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TO STUDY THE EFFECT OF CUTTING FLUID CONCENTRATION AND CUTTING PARAMETERS ON SURFACE ROUGHNESS OF STEEL AFTER TURNING

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Keywords:

CNC Machine, AISI 1030,Cutting Fluid,Surface Roughness Tester,

Abstract

In present industrial era, strict tolerance limits are used in manufacturing parts that require higher surface finish and the given work laid emphasis on optimizing the surface roughness of AISI 1030 steel during wet CNC turning operation. The main purpose of this experimental investigationis to analyse the effect of cutting parameters such as cutting speed, feed rate, depth of cut, cutting fluid concentration and two cutting fluids with different base oils on surface roughness (R_a) on AISI 1030 steel during turning operation. The design of experiments, custom design method, and Taughci method are used to achieve this objective. The analysis reveals that feed rate has the most significant effect on surface roughness (R_a) and value of surface roughness does not significantly differ for two different cutting fluids used.

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1. Introduction:

Turning is the primary operation in most of the production process in the industry. It is a material removal process in which major motion of the single point cutting tool is parallel to the axis of rotation of the rotating workpiece . The workpiece is usually held in a work holding device known as chuck and the tool is mounted in the tool post.

Parameters affecting characteristics of turned parts

The dimensional accuracy, surface roughness of the turned parts are affected by tool or insert geometry, tool material, cutting speed, feed rate, depth of cut, dry cutting conditions, wet cutting conditions etc., a brief explanation of which has been given below

Cutting speed: It is defined as the relative velocity between the cutting tool and the surface of the workpiece. It is expressed in metres per minute. It is important to know cutting speed or peripheral speed to calculate spindle speed as if the spindle speed is not proper it could lead to chatter and tool breakage.

Feed rate :It is the relative velocity at which the cutter is advanced along the work piece. Its vector is perpendicular to the vector of cutting speed, feed rate units depend on the motion of tool and the workpiece; when the workpiece rotates as in case of turning and boring its units are distance per spindle revolution in/rev or mm/rev.

Depth of cut It is thickness of the material that is removed by one pass of the cutting tool over the workpiece. Its units are mm or inch.

Surface finish

Surface finish or surface texture consists of repetitive and/or random deviations from the nominal surface of the object; it has four components lay, waviness, surface roughness and flaws as shown in fig. 1.1. Lay is the direction of predominant surface pattern determined by production method used. Within limitations resulting from components manufacture, a designer must select a functional surface condition that will satisfy operational constraints which might be a requirement for a smooth or a rough surface [4].

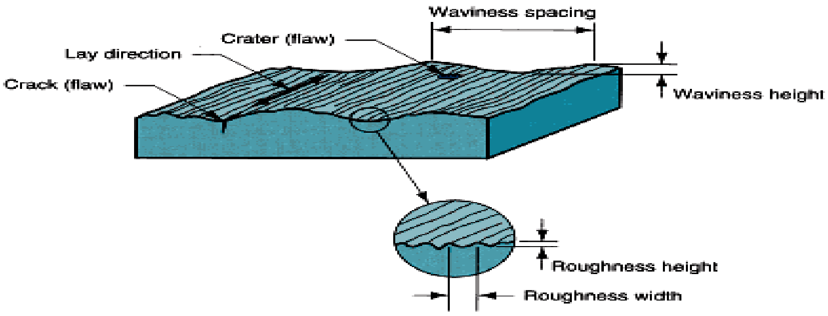

Fig. 1.1 Surface texture features [4]

Cutting fluids

Cutting fluids or cutting oils are engineering materials that optimize the machining operation. They are used for lubrication, heat dissipation, corrosion prevention, chip disposal etc. The advantages of using cutting fluids are mentioned below [9].

1) The use of cutting fluid reduces friction and heat. The removal of heat prevents the workpiece from expanding during the machining operation, which would cause size variation as well as damage to the microstructure of material.

2) Proper use of cutting fluids increase the tool life, which reduces the tooling costs. Increased tool life also reduces tool changes and downtime which decreases labour costs.

