Study Effects of Parameters on Surface Roughness in Turning Process by using Analysis of Variance(ANOVA)

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Abstract

Turning is a widely used machining operation to produce various components. The finished component depends not only on the dimensional accuracy but also on the surface finishing. In the present work we get some relation between input parameter and output parameter by using Analysis of variance (ANOVA) method. Here ASTM A29 Grade 1020 mild steel is used as a work piece and high speed steel (HSS) is used as cutting tool. Our work determines that, the input parameter like cutting speed, depth of cut (DOC) and feed rate has some contribution in surface roughness, that contribution will help us to know about significant factor and that relation with surface roughness, that contribution and significant parameter we determine by the statistical analysis of variances. The number of experiment to be conducted is decided from the full factorial design of experiment method. As per factorial design of experiment method, 27 experiments were conducted.
Keywords: ANOVA, Full Factorial, Surface Roughness, Turning, ASTM A29 Grade 1020 Mild Steel, HSS (High Speed Steel)

I. INTRODUCTION

Now a day's customers required quality product therefor, turning operation we concentrate on the surface roughness of the material. It is the essential output factor that directly affects the quality of product as well as further machining processes. It depends on few machining parameters which are controllable thus by varying those parameters spindle speed, depth of cut and feed rate to we get desired surface finishing. Here we take three levels for each factor and analyzed that which factor is significant for surface roughness by using statistical ANOVA method.

II. LITERATURE REVIEW

Sunil P **.** Maghodiya et al**.** [1] analyzed the influences of work piece material and the machining parameters on surface roughness . They used the ANOVA method for know about the effect of machining parameters on surface roughness in hard turning process . They used the w/p material of steel H-11 and cutting tool material of polycrystalline cubic boron nitride for perform experiment . They take input parameter as nose radius, feed rate, cutting speed .They performed experiments as per L27 orthogonal array . They determine that nose radius and feed rate significantly affect surface roughness.

Devesh tripathi et al[2] used the Taguchi and ANOVA method for analysis surface roughness .They machined the mild steel work piece with high speed steel. Three cutting parameters namely cutting speed, feed rate and depth of cut are selected for this study to get the optimal cutting parameters for surface roughness in turning operation. They were used L16 orthogonal array.

Mohammad Ramezani al [3] used the artificial neural network (ANN) method forecast surface roughness with related inputs, including cutting speed and feed rate .They used particulate reinforced aluminum matrix composites (PAMCs) material .They used L12 orthogonal array. Their aim of this work is to decrease the production cost and consequently increase the production rate of these materials for industry without any trial and error method procedure

Vijay Singh et al. [4] analyzed effect of cutting parameters of turning process on cutting tool vibrations and surface roughness of stainless steel using taguchi method .If any cutting tool and work piece between more vibration will produce then there might able to decrease in the surface roughness of the turned work piece, thus they take the optimum cutting parameter like speed, feed & depth of cut because vibration is depending on the input parameter .They used L27 orthogonal array.

Parshvam jain et al [5]used mathematical tools taguchi method and ANNOVA(analysis of variance) are employed to investigate the optimized value of cutting parameters for high grade of surface finish. They used to cut speed, feed rate and depth of cut as a cutting parameter .They used L_9 orthogonal array .They optimize surface roughness on the mild steel and cemented carbide tip as a cutting tool.

Kapil kumar et al[6] investigate the effect of machining cutting speed, feed rate, depth of cut and tool nose radius on material removal rate and surface roughness in finish hard turning on H13 tool steel using carbide tool .The MRR and SR increase by increasing the cutting speed, feed rate and depth of cut .The depth of cut and feed rate are the most influential factors for increasing the MRR and SR respectively. They used the mathematical tool as ANOVA method .They performed experiment by L_{21} orthogonal array.

III. EXPERIMENTAL SETUP AND METHODOLOGY

A. Work Piece Material

ASTM A 29 1020 is a low hardenability and low tensile mild steel with Brinell hardness of 119 –235 and tensile strength of 410-790 MPa .It has high machinability, high strength, high ductility and good weldability .It is normally used in turned and polished or cold drawn condition .Due to its low carbon content, it is resistant to induction hardening or flame hardening .Due to lack of alloying elements, it will not respond to nitriding .However, carburization is possible in order to obtain case hardness more than Rc65 for smaller sections that reduces with an increase in section size .Core strength will remain as it has been supplied for all the sections .Alternatively, carbon nitriding can be performed, offering certain benefits over standard carburizing . The work piece used for experiment is round bar with 50 mm diameter and 600 mm length.

Table - 1
Chemical composition of material

Element	*Content*
Carbon (%)	*0.229*
Sulfur (%)	*0.038*
Phosphorous (%)	*0.038*
Manganese (%)	*0.60*

B. Machining Process

The cutting tests were performed on light duty lathe machine and high speed steel cutting tool is used. The experiments were conducted as per the full factorial design and surface roughness for various combinations of parameters was measured using mitutoyo SJ-210 surface roughness tester. The cutting parameter identified were spindle speed, feed rate and depth of cut.

