International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in

Vol.3., Issue.6., 2015
(Nov.-Dec.,)

RESEARCH ARTICLE

ISSN: 2321-7758

INVESTIGATE THE EFFECT OF MACHINING HARD TURNING PROCESS PARAMETER ON SURFACE ROUGHNESS OF Cr-Mo ALLOY USING TAGUCHI METHOD

MOHD ASHAR[1], AJITANSHU MISHRA[2], ADNAN KHAN[3]
[1,3]M.Tech scholar Invertis University Bareilly U.P. India
[2]Assistant Professor (HOD) Mechanical Engineering Invertis University Bareilly U.P. India

ABSTRACT

In the present research work, the work piece material taken is chrome-molybdenum alloy steel. This is a hard material having hardness 58 HRC. This material stands at very high temperature and high pressure and it also consist up of very high tensile strength. For these useful properties of this material it is used in power producing industry and chemical industry. Also it is used to make pressure vessels. For machining of work piece the insert chosen is coated carbide cutting insert. Three factors depth of cut, feed and speed were taken at three levels high, medium and low. By using the L27 orthogonal array design twenty seven runs of experiments were performed. For each run of experiment the time of cut was 3 minutes. The output responses measured were roughness of the surface.

Keywords: Hard turning, Taguchi Technique, ANOVA, Surface finish.

1. INTRODUCTION

The methodology applied in this study is Taguchi method. It is a combination of methodologies by which inherent variability of materials and manufacturing processes has been taken into consideration during design. Controlled and noise both factors are considered in this design. Taguchi design is similar to design of experiment but it conducts the orthogonal experimental combinations which makes the method more effective than fractional factorial design. Taguchi method uses special design of orthogonal arrays to study the entire parameter space with small no of experiments. Taguchi uses the loss function for the measurement of the performance characteristics deviating from the desired value. The value of loss function is converted to S/N ratio. There are three types of S/N ratios e.g. lower-the-better, Higher-the-better, Nominal-is-best. The need for improving the technological performance of machining operations as assessed by the cutting forces, power, tool life and surface finish has long been recognized to increase the economic performance of the machining operations. It is extremely difficult to machine hard materials because of poor machinability and high tool wear and fracture. Hard machining involves machining of steels having hardness of 45 HRC and above. The heat generated in hard machining is used to plasticise or anneal the material at the cutting point. The high speed makes the heat flow away from the cutting point and thus chips carry away the heat. In hard machining the tool just skids over the work place.

2. Literature Review

Gowd et. al.[1] Mainly the problems in turning are due to cutting parameters (Fx, Fy, Fz and surface roughness S.R.). Experiments were and it is concluded that cutting force, feed force, thrust force and surface roughness are significantly affected by speed, feed and depth of cut. Prediction of mathematical models for estimation of Fx, Fy, Fz and S.R, RSM is used.

Kumar et. al.[2] Surface finish of EN-8 is affected by spindle speed, feed, and depth of cut. Experimental measurements were determined multiple regression analysis and ANOVA. Cemented carbide inserts are used to predict surface roughness by multiple regression analysis. The purpose is to form a relation between cutting speed, feed and depth of cut to optimise S.R. using multiple regression analysis.

S.B. Salvi et. al. [3] Studied on hard turning of 20MnCr5 steel. The purpose of this study is to analyse optimum cutting conditions to get lowest surface roughness in turning of 20MnCr5 steel. Taguchi method is applied in this process. Orthogonal array, signal to noise ratio and analysis of variance are applied to investigate the cutting characteristics. From the experiment it is concluded that feed rate has the significant role to produce lower surface roughness followed by cutting speed. In this experiment the cutting insert used is ceramic based TNGA160404.

F.Puh et. al. [4], used Taguchi design and optimised the process parameters for hard turning of AISI 4142 steel and in this experiment he used PCBN (polycrystalline cubic boron nitride cutting tool). L9 orthogonal array having three level and four factor, SN ratio and ANOVA are used for this to study cutting parameters (speed, feed, depth of cut) with consideration of S.R. Multiple regression analysis was used to find first order linear and second order prediction model for surface roughness and independent variables.

Bagawade et. al. [5], evaluated the area ratio of chip. He also evaluated S.R. in hard turning of AISI 52100 (EN-31) steel. The hardness of steel was about 48-50 HRC and this was machined by PCBN tool. The effect of speed, feed, and depth of cut on chip area ratio and S.R were found.