3) The use of cutting fluids reduces friction and heating in a cutting operation. This allows high speeds and feeds to be used so as to achieve optimal cutting conditions.

4) Effective use of cutting fluids help in chip removal, which if caught in between tool and workpiece could cause scratches and it also helps in preventing formation of built up edges thus improving surface finish.

5) Cutting fluid leaves a residual film behind after evaporation of water from the surface of tool and workpiece thus preventing it from corrosion.

Types of cutting fluids

The cutting fluids are divided into four broad categories according to their constituents which are as given below [10].

1) Straight oils These are also called mineral oils and are not diluted with water. These contain mineral or petroleum oil as base oil and often contain polar lubricants such as fats, vegetable oils and esters as well extreme pressure additives such as chlorine, sulphur, phosphorus etc., they provide best lubrication and the poorest cooling characteristics amongst cutting fluids.

2) Soluble oils They are a mixture of water with mineral oil. Emulsifier is added to help produce stable mixture.

3) Synthetic fluids They contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They provide best cooling performance among all cutting fluids.
4) Semi synthetic fluids These are a combination of synthetic and soluble oils having characteristics common to both types of fluids these are very popular these days. Their cost and heat transfer properties lie between synthetic and soluble oils.

2 LITERATURE SURVEY

Kuram et al. (2010) conducted a study using three different types of vegetable based cutting fluids developed from raw and refined sunflower oil, two commercial types (vegetable and mineral based cutting oils) to determine their effects on thrust force and surface roughness while drilling AISI 304 austenic stainless steel using HSSE tool.

Krishna et al. (2011) performed an experimental investigation on the performance of nanoboric acid suspension in SAE- 40 and coconut oil during turning AISI 1040 steel, flow rate of 10 ml/min which is nearly dry was maintained for different concentration of boric acid in coconut oil and SAE oil.

Singh H. et al (2012) presented an experimental study to investigate the effects of cutting parameters like spindle speed, feed rate and depth of cut on surface finish of EN-8 material while dry turning, employing taguchi method and using L-16 orthogonal array.

Sharma et al. (2013) performed an experiment to optimize the cutting parameters for surface roughness during turning of AISI 410 carbon steel, Cutting speed, feed rate, depth of cut and insert radius were chosen as control parameters, the signal to noise ratio and ANOVA were used to analyse the effect of different control parameters on surface roughness.

Davis and Alazhari (2014) analysed the effects of major cutting parameters of speed, feed rate and depth of cut during dry turning of mild steel for obtaining optimum surface roughness, MINITAB 15 software.

Das et al. (2014) conducted a study to optimize cutting parameters on tool wear and workpiece surface temperature during dry turning of AISI D2 steel employing Taguchi's orthogonal array design, ANOVA, main effect plots using MINITAB 15 software

Singh D. et al (2015) performed an experimental investigation on surface roughness and MRR during dry turning of EN-8 on CNC lathe using Response surface methodology [RSM] to optimize the cutting parameters of speed, feed and depth of cut.

3.OBJECTIVES AND METHODOLOGY

1) To optimize the surface roughness of AISI 1030 steel during wet CNC turning on cylindrical workpiece

2) To analyse the effects of various cutting parameters i.e. spindle speed, feed rate, depth of cut and cutting fluid concentration on surface roughness using Taguchi method and plot various interactions.

3) To compare the effect of two base oils used in water soluble cutting fluids namely heavy duty diesel and spindle oil.

4.EXPERIMENTATION AND OBSERVATIONS

Workpiece :The AISI 1030 steel is a high carbon steel, and has moderate strength and hardness in the as-rolled condition. It can be hardened and strengthened by cold work. It also has fair machinability, ductility and good weldability.

Table 1.1 Chemical composition of AISI 1030

Fe %	**Mn %**	**C %**	**P %**	**S %**
98.67-99.13	0.60-0.90	0.270-0.340	≤ 0.040	≤ 0.050

Cutting tool : The cutting tool used was Sandvik Coromant made carbide turning insert CNMG 431 PF- 4225, which was considered taking care of workpiece material and cutting conditions. The specifications of the cutting tool insert are shown below in the table 3.

