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"OPTIMIZATION OF TURNING PARAMETERS USING TAGUCHI STATISTICAL APPROACH"

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ABSTRACT

The main purpose of today's manufacturing industries is to produce low cost, high quality products in short time. They mainly focused on achieving high quality, in term of part accuracy, surface finish, high production rate etc. So, the selection of optimal cutting parameters is a very important issue for every machining process in order to reduce the machining costs and increase the quality of machining products. In this project the cutting of Ductile Iron under wet and dry condition is carried out using CNC lathe machine. Taguchi method is used to formulate the experimental layout. The effect of cutting condition (spindle speed, feed rate and depth of cut) on surface roughness were studied and analysed. The CNC turning machine is used to conduct experiments based on the Taguchi design of experiments (DOE) with orthogonal L9 array. Optimal cutting parameters for each performance measure were obtained employing Taguchi techniques. The orthogonal array, signal to noise ratio and analysis of variance were employed to find minimum surface roughness. Optimum results are finally verified with the help of confirmation experiments.

Key Words: *CNC, Surface roughness, DOE*

I. INTRODUCTION

Manufacturing means transformation of raw materials into finished goods for the satisfaction of human needs. To transform the raw material different manufacturing processes are applied because of which the shape, size and physical properties of given material are altered. Different types of manufacturing process for metals are: -

Turning Process

Turning is a form of machining, a material removal process, which is used to create rotational parts by cutting away unwanted material as shown in figure1.1. The turning process requires a turning machine or lathe, work piece, fixture, and cutting tool. The work piece is a piece of pre-shaped material that is secured to the fixture, which itself is attached to the turning machine, and allowed to rotate at high speeds. The cutter is typically a single-point cutting tool that is also secured in the machine, although some operations make use of multi-point tools. The cutting tool feeds into the rotating work piece and cuts away material in the form of small chips to create the desired shape.

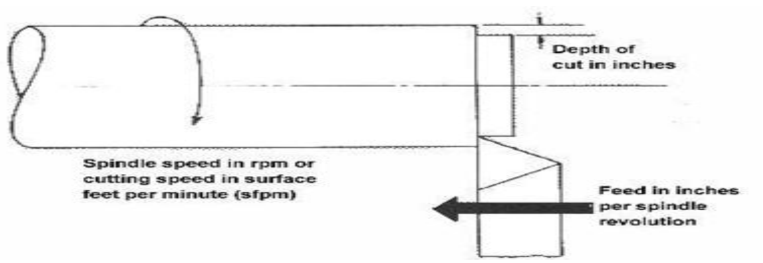

Figure 1.1: Turning Process

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Turning is used to produce rotational, typically axi-symmetric, parts that have many features, such as holes, grooves, threads, tapers, various diameter steps, and even contoured surfaces. Parts that are fabricated completely through turning often include components that are used in limited quantities, perhaps for prototypes, such as custom designed shafts and fasteners. Turning is also commonly used as a secondary process to add or refine features on parts that were manufactured using a different process. Due to the high tolerances and surface finishes thatturning can offer, it is ideal for adding precision rotational features to a part whose basic shape has already been formed.

Speed

Speed always refers to the spindle and the work piece.

$$V = \frac{\pi D N}{1000} mm^{-1}$$

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

Feed

It is the rate at which the tool advances along its cutting path. The feed of the tool also affects to the processing speed and the roughness of surface.

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

Here, Fm 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 can be defined as 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.

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

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

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.

II. LITERATURE REVIEW

S. Khrais, A.M. Hassan, A. Gazawi(2016) develop a multiple regression model for surfaceroughness as a function of cutting parameters during the turning of flame hardened medium carbon steel with TiN-Al2O3-TiCN coated inserts. An experimental plan of work and signal-to-noise ratio (S/N) were used to relate the influence of turning parameters to the workpiece surface finish utilizing Taguchi methodology. The effects of turning parameters were studied by using the analysis of variance (ANOVA) method. Evaluated parameters were feed, cutting speed, and depth of cut. It was found that the most significant interaction among the considered turning parameters was between depth of cutand feed. The average surface roughness (Ra) resulted by TiN-Al2O3-TiCN coated inserts was about 2.44 µm and minimum value was 0.74 µm. In addition, the regression model was able to predict values for surface roughness in comparison with experimental values withinreasonable limit.

