. Response for the S-N ratio for the surface roughness

Level	Speed	Feed	DoC
1	0.6415	1.4726	1.3392
2	1.2189	1.4867	1.4282
3	1.5793	0.4805	0.6723
Delta	0.9379	1.0062	0.7559
Rank	2	1	3

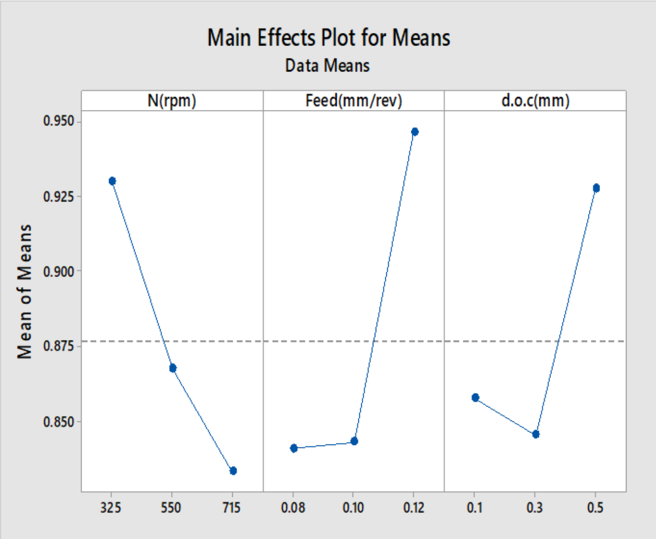

Fig. 11. Effect of process parameters on the surface roughness – raw data

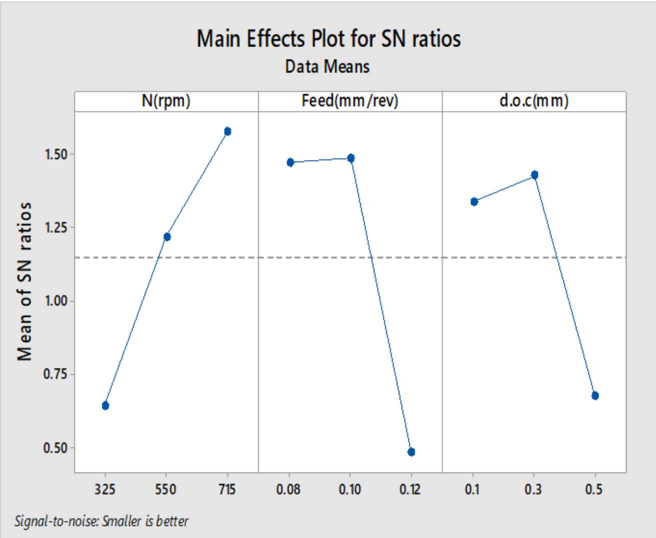

Fig. 12. Effect of process parameters on the surface roughness – S/N ratio

From Figure 11 and 12 it is clear that the optimal setting for the surface roughness (smaller the better) is the speed at 715 rpm, feed at 0.08 mm/rev and depth of a cut at 0.3 mm. It is clear from the main effect plots that a better finish is obtained with the increase of speed. On increasing feed, finish gets poor which response during its turning and obtain an optimal combination of the process parameters, which are under the control satisfactory. So it becomes necessary to optimize the various output parameters .

5. Conclusion

Due to its wide range of applications in almost every field, such as aviation, marine or automotive industry, military, etc. it is necessary to have a good knowledge of various machining characteristics of Aluminum alloy 7075-T651 so as to produce the product of excellent quality.

From the Taguchi method, it is observed that:

- For the feed force, depth of a cut is the most significant factor with 83.99% contribution followed by the feed rate with a contribution of 8.58% while the speed is the least significant with 3.68% contribution, while error only contributes 3.76%. For the feed force the optimal setting is the speed at 715 rpm, feed rate at 0.08 mm/rev, and cut at 0.1 mm.
- For the cutting force, the depth of a cut is the most significant with 61.22% contribution followed by the feed rate with 19.01% contribution. The speed is the least significant with 3.10% contribution, while error contributes about 16.66%, which calls for some more significant factor or interaction not considered in this study. For the cutting force the optimal setting is the speed at 715 rpm, feed rate at 0.08 mm/rev, and depth of a cut at 0.1 mm.
- For the radial force, the depth of cut is the most significant with a contribution of 53.85%, followed by the feed with 28% contribution. The speed is the next significant factor with a contribution of 4.92%, while error also contributes about 13.23% , which calls for considering either interactions or a new factor. For radial force the optimal setting is the speed at 715 rpm, feed rate at 0.08 mm/rev, and depth of a cut at 0.5 mm.
- For the MRR, depth of a cut is the most significant factor with a contribution of 75.44% followed by speed, which contributes 19.07%. The feed rate is the next significant factor with 5.41% while error contribution is negligible. For the MRR, the optimal setting is the speed at 715 rpm, feed rate at 0.12 mm/rev, and depth of a cut at 0.5 mm.
- For the surface roughness, the feed is the most significant factor with the contribution of 26.60%, followed by the speed with 17.74% contribution. Depth of a cut is the least significant with a contribution of 14.41%.

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7075-T651 铝合金车削加工参数试验研究及优化

關鍵詞
田口法
进给力
切削力
径向力
MRR

摘要
7075-T651 铝合金是航空、船舶、汽车等领域广泛使用的材料。 广泛的应用标志着该材料研究在制造领域的重要性。 本研究工作的重点是优化使用碳化钨刀片加工 7075-T651 铝的车削工艺的输入工艺参数。 输入加工参数为切削速度、进给和切削深度，输出响应参数为工件切削力、进给力、径向力、材料去除率和表面粗糙度。 为优化工艺参数，使用具有标准 L9 正交阵列的田口方法。 应用方差分析来获得重要因素和工艺参数的最佳组合。