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Optimization of Machining Parameters in Turning Operation of Aluminium Alloy for MRR and Hardness

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Abstract

Metal removal turning is a process in production industries for the manufacturing of number of components. The mostly used turning machines are centre lathe, turret lathe, and cnc machine. Centre lathe is a general purpose machine which is mostly used in most of industries. First pilot experiments were done on the work piece using random values and then from those pilot experiments the suitable values of these parameters were selected. On the basis of observations from the pilot experiments four values of Spindle speed 59,118,165,220, four values of feed .12, .14, .16, .18 and four values of Depth of cut .8, 1, 1.2, 1.4 were chosen. L16 orthogonal array performed using these values. It is concluded that for MRR be maximum factor Cutting speed has to be at high level 4, Feed has to be at high level 4 & D.O.C has to be at high level 4. It is concluded that for hardness to be maximum Cutting speed has to be at high level 4, Feed has to be at low level 1 & D.O.C has to be at level 2.

Keywords: *Machining, Taguchi, Orthogonal Array, Signal to noise ratio*

1. Introduction

Metal removal turning is a process in production industries for the manufacturing of components. The mostly used turning machines are centre lathe, turret lathe, and cnc machine. Centre lathe is a general purpose machine which is mostly used in most of industries. Mild steel is an unalloyed medium carbon steel which is used for manufacturing of shafts, studs, keys etc. Metal removal turning process is requiring to manufacturing them. Quality and quantity is also essential in industries. Therefore to optimize these parameters are necessary.

1.1 Adjustable Cutting Factors In turning process

The primary factors in any basic turning operation are speed, feed, and depth of cut. Other factors such as kind of material and type of tool may have a large influence, of course, but these three are the ones the operator can change by the controls, right at the machine.

Speed: Speed always refers to the spindle and the work piece. When it is stated in revolutions per minute (rpm) it is their rotating speed. The important aspect for a particular turning operation is the speed at which the work piece material is moving past the cutting tool. It is simply the product of the rotating speed times the circumference of the work piece before the cut is started. It is expressed in meters per minute (m/min) and it refers only to the work piece. Every different diameter on a work piece will have a different cutting speed even though the rotating speed is same.

$$v = \frac{\pi DN}{1000}\ \text{m/min}$$

Where v is the cutting speed, D is the initial diameter of the work in mm and N is the spindle speed in RPM.

Feed: Feed always refers to the cutting tool, and it is the rate at which the tool advances along its cutting path. On most power-fed lathes the feed rate is directly related to the spindle speed and is expressed in mm (of tool advance) per revolution (of the spindle) or mm/rev.

$$F_m = f.N\ \text{mm min}^{-1}$$

Where F_m is the feed in mm per minute, f is the feed in mm/rev and N is the spindle speed in RPM.

Depth of Cut: Depth of cut is practically self explanatory. It is the thickness of the layer being removed (in a single pass) from the work piece or the distance from the uncut surface of the work to the cut surface, expressed in mm. It is important to note, though, that the diameter of the work piece is reduced by two times the depth of cut because this layer is being removed from both sides of the work.

$$d_{cut} = \frac{D-d}{2}$$

Where D and d represent initial and final diameter (in mm) of the job respectively.

2. Literature Study

Francis John and Santosh Kumar(2017)[1] This experiment shows the optimization of cutting parameters for surface roughness & material removal rate in the turning process to obtain the optimal setting for the process parameters and analysis of variance is used to analysis the influence of cutting parameters while turning. This experiment are based on the basis of different tool materials, High Speed Steel tool (HSS), Carbide tool and Cobalt tool with 5% carbon contents.

V Muthuraman and S Arun Kumar(2017)[2]The influence of the cryogenic LN2 coolant compared with that of the conventional coolant on the cutting performance parameters, such as the cutting force, cutting temperature, and surface finish was analysed and investigated. The use of the cryogenic liquid nitrogen coolant influenced the cutting temperature and the cutting force by about 17 to 29% and 11 to 20% reduction respectively.

