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Effect of Cutting Parameter in Engine Valve Turning Process

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ABSTRACT
Engine valve manufacturing involves significant amount of machining during its manufacturing activity. Suitable cooling agents or cutting fluid are used to remove heat produced during cutting operation to maintain machining finish and insert life. Cutting fluids are one of major waste involving cost for disposal and hazard to environment, reduction in their use can play key role to meet stringent environment norms and achieve economic machining. Dry machining is an alternative solution involving compressed air replacing cutting fluids. The most important measures of surface quality during the machining process is the average surface roughness (Ra) which is mostly caused by many machining parameters such as true rake angle, side cutting edge angle, cutting speed, feed rate, depth of cut and nose radius. This paper a model of surface roughness was developed based on the response surface method to investigate the machining parameters such as feed rate, cutting speed, nose radius, and machining time, affecting the roughness of surface produced in dry turning process. The experiment has been designed and carried out on the basis of a three-level factorial design which provide the perfect combination of cutting parameter to obtain optimum result of turning process.

Keywords: *Machining, cutting process, roughness, tool life, machining time*

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INTRODUCTION

Manufacturing activity is a major consumer of energy and natural resources. In the machining process, a large amount of heat is produced whose removal requires the use of suitable cooling agent of cutting fluid. This cutting fluid is a major source of waste generation and environmental damage therefore to eliminate harmful cutting fluid during the machining operations, researchers have tried machining component without applying cutting fluid which is known as dry machining.

Dry machining is considered to be more acceptable process than machining with cutting fluid due to the absence of coolants and lubricants which results in a reduced use of resources. There are many advantages of dry machining such as decreased cycle time, increased flexibility, reductions in machine tool cost and elimination of environmentally harmful cutting fluid. Surface roughness is important in machining process for achieving certain surface roughness in dry machining tools with carbide coating is necessary also the different types of coated tool is important for cutting parameter. This type of tools influences the high temperature, high resistive and also less tool wear. While turning operation in lathe or CNC machine hard coating deposits are necessary, it can be either done by PVD (Physical vapour deposition) and CVD (chemical vapour deposition).also some coating of PVD can be used at sharp edges and complex edges. Also, this carbide coating tools play and vital role in tool life and machining performance.

Ling Chen et al. (2018) presents a detailed Assessment on abrasiveness of high chromium cast iron material on the wear performance of PCBN cutting tools in dry machining, with the use of work piece material-high chromium white cast irons (HCWCI) and PCBN (poly-crystalline Cubic Boron Nit-ride) cutting tool (insert).This work piece and cutting tool used in the machine SMT500 with processing parameter of feed 0.4 mm/rev, speed 160 m/min, depth of cut 1.5 mm. After machining of the six materials, the defect of the cutting insert is the combination of the crater wear and abrasive wear. But the abrasive wear is the main wear type in all of wear morphology of all used cutting edge [1].

D. Chakradhar et al. (2018) presents a detail analysis on Effect of cryogenic coolant on turning performance characteristics during machining of 17–4PH stainless steel: A comparison with MQL, wet, dry machining. With the use of work piece material and size 17–4PH SS round bar and (Ø50 mm × 300 mm) and AlTiN physical vapour deposition (PVD) coated KC5010 tungsten coated carbide inserts SNMG120408. Work piece and cutting tool used in Kirloskar Lathe Machine with cutting velocity (v): 78.5 m/min. Feed rate (f): 0.143 mm/rev Depth of cut(d): 0.2, 0.4, 0.6, 0.8 and1mm. It was observed that as depth of cut increases turning performance characteristics like cutting temperature ,tool wear surface roughness was increased under cryogenic, MQL, wet, dry machining condition [2].

K. Venkatesan et al. (2018) present a Comparative study on Mach inability characteristic In dry machining of mnemonic 263 alloy using carbide inserts, with the use of work piece material Mnemonic 263 alloy and Cutting tool is (CNMG 120408-MP, KCU 25) (CNMG120408-MP, KCM25) in Cone-National Centre Lathe (ETM510) with the speed range of 25–1600 rpm, and feed rate range (0.044 to 1.04 mm/rev). Trials performed using the L16 design matrix, the roughness is lower at higher speed in case of PVD and CVD inserts machining. PVD coated insert has the better performance compared with CVD coated insert at moderate range of feed [3].