U. K. Yadav, D. Narang, P.S. Attri(2016)analyzed the effect and optimization of machining parameters (cutting speed, feed rate and depth of cut) on surface roughness is investigated. An L'27 orthogonal array, analysis of variance (ANOVA) and the signal-to-noise (S/N) ratio are used in this study. Three levels of machining parameters are used and experiments are done on STALLION-100 HS CNC lathe. The optimum value of the surface roughness (Ra) comes out to be 0.89. It is also concluded that feed rate is the most significant factor affecting surface roughness followed by depth of cut. Cutting speed is the least significant factor affecting surface roughness. Optimum results are finally verified with the help of confirmation experiments.

M. V. Ramana, A. V. Vishnu, G. K.M. Rao, D.H. Rao (2017)analyzed experimentally and optimization of process parameters for surface roughness in turning of Ti-6Al-4V alloy under dry, flooded and Minimum Quantity Lubrication (MQL) conditions using Taguchi's robust design methodology and development of prediction models for surface roughness using multiple regression analysis. The results have been compared among dry, flooded and MQL conditions and it reveals that MQL shows better performance and improvement in reduction of surface

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roughness compared to dry and flooded lubricant conditions. From Analysis of Mean (ANOM), it is observed that MQL is suitable at higher depth of cut compared to dry and flooded lubricant conditions. It is observed from ANOM that, under MQL condition uncoated tool shows better performance compared to the CVD and PVD coated tools, whereas CVD coated tool shows better performance for dry and flooded lubricant conditions compared to uncoated and PVD coated tools. It is also observed from the ANOVA that, feed rate has major contribution in optimizing the surface roughness.

K. Hassan, A. Kumar, M.P. Garg (2018) investigates the effects of process parameters on material removal rate (mrr) in turning of C34000. The single response optimization problems i.e. optimization of mrr is solved by using Taguchi method. The optimization of MRR is done using twenty seven experimental runs based on L'27 orthogonal array of the Taguchi method are performed to derive objective functions to be optimized within the experimental domain When the MRR is optimized alone the MRR comes out to be 8.91. The optimum levels of process parameters for simultaneous optimization of MRR have been identified. Optimal results were verified through confirmation experiments.

III. EXPERIMENTATION

Cutting Parameters and Levels for Dry and Wet Turning

Parameters/Factors		level		
		1	**2**	**3**
A	**Spindle speed (rpm)**	160	320	620
B	**Feed rate (mm/rev)**	0.3	0.4	0.5
C	**Depth of cut (mm)**	0.7	0.8	0.9

Design of Experiments

Experiment no.	**Spindle speed (rpm), N**	**Feed rate (mm/rev), f**	**Depth of cut (mm), A**
1	160	0.3	0.7
2	160	0.4	0.8
3	160	0.5	0.9
4	320	0.3	0.8
5	320	0.4	0.9
6	320	0.5	0.7
7	620	0.3	0.9
8	620	0.4	0.7
9	620	0.5	0.8

Chemical Composition of SG Iron steel in %

C	**Si**	**Mn**	**P**	**S**	**Cu**	**Ni**	**Cr**
0.45	0.20	0.72	0.015	0.018	0.10	0.09	0.07

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IV. RESULT & DISCUSSION

Analysis of Variance for Means of Surface Roughness (Ra) for Dry Turning

Source	**DF**	**Adj SS**	**Adj MS**	**F**	**P**
Spindle speed (rpm), N	2	3.4417	1.7208	2.11	0.322
Feed rate (mm/rev), f	2	7.2395	3.6197	4.43	0.184
Depth of cut (mm), d	2	2.6564	1.3282	1.63	0.381
Error	2	1.6347	0.8173		
Total	8	14.972			

Response table of Means for Surface roughness (Ra) for Dry Turning

Level	**Spindle Speed (rpm), N**	**Feed rate (mm/rev), f**	**Depth of Cut (mm), d**
1	4.613	3.497	4.030
2	5.427	4.773	5.353
3	3.913	5.683	4.570
Delta	1.513	2.187	1.323
Rank	2	1	3