G.Guruvaiah Naidu and M.Gopi Srinivas(2017)[3] The objective of the work is to find out the set of optimum values for the selected factors in order to improve material removal rate to determine the optimum cutting conditions more efficiently considering the control factors viz. type of lubricant; cutting speed; feed rate and depth of cut are investigated at three different levels for EN 36 Steel Alloy. The selected control factors are significant for the Material Removal rate. The results obtained for speed and feed are 650m/min and 0.4mm/min respectively.

Harjit Singh, Harish Garg and Ajay Kumar(2016)[4] The Hybrid Metal matrix composites (HMMC) are most advanced material. In this research, calculate the influence of most prominent parameters of CNC turning machine on material removal rate (MRR) and surface roughness (SR) of the hybrid composite material. Our output parameters, RSM (response surface methodology) is used. The best combination of input parameters for the maximum output (MRR) and minimum (SR). TNMG160408, TNMG2000 and K10 tool inserts are used as cutting tool. The purpose of the present study is to calculate the optimum setting of process parameters for better output results.

Varanpal Singh Kandra(2016)[5] In this research work turning operation is performed on AISI 1020 mild steel work piece using carbide insert 0.8 mm nose radius. The results obtained, The analysis of the experimental observations highlights that MRR in CNC turning process is greatly influenced by depth of cut followed by feed. It is observed that the cutting speed is most significantly influences the Ra followed by the feed. simultaneous optimization of Surface roughness (Ra) and material removal rate (MRR) depth of cut is themost significant parameter affecting the performance followed by the feed.

M.A. Saloda and M.S. Khidiya(2016)[6] This research investigates the machinability of mild steel in turning process perform on conventional lathe machine. Two parameters like tool rake angle and feed are varied to investigate their effect on material removal rate.The main aim of this work is save power and useful production time during manufacturing of product.

Rahul Dhabale(2015)[7] In the present study genetic algorithm was used to optimize the turning process parameter to obtain maximum material removal rate. Experiments were carried out on NC controlled machine tool by taking AlMg1SiCu as workpiece material and carbide inserted cutting tool. Finally, genetic algorithn has been employed to find out the optimal setting of process parameters that optimize material removal rate.The response value for material removal rate obtained from single objective optimization by genetic algorithm was 6021.411 mm3/min. Comparisons of experimental and predicted results at optimum conditions showed an error of 3.35 %.

Amol N. Varade(2015)[8] The experiments will be obtained by varying one parameter while, the remaining two parameter were kept constant. So the influence of tool tip on different machining parameters is done in this research work. The aim of the research is decided on approach of performance measurement of high material removal rate(MRR),low surface roughness(Ra) and low tool tip temperature during hard turning of EN19 material.

M.P. Prabakaran and G.R. Kannan(2014)[9] This work with Aluminium alloy5083. The experimental values of surface finishing. The central composite face centered design(CCFD) of full factorial design for turning machining the process of Aluminium alloy 5083 and the results are tabulated. The response surface methodology is utilized to develop an effective mathematical model to predict surface finish. The model found statistically fit for 95% confidence level.

Wang Lan (2008) [10] Utilizing orthogonal cluster of Taguchi strategy dim social examination with considering four parameters viz. speed, profundity, rate of slicing instrument nose to deplete, and so forth., for the advancement of three reactions: surface harshness, the apparatus wear and material evacuation rate on the precision of light an ECOCA-3807 CNC machine. It investigated the MINITAB programming to dissect the normal flag to-commotion (S/N) impact to accomplish the multi-reason highlights.