Suresh et. al. [6], used Response surface methodology (RSM) to study surface roughness prediction model for turning of mild steel. CNMG cutting tools are used for experiment. A second order mathematical model is developed for surface roughness using RSM.

Sharma et. al. [7], investigated the machining AISI 52100 steel using a carbide-coated tool. It was found that the cutting force increases with the feed rate and depth of cut. The approach angle has little effect on the cutting force, and increasing the speed causes the cutting force to decrease slightly. The feed force increased with increasing depth of cut and decreased with increasing approach angle, speed, and feed rate.

Avila et. al. [8], analysed cutting tool life cemented carbide tools is used the depth of the crater is located on the rake face, given as a function of the feed rate. The result brought a new approach and confirm the importance of the coating to the crater wear resistance, even if the coating has already been delaminated on the rake face.

Roy et. al. [9], studied the compatibility of cutting materials in dry machining of Aluminium and Al–Si alloys. They have shown that chemical inertness of diamond towards aluminium was principally responsible for outperforming an uncoated tool along with other tools coated with hard coatings like TiC, TiN, TiB_2, Al_2O_3, and AlON.

Coelhoa et. al. [10], analysed on tool wear when turning hardened AISI 4340 steel with coated PCBN tools using finishing cutting conditions. They have shown the results of tool wear, cutting force and surface finish obtained from the turning operation on hardened AISI 4340 steel using PCBN coated and uncoated edges. Due to a combination of high hardness in the cutting temperature range and the presence of an oxidizing layer, TiAlN-Nano coating performed better in terms of tool wear and surface roughness.

Longbottom et. al. [11], described that during the machining process, a considerable amount of the machining energy is transferred into heat through plastic deformation of the work piece surface, the friction of the chip on the tool face and the friction between the tool and the work piece.

Arsecularatne et al. [12], described an experimental investigation on machining of a difficult-to-cut material, AISI D2 steel of hardness 62 HRC with PCBN tools. They have found that most of the tested PCBN tools reached the end of life mainly due to flank wear. The highest acceptable values of tool life and volume of material removal were obtained at the lowest speed tested (70 m/min) but the highest feed used resulted in the highest volume of material removal, lower feeds resulted in higher tool life values.

3. Experimental Procedure

The final diameter of the work piece is made 50 mm. Chemical composition of Cr-Mo alloy is C-0.15% max. , Mn-0.3-.06%, Cr-4-6%, Mo-0.44-0.65%. The two ends of the work piece are faced and centring is done using carbide centre drill. The final length of the work piece was made 600 mm. The purpose of this experiment is to find the effect of speed, feed and depth of cut on output response like surface roughness, power consumption, chip reduction coefficient and tool wear. The levels of speed, feed and depth of cut are three each which is given in table-1. Total 27 experiments were done according to L_{27} orthogonal array. The work piece was held rigidly on the lathe and for each set of the data work piece is turned for 3 minutes so 27 cuts were made on the work piece. The surface roughness component (Ra) was measured using Taylor/Hobson (sutronic 3+) for 27 cuts. The power consumed in machining was measured by wattmeter connected to the Lathe machine. The wattmeter gave the reading of voltage (V), current (I) and power factor (cosφ) for each of the runs of the experiment. The power consumption can be given by formula P= V.I.cosφ.The optimal levels of process parameters can be:

Table 1 – Level of speed, feed and depth of cut

Levels	Speed in mm/rev	Feed in mm/rev	DOC in mm
Low	39.2750	0.10	0.30
Medium	65.9820	0.130	0.50
High	111.5410	0.150	1.00

Figure 1 - Surface roughness tester

Experimental table- 2 is given below. This table contains three input variables speed, feed and depth of cut. The levels of were in r.p.m. and they were 250, 420 and 710 r.p.m. These speeds were converted into m/min using formula πDN/1000 where D is the diameter of work piece and N is in the r.p.m of lathe machine. The output are surface roughness in micron.