Table 1.2 Specifications of the cutting tool insert

Insert thickness	0.1875 inches.
Nose radius	0.0157 inches
ISO number	CNMG 12 04 04-PF 4225
No. of edges	4
Coating	MTCVD

Cutting fluids: The environmental conditions for the turning were wet flood cooling conditions, the flow rate of 8litre/min. There were two types of cutting fluids used which were specially prepared by Nirmal Industries, Phase1, Chandigarh for the purpose of experiments which are as given below

1. Cool-cut-Nirma 40 A – Water soluble cutting fluid with spindle oil as base oil.
2. Cool-cut-Nirma 30 A – Water soluble cutting oil with heavy duty diesel oil as base oil.

Equipment

CNC Machine:The advantages of using CNC over conventional lathe are that CNC turning machines are said to deliver components at a faster production rate with optimum manufacturing accuracy. It allows reaching tight tolerances in every piece; other advantages are parts consistency and uniformity. The lathe that was used in experiment for turning was a Lokesh made CNC with specifications given in the table 1.3.

Table 1.3 CNC lathe specifications

Model	LOKESH TL 30 XL
Power	11 hp/8.2 KW
controller	FANUC Series 0 i TC
Max. Spindle speed	3000 RPM
Chuck size	249.6 mm
Spindle size	A_26
Tool holder	Standard Lokesh made with 25*25 mm shank

Surface Roughness Analyser:A contact type profilometer was used for measuring the surface roughness; these are the devices which use diamond stylus, which is moved across the surface for a specified distance. A profilometer can measure small surface variations in vertical stylus displacement as a function of position.

Fig. 1.2 Surface roughness tester

Design of Experiment

The objective functions to be optimized are also identified with control factors and their levels.

Table 1.4 The machining parameters and their levels

S. No.	Machining Parameters	Symbols	Unit	Level		
				Level 1	Level 2	Level 3
1.	Fluid	A40, A30		A40	A30	
2.	Velocity	V	rpm	800	1200	1500
3.	Feed	F	mm/rev.	0.10	0.15	0.20
4.	Depth	D	mm	0.50	1.00	1.50

L 18 orthogonal mixed array was selected for this study, because one parameter has two levels and rest parameters have three levels. After selection the orthogonal array matrix, the design of experiment procedure (flow chart of experiment procedure) adopted for the experimentation. The experimental matrix based on L18 mixed orthogonal array of Taguchi method is shown in Table 1.5.

Table 1.5 Design of experiment of L18 orthogonal array

S. No.	Fluid	V (rpm)	F (mm/rev.)	D (mm)
1.	A40	800	0.10	0.50
2.	A40	800	0.15	1.00
3.	A40	800	0.20	1.50
4.	A40	1200	0.10	0.50
5.	A40	1200	0.15	1.00
6.	A40	1200	0.20	1.50
7.	A40	1500	0.10	1.00
8.	A40	1500	0.15	1.50
9.	A40	1500	0.20	0.50
10.	A30	800	0.10	1.50
11.	A30	800	0.15	0.50
12.	A30	800	0.20	1.00
13.	A30	1200	0.10	1.00
14.	A30	1200	0.15	1.50
15.	A30	1200	0.20	0.50
16.	A30	1500	0.10	1.50
17.	A30	1500	0.15	0.50
18.	A30	1500	0.20	1.00

5.RESULTS AND DISCUSSIONS

Analysis of Surface Roughness

Surface roughness was measured using surface roughness tester Mututoyo SJ .201. Two replications were made for each sample. These results of surface roughness are compiled into average of the two replications in the Table 1.6. The surface roughness is measured in µm.
The mean effects plot of the S/N ratio for SR using "smaller is better" is shown in Fig. 5.1 which reveals that the SR is minimum at 1^{st} level of fluid (A40), 1^{st} level of velocity (800rpm), 1^{st} level of feed rate (0.10 mm/rev.) and 2^{nd} level of depth (0.10mm). Thus the S/N ratio shows that F_1, V_1, f_1, and D_1 parameter set gives the minimum SR. Main effects of plot for S/N ratio of SR also reveals that feed rate gives higher surface roughness as compared to the other input parameters.