Srikanth and Kamala (2008) [11] Assessed the ideal benefits of cutting parameters utilizing a hereditary calculation coded Real (RCGA) and different issues RCGA and its favorable circumstances over the present approach of Binary Coded Genetic Algorithm clarified (BCGA). They presumed that RCGA was solid and exact to unravel the improvement parameter and assemble cutting streamlining issue with numerous choice factors. These choice factors were cutting pace, nourish, profundity of cut and nose sweep. The creators noticed that the quickest arrangement RCGA can be acquired with moderately high achievement rate, with chose machining conditions accommodating general change mode item quality by lessening the cost of generation, decrease in time creation, adaptability in the choice of machining parameters.

Sahoo *et al*. (2008) [12] Examined for enhancement of machining parameters mixes accentuation on fractal qualities of surface profile created in CNC turning operation. The creators utilized the L27 orthogonal exhibit outline with machining Taguchi parameters: speed, bolster and profundity of cut in three distinctive work piece materials viz. aluminum, gentle steel and metal. It was reasoned that the bolster rate was more critical impact surface complete on the three materials.

Doniavi *et al*. (2007) [13] Utilizing the reaction surface approach (RSM) keeping in mind the end goal to build up the observational model for the forecast of surface harshness, in choosing the ideal cutting condition in the change. The creators demonstrated that the encourage rate fundamentally affected surface unpleasantness. With expanded surface unpleasantness speed control was observed to be expanded. With the expansion in the cutting pace diminished surface unpleasantness.

Kassab and Khoshnaw (2007) [14] Inspected the connection between surface unpleasantness and vibration cutting instrument for turning operations. The procedure parameters were cutting pace, profundity of cut, encourage rate and extraordinary apparatus. The examination presumed that it was watched that the surface harshness of the workpiece to be influenced more by the speeding up cutting instrument; quickening expanded shade of the cutting apparatus. The surface unpleasantness was found to increment with expanding encourage rate.

Al-Ahmari (2007) [15] Created experimental models for the apparatus life, surface harshness and cutting power for turning operation. The procedure parameters were utilized as a part of the investigation speed, nourish, profundity of slice and the nose range to build up the model machining. The strategies used to create 48 models specified above were Response Surface Methodology (RSM) and Neural Systems (NN).

3. Problem formulation & Methodology

The steps covered in Methodology are as follows:

Determine the quality characteristic to be Identify the noise factors and test conditions.

- Identify the control parameters and their alternative levels.
- Design the matrix experiment and define the data analysis procedure.
- Conduct the matrix experiment.
- Analyze the data and determine the optimum levels for control factors.

4. Results and Discussions

4.1: MRR

Density 0.007 gm/mm3

Table:1 Calculation of MRR

Sr. No.	RPM	FEED	D.O.C	MRR (mm3/sec)	SNRA1
1	59	0.12	0.8	8.15	18.22
2	59	0.14	1	9.65	19.68
3	59	0.16	1.2	10.51	20.43
4	59	0.18	1.4	11.12	20.92
5	118	0.12	1	13.66	22.70
6	118	0.14	0.8	17.23	24.72
7	118	0.16	1.4	24.53	27.79
8	118	0.18	1.2	29.80	29.48
9	165	0.12	1.2	20.44	26.20
10	165	0.14	1.4	31.09	29.85
11	165	0.16	0.8	23.74	27.51
12	165	0.18	1	31.12	29.86
13	220	0.12	1.4	31.39	29.93
14	220	0.14	1.2	27.56	28.80
15	220	0.16	1	39.28	31.88
16	220	0.18	0.8	71.23	37.05

Linear Model Analysis for MRR:

Table 2: MRR Response Table for Signal to Noise Ratios Larger is better

Level	RPM	FEED	D.O.C
1	19.82	24.27	26.88
2	26.18	25.77	26.03
3	28.36	26.91	26.23
4	31.92	29.33	27.13
Delta	12.10	5.06	1.09
Rank	1	2	3

Table 3: MRR Response Table for Means

Level	RPM	FEED	D.O.C
1	9.858	18.409	30.087
2	21.303	21.379	23.427
3	26.598	24.516	22.078
4	42.363	35.818	24.531
Delta	32.504	17.409	8.009
Rank	1	2	3

The main effect plots for S/N ratios are shown in figure 2 This plot shows the variation of MRR with change in three parameters: In the plots, the x-axis indicates the value of each process parameter, y-axis the response value (MRR). Horizontal line indicates the mean value of the response or MRR. The main effects plots are used to determine the optimal design conditions to obtain the optimum MRR.