Analysis of Variance for Means of Surface Roughness (Ra) for Wet Turning

Source	**DF**	**Adj SS**	**Adj MS**	**F**	**P**
Spindle speed (rpm), N	2	0.03442	0.01721	0.09	0.92
Feed rate (mm/rev), f	2	3.09109	1.54554	7.8	0.114
Depth of cut (mm), d	2	0.13976	0.06988	0.35	0.739
Error	2	0.39636	0.19818		
Total	8	3.66162			

Response table for Means for Surface roughness (Ra) for Wet Turning

Level	**Spindle Speed (rpm), N**	**Feed rate (mm/rev), f**	**Depth of Cut (mm), d**
1	3.047	2.2	2.9
2	2.953	3.623	2.857
3	2.897	3.073	3.140
Delta	0.15	1.423	0.283
Rank	3	1	2

Main Effect Plots for Surface Roughness

Main effect plots for surface roughness for dry and wet turning are shown in the fig. 4.1 and fig. 4.2. Main effect plot shows the variation of surface roughness with respect to Spindle speed, feed rate and depth of cut. X axis represents change in level of the variable and y axis represents the change in the resultant response.

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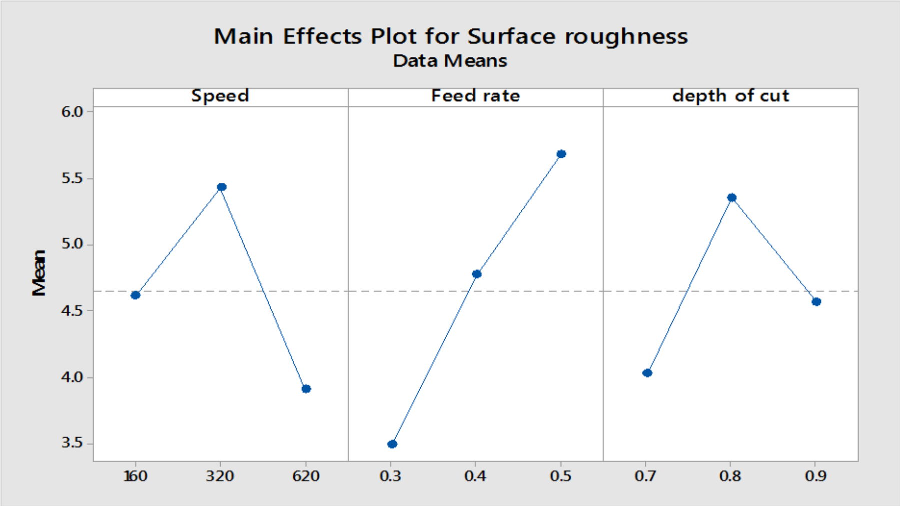
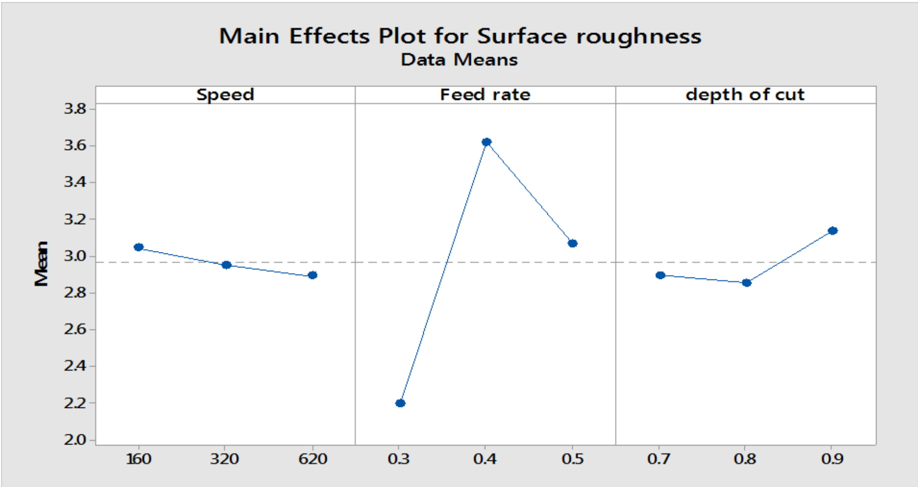
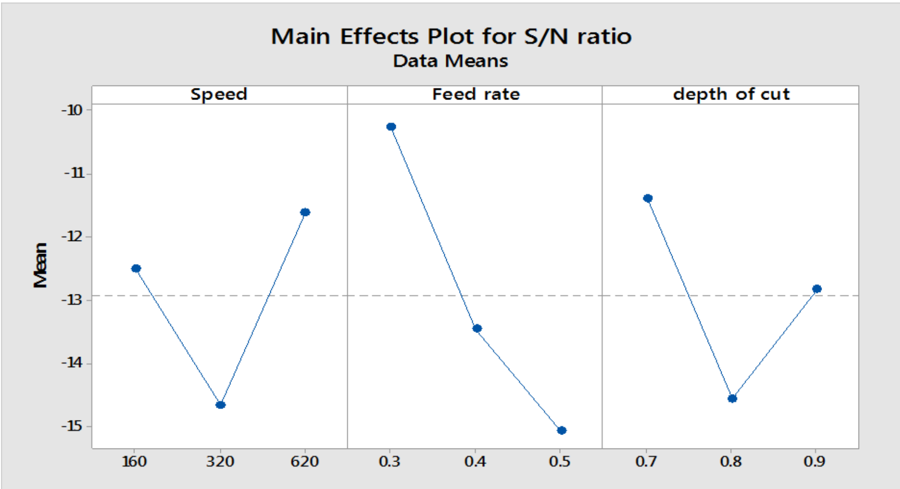