Table 2- Experimental Table

Run No.	Speed in m/min	Feed in mm/rev	Doc in mm	S.R. in micron
1	39.2750	0.10	0.30	1.10
2	39.2750	0.10	0.50	1.44
3	39.2750	0.10	1.00	0.04
4	39.2750	0.130	0.30	1.56
5	39.2750	0.130	0.50	1.66
6	39.2750	0.130	1.00	1.42
7	39.2750	0.150	0.30	1.02
8	39.2750	0.150	0.50	1.82
9	39.2750	0.150	1.00	1.50
10	65.9820	0.10	0.30	0.88
11	65.9820	0.10	0.50	1.64
12	65.9820	0.10	1.00	0.80
13	65.9820	0.130	0.30	0.72
14	65.9820	0.130	0.50	1.70
15	65.9820	0.130	1.00	1.16
16	65.9820	0.150	0.30	0.84
17	65.9820	0.150	0.50	1.20
18	65.9820	0.150	1.00	1.14
19	111.5410	0.10	0.30	0.84
20	111.5410	0.10	0.50	1.32
21	111.5410	0.10	1.00	1.18
22	111.5410	0.130	0.30	1.2
23	111.5410	0.130	0.50	1.32
24	111.5410	0.130	1.00	2.50

25	111.5410	0.150	0.30	1.92
26	111.5410	0.150	0.50	3.08
27	111.5410	0.15	1.00	1.50

5. Result and Discussion

5.1. ANOVA and Response table for surface roughness

The Anova table for surface roughness shows DF, SS, MS, F- value, P- value. From F-statistics it is clear that feed and depth of cut are significant. Cutting speed has not any significant effect on surface roughness. The response table shows that the rank of feed is one and rank of depth of cut is two that means feed and depth of cut has significant effect on surface roughness. Table- 3 shows the Anova table for surface roughness and Table-4 shows the response table for surface roughness.

Table- 3 ANOVA for surface roughness

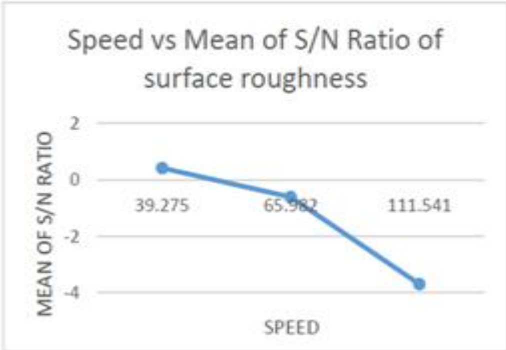
Source	DF	Seq. SS	Adj. SS	Adj. MS	F	P
V	2	82.410	82.41	41.20	1.20	0.349
F	2	171.560	171.56	85.75	2.51	0.143
D	2	123.870	123.87	61.93	1.81	0.225
V*F	4	134.480	134.48	33.62	0.98	0.469
V*D	4	147.500	147.50	36.87	1.08	0.428
F*D	4	178.820	178.82	44.70	1.31	0.346
Residual error	8	273.910	273.91	34.20		
Total	26	1112.550				

Table- 4 Response table for S/N ratio of surface roughness

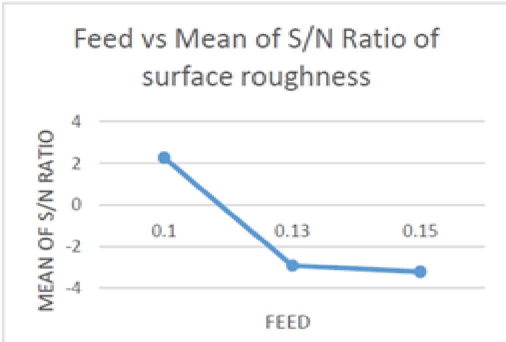
Level	Speed	Feed	Depth of cut
1	0.41760	2.26450	-0.56880
2	-0.61120	-2.92320	-4.20600
3	-3.69420	-3.22900	0.88710
Delta	4.11170	5.49360	5.09310
Rank	3	1	2