C. Moganapriyaa et al. (2018) present an influence of cutting parameters (coating material, depth of cut, feed rate, and Spindle speed) on material removal rate (MRR) and coated tool on surface roughness of TiAlN/WC-C during CNC turning of AISI 1015 mild steel. In this research Taguchi L9 Orthogonal Array method is used for optimization method of MRR and minimization of surface roughness on Jober XL CNC lathe machine. It is inspecting that the coating material (TiAlN /WC-C) has significant influence in determining the output parameters. This study also determined a predictive equation for determining MRR and Surface roughness with a given set of parameters in CNC turning [4].

Zi-he-he et al. (2016) present a Comparison of residual stresses in cryogenic and dry machining of Inconel 718, with the use of work piece material nickel based high temperature alloy

Inconel 718 and cutting tool is WNMG080404SF1105. Tn this experiment process parameter depth of cut is varies from 0.3, 0.5, 0.7 mm, Feed rate: 0.2 mm/rev and cutting speed: 80 mm/min. Cutting forces turn out to be almost the same for cryogenic and dry machining except for few cutting condition of largest difference of 13% this validate the assumption that the mechanical deformation including the elastic stress and strain for cryogenic and dry machining are almost the same so the residual stresses in the cutting direction is only related to change in temperature [5].

Sunil J Ray Kara et al. (2014) presents a detailed analysis of surface in dry machining of EN-8 steel which is widely used material for general-purpose shafts, axles, gears, studs and bolts. Regression models are developed for Ra, Rq, and Rz parameters of mathematical model of surface roughness which are very significant parameters from contact stiffness, fatigue strength and surface wear point of view. For all the regression models a good correlation is found between surface roughness and cutting parameters and hence these models can be used to predict the surface roughness within the range of cutting parameters under investigation. Regression models are compared with experimental values of roughness and with available geometrical models. Percent errors are also calculated by comparing regression models and experimental values and a geometrical model. It is found that the percent errors are very small for regression model as compared to geometrical model. Finally, performance of dry machining is compared with that of machining with coolant, no significant difference is found for the surface roughness with the dry machining and that of machining with coolant [6].

Thakur and Gangopadhyay et al. (2016). The work-piece material also plays a major role in deciding whether dry machining can be applied or not. While certain materials with easy amenability are natural choices for dry cutting, certain difficult to cut materials may pose serious problems when machined dry [7]. Shala by et al. (2014) studied Different cutting tool materials in the machining of high carbon chromium tool materials. The cutting tools show the fast tool wear and instability in the machining process, and the cost of the machining is very high. The application of the CBN cutting tool is the potential approach to improve the machining efficiency and reduce the cost of machining [8].

EXPERIMENTAL CONDITION

Machine used for this investigation was the ACE CNC CUB LM, P = 3.7 kW, maximum spindle speed = 4000 rpm, max. turning diameter = 140 mm.

The work piece was made up of using forging process of materialistic steel of grade SUH 3 having hardness after heat treatment is 25HRC, tensile strength 90.0 kg f/mm², yield strength 70.0 kg f/mm².

Machining tool used for the experiment is carbide coated cutting insert TNMG 160408 HSPC 8110, TNMG 160408 SM H5D6, TNMG160404 VP3 PC 8105.

CALCULATION OF MACHINING PARAMETER

The selection of machining parameter for turning operation is as follows.