C. ANOVA (Analysis of Variance)

Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures)such as "variation "among and between groups. ANOVA is useful for comparing testing three or more means groups or variables for statistical signification. ANOVA is a particular form of statistical testing heavily used in the analysis of experimental data .

D. Full Factorial Designs

In statistic, a full factorial experiment is an experiment whose design consists of two or more factors, each with discrete possible values or "levels", and whose experimental units take on all possible combinations of these levels across all such factor. A full factorial design may also be called a fully crossed design. Such an experiment allows the investigator to study the effect of each factor on the response variable, as well as the effects of interactions between factors on the response variable. In a full factorial experiment, responses are measured at all combinations of the experimental factor levels .The combinations of factor levels represent the conditions at which responses will be measured .Each experimental condition is a called a "run "and the response measurement an observation .The entire set of runs is the "design".

Table - 2
Different level

Symbol	*Control Factors*	*Unit*	*Level 1*	*Level 2*	*Level 3*
A	*Speed*	*RPM*	*379*	*578*	*908*
B	*Feed*	*mm/rev*	*0.06*	*0.07*	*0.08*
C	*Depth of cut*	*Mm*	*0.4*	*0.6*	*0.8*

IV. RESULT

After experimentation we have measured the surface roughness using surface roughness tester and took 3 reading for each run and take its average value for final surface roughness.

Table - 3
Experimental table for measured surface roughness according to selected machining parameters

Sr. No.	*Spindle Speed* (*RPM*)	*Feed* (*mm/rev*)	*Depth of cut* (*mm*)	*Surface Roughness* (*μm*)
1	*379*	*0.06*	*0.4*	*2.904*
2	*379*	*0.06*	*0.6*	*2.672*
3	*379*	*0.06*	*0.8*	*2.532*

4	379	0.07	0.4	5.515
5	379	0.07	0.6	5.217
6	379	0.07	0.8	3.198
7	379	0.08	0.4	3.425
8	379	0.08	0.6	3.622
9	379	0.08	0.8	2.599
10	578	0.06	0.4	3.643
11	578	0.06	0.6	2.300
12	578	0.06	0.8	2.010
13	578	0.07	0.4	5.509
14	578	0.07	0.6	6.271
15	578	0.07	0.8	2.563
16	578	0.08	0.4	5.011
17	578	0.08	0.6	3.801
18	578	0.08	0.8	2.252
19	908	0.06	0.4	2.178
20	908	0.06	0.6	2.570
21	908	0.06	0.8	2.397
22	908	0.07	0.4	6.551
23	908	0.07	0.6	6.004
24	908	0.07	0.8	4.159
25	908	0.08	0.4	3.094
26	908	0.08	0.6	3.454
27	908	0.08	0.8	3.145

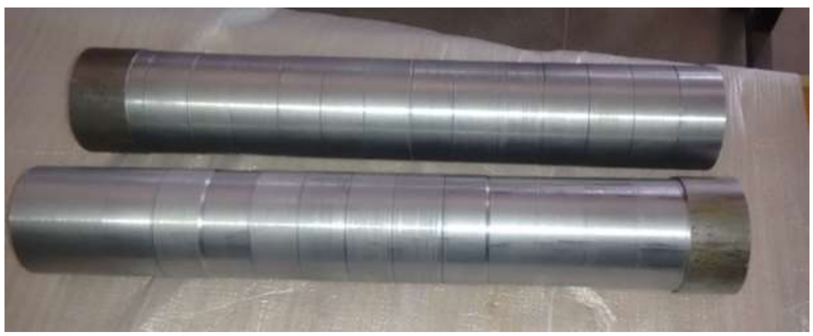

Fig. 1: Material after experiment run

By using Minitab v17 we have concluded following table and graphs to get contribution percentage for each parameter.

Table – 4
Result of Analysis of Variance for Surface Roughness

Source	DF	SS	MS	F	P	Contribution %
Spindle speed	2	0.2346	0.1173	0.21	0.812	0.47
Feed	2	27.3667	13.6834	24.59	0.000	55.14
Doc	2	10.8988	5.4494	9.79	0.001	21.96
Error	20	11.1274	0.5564			22.42
Total	26	49.6276				