5.2. Main effect plots of surface roughness

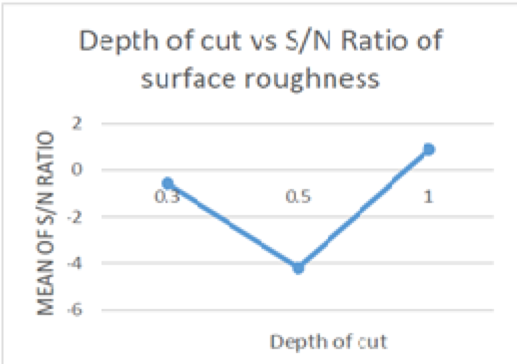
The graph- 1, 2 & 3 shows the main effects for surface roughness that means the graphs of speed vs. mean of S/N ratios of surface roughness, feed vs. mean of S/N ratios of surface roughness, depth of cut vs. mean of S/N ratios of surface roughness for lower is better. As the speed increases the mean of S/N ratios decreases that means good surface finish is obtained with increase in speed. From the graph 2 it is clear that as the feed increases surface roughness decreases that means increase in feed also gives good surface finish. From the graph 3 it is clear that as the depth of cut increases first surface roughness decreases up to some value and then increases. From three graphs the slope of feed vs. mean of S/N ratio graph is largest, depth of cut vs. mean of S/N ratio graph possesses second largest slope so surface roughness is significantly affected by feed and depth of cut but cutting speed has not significant effect on surface roughness.



Graph 1



Graph 2



Graph 3

6. Conclusion

1. The study of Main effect plots of surface roughness indicates that as speed increases mean of SN ratio decreases that means good surface finish is obtained with increase in speed. As the feed increase mean of SN ratio decreases that means good surface finish is obtained with increase in feed. As the depth of cut increases from 0.3mm to 0.5 mm surface roughness decreases but when depth of cut increase from 0.5 mm to 1 mm surface roughness increases.
2. The slope of feed vs. mean of SN ratio is largest, depth of cut vs. mean of SN ratio has the second largest slope so feed and depth of cut affect the surface roughness significantly which is clear from F-statistics of ANOVA and rank of response table. So feed and depth of cut are dominant factors for surface roughness.

7. References

[1]. Dr. G. Harinath Gowd, M. Gunasekhar Reddy, Bathina Sreenivasulu “Empirical modelling of hard turning process of Inconel using response surface methodology” Int. J. of emerging technology and advanced engineering, ISSN 2250-2459, volume2, Issue 10, October 2012.

[2]. K. Adersh Kumar et. al. “ Optimisation of surface roughness in face turning operation in machining of EN-8” International Journal of Engineering Science and emerging technology Vol 2, issue-4, 807-812, July-Aug 2012.

[3]. S.B.Salvi et. al. “Analysis of surface roughness in hard turning by using Taguchi method” international Journal of Engineering science and technology vol5, No-2 Feb 2013.

[4]. [7] F. Puh et al “optimisation of hard turning process parameters with PCBN tool based on the Taguchi method” Technical Gazette 19, 2(2012), 415-419.

[5]. A.D.Bagawade et al. “The cutting conditions on chip area ratio and surface roughness in hard turning of AISI 52100 steel” International Journal of Engineering research and Technology Vol 1 Issue-10 December 2012.

[6]. P.V.S Suresh et al. “A genetic algorithm approach for optimisation of surface roughness prediction model” International Journal of machine tool and manufacture 42(2002)675-680.

[7]. Vishal S Sharma, Suresh Dhiman, Rakesh Sehgal and Surinder Kumar Sharma, Assessment and Optimization of Cutting Parameters while Turning AISI 52100 Steel, International journal of precision engineering and manufacturing, Vol. 9, No.2, pp.54-62,2007.

[8]. R.F. Avila , C. Godoy, A.M. Abra, M.M. Lima, Topographic analysis of the crater wear on TiN, Ti(C,N) and (Ti,Al)N coated carbide tools, Wear 265 (2008) 49–56.

[9]. P. Roy, S.K. Sarangi, A. Ghosh, A.K. Chattopadhyay, Machinability study of pure aluminium and Al–12% Si alloys against uncoated and coated carbide inserts, International Journal of Refractory Metals & Hard Materials 27 (2009) 535–544.

[10]. Reginaldo T. Coelho, Eu-Gene Ng, M.A. Elbestawi, Tool wear when turning hardened AISI 4340 with coated PCBN tools using finishing cutting conditions, International Journal of Machine Tools & Manufacture 47 (2007) 263–272.

[11]. T.M.Longbottom T.D.Lanham, Cutting temperature measurement while machining – a review, Aircraft Engineering and Aerospace Technology; An International Journal. 2005, pp. 122-130.

[12]. J.A. Arsecularatne , L.C. Zhang , C. Montross , P. Mathew, On machining of hardened AISI D2 steel with PCBN tools, Journal of Materials Processing Technology171(2006)141-24.