Table 1.6 Response Table for the SR

S. No.	Fluid	V (rpm)	F (mm/rev.)	d (mm)	R_{a1}	R_{a2}	Avg. Ra
1	A40	800	0.10	0.50	1.65	1.89	1.77
2	A40	800	0.15	1.00	1.91	1.87	1.89
3	A40	800	0.20	1.50	2.31	2.35	2.33
4	A40	1200	0.10	0.50	1.85	1.89	1.87
5	A40	1200	0.15	1.00	1.93	2.02	1.98
6	A40	1200	0.20	1.50	2.44	2.58	2.51
7	A40	1500	0.10	1.00	2.27	2.14	2.21
8	A40	1500	0.15	1.50	2.46	2.60	2.53
9	A40	1500	0.20	0.50	2.73	2.88	2.81
10	A30	800	0.10	1.50	1.78	1.84	1.81
11	A30	800	0.15	0.50	1.88	1.93	1.91
12	A30	800	0.20	1.00	2.29	2.38	2.34
13	A30	1200	0.10	1.00	1.99	1.85	1.92
14	A30	1200	0.15	1.50	2.12	1.90	2.01
15	A30	1200	0.20	0.50	2.47	2.70	2.59

16	A30	1500	0.10	1.50	2.23	2.29	2.26
17	A30	1500	0.15	0.50	2.61	2.69	2.65
18	A30	1500	0.20	1.00	3.04	2.69	2.87

Fluid and depth also affect the SR, but doesn't give significant results. The main effect plots of the S/N ratios for SR are found with the help of Minitab-18 software. This plot revealed that the steeper slope with longer lines gives significant effect on the surface roughness.

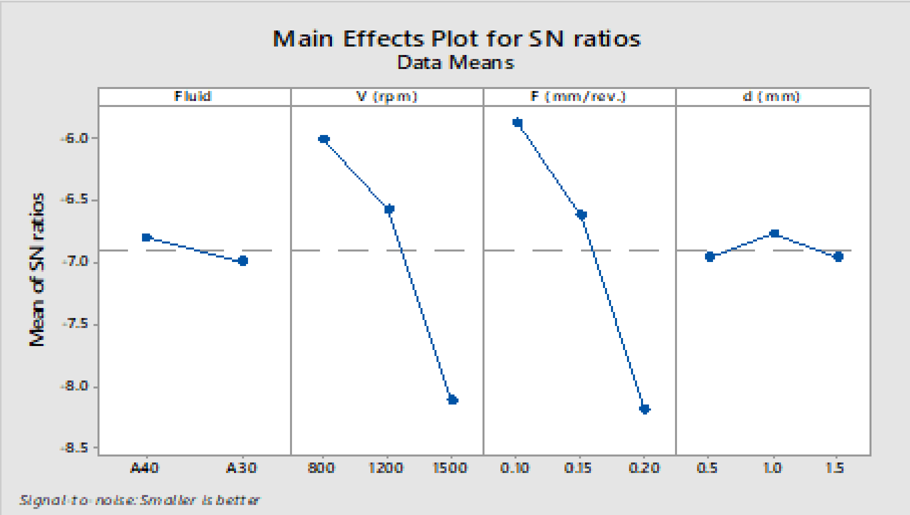

Fig. 1.3 Mean effect plot for S/N ratios for surface roughness

Response table of the ANOVA (Analysis of Variance) also shows that the feed rate is the most significant parameters and second one is the velocity which is significant parameter. Fluid and