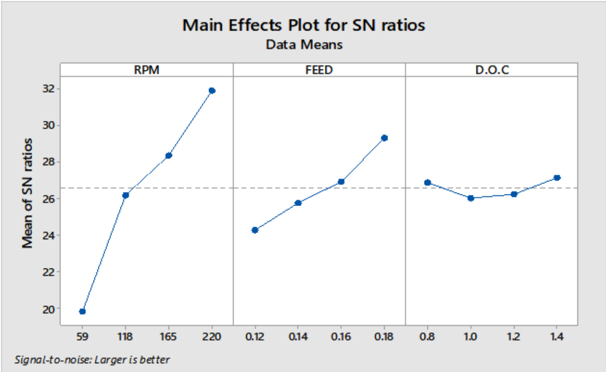

Fig 1 Main effects of Plot for S/N Ratio Material Removal Rate

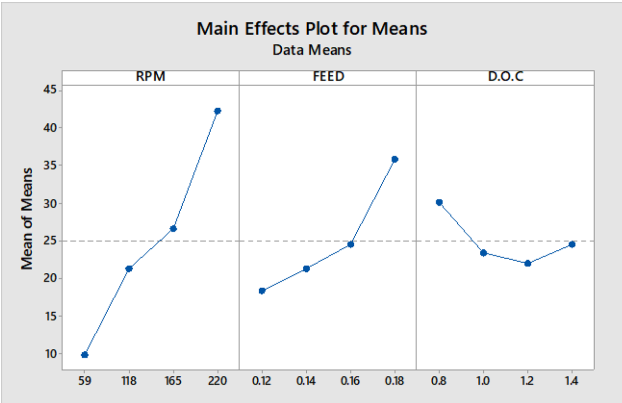

Fig 2 Main effects of Plot for Means Material

It can be clearly seen that the MRR with an increase in the values of cutting speed, feed & slightly decrease with increasing depth of cut.

Table 4: Analysis of Variance of MRR for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
RPM	3	310.232	310.232	103.411	26.10	0.001
FEED	3	54.688	54.688	18.229	4.60	0.053
D.O.C	3	3.216	3.216	1.072	0.27	0.845
Residual Error	6	23.771	23.771	3.962		
Total	15	391.906				

Table 5: Analysis of Variance of MRR for Means

Source	DF	Seq SS	Adj MS	F	P
RPM	3	2187.8	729.28	7.44	0.019
FEED	3	695.2	231.74	2.37	0.170
D.O.C	3	148.4	49.47	0.50	0.693
Residual Error	6	587.9	97.99		
Total	15	3619.4			

4.2 Calculation of Hardness

The results of the test are shown in the observation table below. The Signal to noise ratio maximum is better for all runs of hardness are shown in following table:-

Table 6 Calculation of Hardness

Sr. No.	RPM	FEED	D.O.C	Hardness	SNRA1
1	59	0.12	0.8	88	38.88965
2	59	0.14	1	88	38.88965
3	59	0.16	1.2	86	38.68997
4	59	0.18	1.4	86	38.68997
5	118	0.12	1	87	38.79039
6	118	0.14	0.8	89	38.9878
7	118	0.16	1.4	82	38.27628
8	118	0.18	1.2	80	38.0618
9	165	0.12	1.2	83	38.38156
10	165	0.14	1.4	84	38.48559
11	165	0.16	0.8	86	38.68997
12	165	0.18	1	85	38.58838
13	220	0.12	1.4	84	38.48559
14	220	0.14	1.2	85	38.58838
15	220	0.16	1	84	38.48559
16	220	0.18	0.8	86	38.68997