Main effects plot for means for surface roughness for dry turning



Main effects plot for means for surface roughness for wet turning



Main effects plot for S/N ratios for surface roughness in Dry Turning

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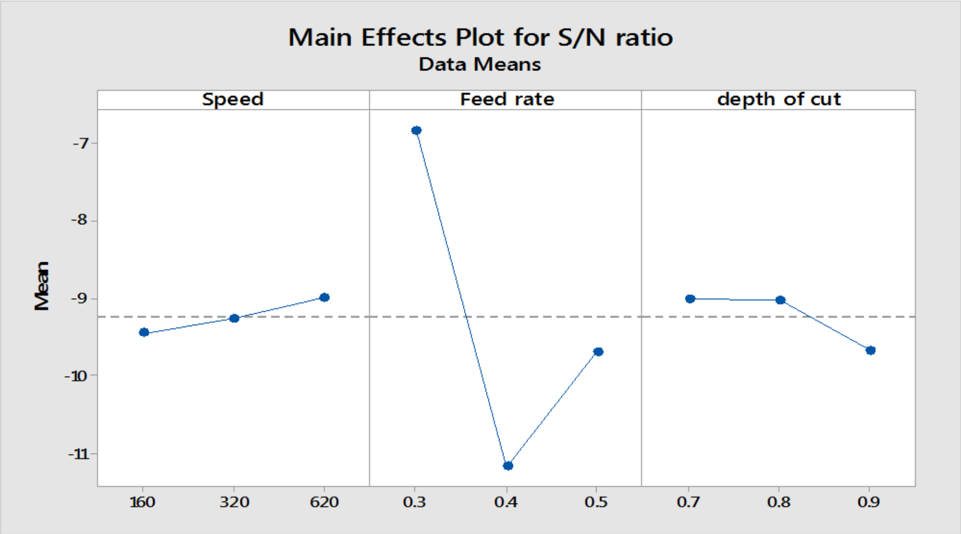
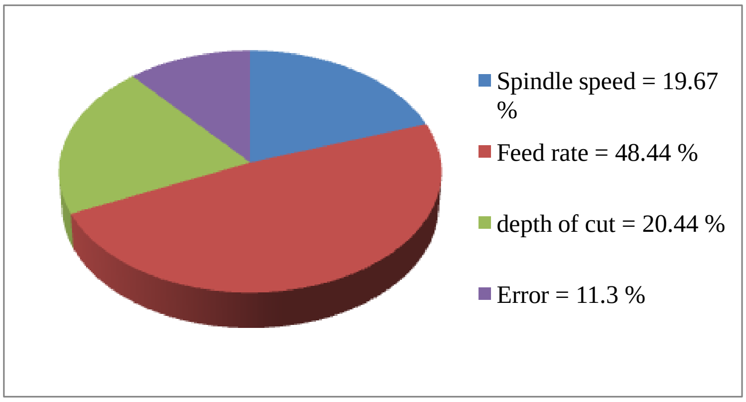
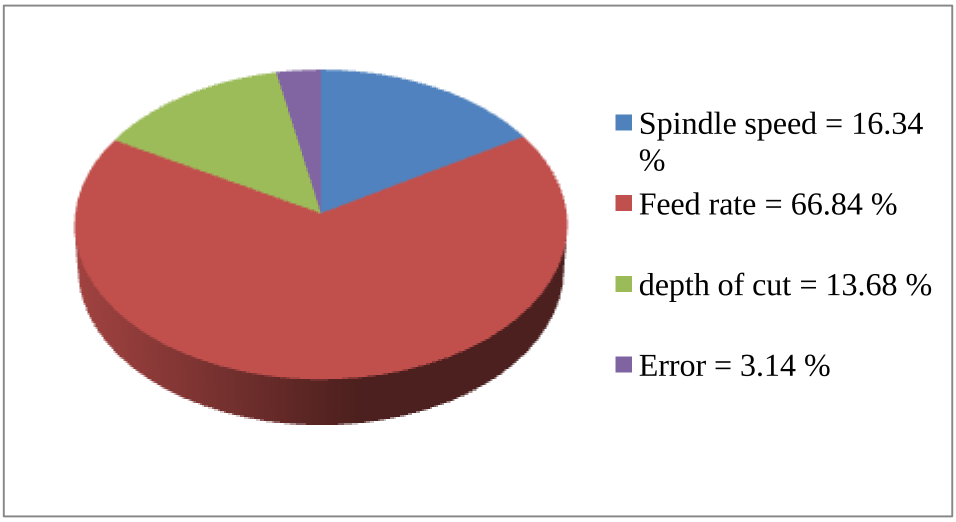