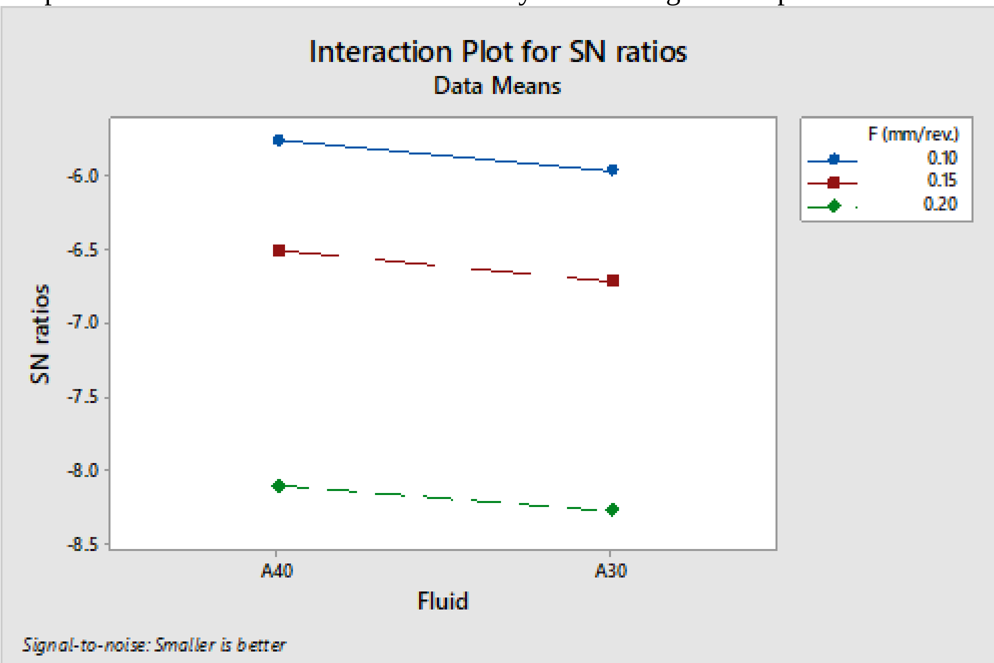

Fig. 1.4 Interactions plot of S/N ratio for SR (feed rate)

The different types of interaction curves are shows in the following figure, which shows that the interactions between the feed rate, velocity and fluid are shown in the fig. 5.2 and fig. 5.3. These figures show that the surface roughness is increase with the sharply increase in feed rate and velocity and there is no significant affect with the fluid type. i.e feed rate and velocity are the significant parameters.

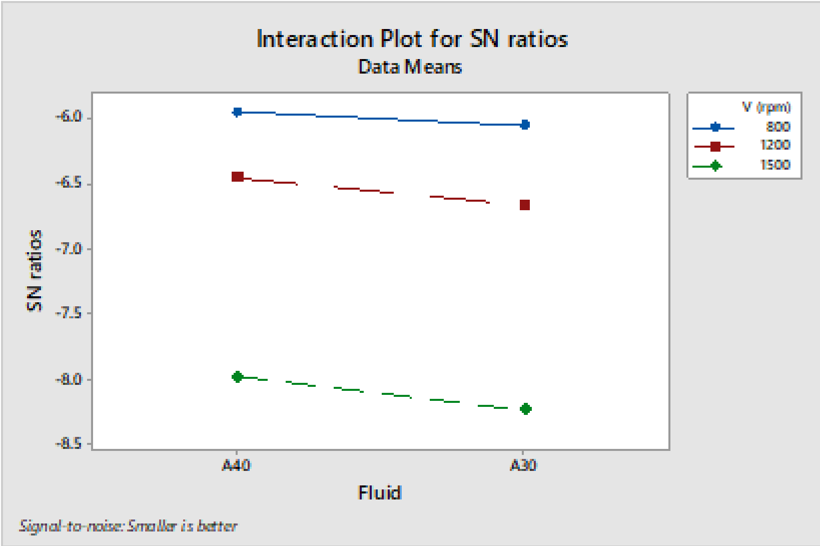

Fig. 1.5Interactions plot of S/N ratio for SR (Velocity)

Conclusions

In this study we used design of experiments and various statistical methods such as Taguchi, ANOVA are used for optimizing surface roughness during wet turning of AISI 1030 steel on CNC lathe machine. Feed rate and cutting velocity have significant and most dominant effect on the surface roughness of AISI 1030 steel during wet CNC turning operation.