Linear Model Analysis for Hardness

Table 7: Hardness Response Table for Signal to Noise Ratios Larger is better

Level	RPM	FEED	D.O.C
1	38.79	38.64	38.81
2	38.53	38.74	38.69
3	38.54	38.54	38.43
4	38.56	38.51	38.48
Delta	0.26	0.23	0.38
Rank	2	3	1

Table 8 Hardness Response Table for for Means

Level	RPM	FEED	D.O.C
1	87.00	85.50	87.25
2	84.50	86.50	86.00
3	84.50	84.50	83.50
4	84.75	84.25	84.00
Delta	2.50	2.25	3.75
Rank	2	3	1

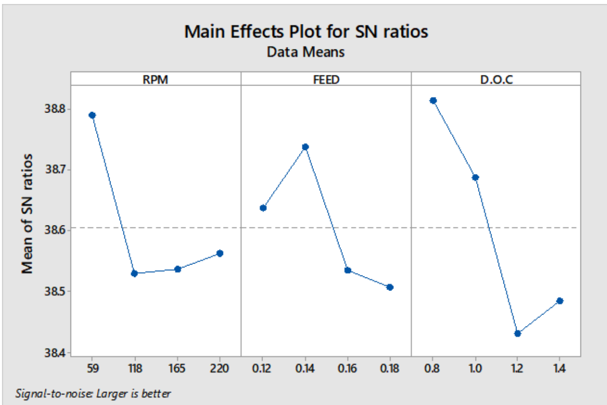

Fig. 3 Main effects of Plot for Signal to noise Ratio of Hardness

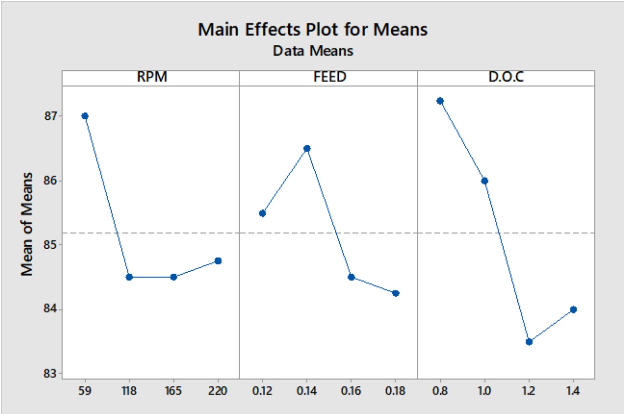

Fig. 4 Main effects of Plot for Means of Hardness

It can be clearly seen that the hardness is maximum at the first level of cutting speed, Depth of cut & at second level of depth of cut.

Table 9: Analysis of Variance of Hardness for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
RPM	3	0.1858	0.1858	0.06193	2.22	0.186
FEED	3	0.1320	0.1320	0.04400	1.58	0.290
D.O.C	3	0.3833	0.3833	0.12777	4.59	0.054
Residual Error	6	0.1671	0.1671	0.02785		
Total	15	0.8682				

Table 10: Analysis of Variance of Hardness for Means

Source	DF	Seq SS	Adj SS	Adj MS	F	P
RPM	3	17.69	17.69	5.896	2.30	0.177
FEED	3	12.69	12.69	4.229	1.65	0.275
D.O.C	3	36.69	36.69	12.229	4.77	0.050
Residual Error	6	15.37	15.37	2.562		
Total	15	82.44				

Conclusions:

1. It is concluded that for MRR be maximum factor Cutting speed has to be at high level 4, Feed has to be at high level 4 & D.O.C has to be at high level 4. As shown in table below.

2. It is concluded that for hardness to be maximum Cutting speed has to be at high level 4, Feed has to be at low level 1 & D.O.C has to be at level 2. As shown in table below.

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