Main effects plot for S/N ratios for surface roughness in Wet Turning



Percentage contribution of process parameters on surface roughness in dry turning



Percentage contribution of process parameters on surface roughness in wet turning

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Determination of Optimum Solution

Optimum condition of the turning process is concerned with minimizing the surface roughness.

Parameters and their selected levels for optimal surface roughness in dry turning

Parameter designation	Process parameters	Optimal levels
A	Spindle speed (rpm), N	**(620 rpm)**
B	Feed rate (mm/rev), f	**(0.3 mm/rev)**
C	Depth of cut (mm), d	**(0.7 mm)**

Parameters and their selected levels for optimal surface roughness in wet turning

Parameter designation	Process parameters	Optimal levels
A	Spindle speed (rpm), N	**(620 rpm)**
B	Feed rate (mm/rev), f	**(0.3 mm/rev)**
C	Depth of cut (mm), d	**(0.8 mm)**

V. CONCLUSION

Dry Turning

- It has been found that feed rate is found to be the most significant factor & its contribution to surface roughness is 48.44 %. The best results for surface roughness (lower is better) would be achieved when SG IRON workpiece is machined at spindle speed of 620 rpm, feed rate of 0.3 mm/rev and depth of cut of 0.7 mm. With 95% confidence interval, the feed rate effects the surface roughness most significantly
- The Surface roughness is mainly affected by feed rate, depth of cut and spindle speed. With the increase in feed rate the surface roughness also increases, as the depth of cutincreasesthe surface roughness first increase and decrease and as the spindle speed increase surface roughness decreases.
    1. Spindle speed = 620 rpm
    2. Feed rate = 0.3 mm/ rev
    3. Depth of cut = 0.7 mm

Wet Turning

- It has been found that depth of cut is found to be the most significant factor & its contribution to surface roughness is 66.84 %. The best results for surface roughness (lower is better) would be achieved when SG IRON work piece is machined at spindle speed of 620 rpm, feed rate of 0.3 mm/rev and depth of cut of 0.8 mm. With 95% confidence interval, the depth of cut effects the surface roughness most significantly
- The Surface roughness is mainly affected by depth of cut, feed rate and spindle speed. With the increase in depth of cut the surface roughness also increases, as the feed ratedecreasesand as the spindle speed increase surface roughness decreases.
    1. Spindle speed = 620 rpm
    2. Feed rate = 0.3 mm/ rev
    3. Depth of cut = 0.8 mm

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