1) Surface roughness increases with increase in feed rate as well as cutting velocity

2) It was found that surface roughness tends to increase with increase in depth of cut but after certain value of depth of cut, it shows downward trend.

3) No significant difference was found between the cutting fluids when compared on the basis of their effect on surface roughness and workpiece tool interface temperature

REFERENCES:

[1] Todd, Robert H., Allen, Dell K., Alting, Leo, Manufacturing processes reference guide, First Edition, Industrial press inc., 200 Madison Avenue, New York, 1994, p. 153.

[2] Somashekara, H.M., Swamy, N. Lakshmana, Optimizing surface roughness in turning operation using taguchi technique and anova, International Journal of Engineering Science and Technology, Vol. 4, No. 5, 2012, p.1967-1973.

[3] Juneja, B.L., Seth Nitin, Sekhon G.S., Fundamentals of metal cutting and machining tools, Second Edition, New Age pub., 4835/24 Daryaganj, New Delhi, 2003, p.89-91.

[4] Groover Mikell P., Fundamentals of modern manufacturing, Third edition, Wiley India P. Ltd., 4435/7, Ansari road, Daryaganj, New Delhi, 2011.

[5] Sandvik Coromant, Insert shape, Retrieved 30/06/2013, online http://www.sandvik.coromant.com/engb/knowledge/general_turning/getting_started/choice_of_insert/insert_shape/pages/default.aspx

[6] Marinov Valery, Manufacturing technology, Cutting tool materials, Retrieved 29/06/2013, online http://me.emu.edu.tr/me364/ME364_cutting_materials.pdf, p. 86-88.

[7] Smid Peter, CNC programming handbook, second edition, Industrial press inc., 200 Madison Avenue, New York, 2003, p. 87-88.

[8] Kadirgama K., Noor M. M., Abou-El-Hossein K.A., Habeeb H.H., Rahman M.M., Mohamad B., R.A. Bakar, Effect of dry cutting on force and tool life when machining aerospace material, International Journal of Mechanical and Materials Engineering, 1:2, 2010, p. 93-97.

[9] Fox valley technical college, Cutting fluid types and uses, Retrieved 20/05/2013, online http://www.wisc-online.com/objects/MTL5302/MLT5302.htm, 2002.

[10] Cutting fluids, Cutting fluids in machining, Retrieved 4/04/2013, online http://www.mfg.mtu.edu/testbeds/cfest/fluid.html
[11] Kuram Emel, Ozcelik Babur, Demirbas Erhan, Green manufacturing processes and systems, Environmentally friendly machining: Vegetable based cutting fluids, Springer Berlin Heidelberg, Tribology, 2013, p. 23-47.
[12] Reliability hotwire, Introduction to design of experiments, Retrieved 21/05/2013, Online http://www.weibull.com/hotwire/issue84/hottopics84.htm, Issue 84, 2008.
[13] SAS Institute Inc., JMP for design of experiments, Custom designs, Retrieved 25/04/2013, Online http://www.jmp.com/uk/applications/doe/, 2013.
[14] Freund Rudolf Jacob, Littell C. Ramon, Creighton Lee, Regression using JMP, First Edition, SAS Institute and Wiley, Cary, North Carolina 27513, USA, 2003, p. 110.
[15] Sall John, Leverage plots for general linear hypotheses, The American Statistician, Volume 44, No.4, 1990.
[16] SAS Institute Inc., Modeling and multivariate methods, Leverage plot details, Online http://www.jmp.com/support/help/Leverage_Plot_Details.shtml, 2013
[17] SAS Institute Inc., Modeling and multivariate methods, The profiler, Online http://www.jmp.com/support/help/The_Profiler.shtml, 2013
[18] Monarch labs, University of Minnesota, Two sample t test, Online http://www.monarchlab.org/Lab/Research/Stats/2SampleT.aspx

Mahapatra S.S, Patnaik Amar, Patniak Prabina Ku., Parametric analysis and optimization of cutting parameters for turning operations based on taguchi method, Proceedings of the International Conference on Global Manufacturin