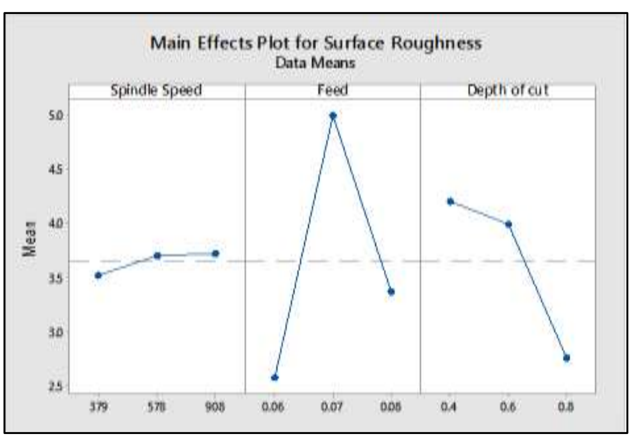

Fig. 2: Main effects plot for surface roughness

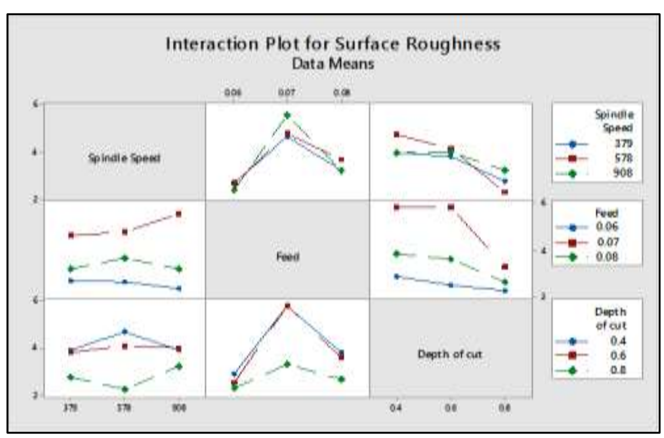

Fig. 3: Interaction plot for surface roughness

The ranks indicate the relative importance of each factor to the response. The ranks and the delta values for various parameters show that feed has the greatest effect on surface roughness and is followed by, depth of cut and cutting speed in that order. From Table 5, it can be seen that the second level of spindle speed = 578 rpm, first level of feed rate = 0.6 mm/rev and third level of depth of cut = 0.8 mm results in minimum value of surface roughness. It is observed from Figure 4.1 that Ra is increased continuously with increased in spindle speed. The Ra is continuously decreased with increase in Depth of cut and The Ra is initially increased with increase in feed rate.

In ANOVA analysis, after calculating percentage contribution for all control factors, it is found that as per the Table 6, cutting speed, feed rate and depth of cut affect surface roughness 0.47%, 55.14%, and21.96% respectively. This analysis shows that feed is most significant control factor for surface roughness.

V. Conclusion

The conclusions drawn based on the tests conducted from the ANOVA, Table 6 and the P value, the feed is the only significant factor which contributes to the surface roughness i.e. 55.14% contributed by the feed on surface roughness. The second factor which contributes to surface roughness is the depth of cut having 21.96%.It is recommended from the results that minimum feed rate can be used to get lowest surface roughness.

- From the results obtained by experiment, the influence of surface roughness (Ra), by the cutting parameters like speed, feed, DOC is the feed rate has the variable effect on surface roughness, cutting speed and depth of cut an approximate decreasing trend.
- ANOVA shows that the feed rate has great influence for the response surface roughness (Ra)The percentage contribution values for Ra response the feed rate55.14 % is significant one followed by cutting speed.
- The interaction of cutting parameters is also studied for the response Ra as follows: The interaction for the cutting parameters are found that feed and depth of cut have great influence on the response Ra and the percentage contribution of feed and depth of cut is 9.86% followed by speed and depth of cut with 4.98%, speed and feed with 3.79%.
- On the basis of the experimental results and derived analysis, one can conclude that feed has the most dominant effect on the observed surface roughness, followed by depth of cut and speed, whose influences on surface roughness are smaller. The surface roughness is continuously deteriorating with the increase in depth of cut, but increase in feed rate and depth of cut causes a significant decrement of surface roughness.

References

[1] Sunil P. Maghodiya, "Effect of machining parameters on surface roughness In hard turning process" International Journal for Research in Education (IJRE), February: 2015.

[2] Devesh TripathI, Dhananjay Pradhan, "Analysis of cutting parameters for surface roughness by turning process using taguchi method" International Journal of Advance Manufacturing System(IJAMS),2015.

[3] Mohammad Ramezani "Surface roughness prediction of particulate composites using artificial neural networks in turning operation", March 2015.

[4] Vineet Tirth, Munish Chhabra, Vijay Singh "Effect of cutting parameters of turning process on cutting tool vibrations and surface roughness of stainless steel using taguchi method"International Conference of Advance Research and Innovation (ICARI-2015),January 2015.

[5] Parshvam Jain, Ranganath M S, Vipin, R. S. Mishra, Sushil Kumar, Karan SinghTanwar"Optimization of machining parameters for turning mild steel using design of experiment"International Conference of Advance Research and Innovation (ICARI-2015), January 2015.

[6] Kapil Kumar, Sumit Kumar Mishra, Sumit Kumar "Modelling and optimization of machining parameters in turning of H13 tool steel using response surface methodology-desirability function approach" International Conference of Advance Research and Innovation (ICARI-2015), January 2015.