Data for Calculation

1. Work piece diameter=35.70
2. Maximum spindle speed =980 rpm
3. Work piece length per min=0.04/min
4. Cutting length per min = 117.55/min
   a. Cutting speed (Vc) = лDmŋ/1000; (m/min) = 110 m/min
   [Vc =cutting speed, л = pie (3.14), Dim = work piece diameter, ŋ =main axis spindle speed]

b. Feed (f) = l/n) =0.11 mm/rev.
[f = feed, l = cutting length per min, ŋ =main axis spindle speed]
c. Depth of cut: 0.2 mm

EXPERIMENTAL SETUP

It is obvious that the effects of factors on the selected target function are nonlinear. An experiment with factors at three levels was set up A design matrix was constructed on the basis of the selected factors and factor levels as shown on the table with the help of MINTAB software. The factor ranges were chosen with different criteria for each factor, aiming at the widest possible range of values, in order to have a better utilization of the proposed models. At the same time, the possibility of the mechanical system and manufacturer's recommendations are taken into account.

Machining conditions used in the experiment also are shown in Table 1. All of the trials have been conducted on the same machine tool, with the different tool type and the same cutting conditions.

EXPERIMENT RESULT

As per selection of cutting factor and their levels, experimental trial matrix is done in Mintab 17 software. This matrix shown in Table 2.

REGRESSION BASED MODELING

Design of experiment of dry cutting operation is based on the response surface method (RSM).

It is obvious that the effects of factors on the selected target function are nonlinear. For analysis of the experiment, regression-based modelling is used.

The main purpose for regression analysis is to show relationship between the machining independent variables and surface roughness. Many authors suggested exponential empirical and linear models for surface roughness as functions of machining parameters, by the following.

$$R_a = f\{[vc],[f],[a_p]+error\} \quad (1)$$

Three parameters: feed rate (f), cutting speed (Vc) and depth of cut (a_p), were selected for this study. Ra is the surface roughness in µm, f is feed rate in mm/rev, r is nose radius in mm, a_p is depth of cut in mm. The experimental errors are measured by a residual error in this study and the response Y is developed as the quadratic polynomial multiple regression.

Table 1. *Cutting factors and their levels.*

S.N.	Code level	Factor	High level	Medium level	Low level
			1	0	-1
1	X_1	Cutting speed (m/min)	130	110	90
2	X_2	Feed (mm/rev)	0.12	0.1	0.08
3	X_3	Depth of cut (mm)	0.3	0.2	0.1

Table 2. *Observation table of Minitab analysis based on experimental trial.*

Test No.	Coded Factor					
	Blokes	*X1*	*X2*	*X3*	*RA*	*MRR*
1	1	-1	-1	0	0.418	1.44
2	1	1	-1	0	0.392	2.08
3	1	-1	1	0	0.475	2.16
4	1	1	1	0	0.510	3.12
5	1	-1	0	-1	0.414	0.9
6	1	1	0	-1	0.531	1.3
7	1	-1	0	1	0.383	2.7
8	1	1	0	1	0.259	3.9
9	1	0	-1	-1	0.400	0.88
10	1	0	1	-1	0.413	1.32
11	1	0	-1	1	0.363	2.64
12	1	0	1	1	0.374	3.96
13	1	0	0	0	0.543	2.2
14	1	0	0	0	0.548	2.2
15	1	0	0	0	0.555	2.2

$$Y = C_0 + \sum_{i=1}^{3} CiXi + \sum_{i=1}^{3} c_{ii}\, x_i^2 + \sum_{1<j}^{3} C_{ij}\, x_i x_j$$

Where, C_0 is constant, C_i, C_{ii}, and C_{ij} are the coefficients of linear, quadratic and cross products terms respectively. Then the use of cutting speed, feed rate, and depth of cut as three input parameters of wet turning process allows the expression of each response Y as follows.

$$Y = C_o + C_1 Vc + C_2 f + C_3 a_p + C_{11} Vc^2 + C_{22} f^2 + C_{33} a_p^2 + C_{12} Vc.f + C_{13} Vc.a_p + C_{23}$$

RESPONSE SURFACE REGRESSION: RESPONSE VERSUS VC, F, Ap

The result of analysis of variance their model summary and coded coefficient of cutting parameters are shown in Tables 3–5.

Table 3. *Analysis of variance using Minitab analysis.*

Source	DF	Adj SS	Adj MS	F-value	P-value
Regression	3	0.026933	0.008978	1.32	0.318
vc	1	0.000288	0.000288	0.04	0.841
f	1	0.019800	0.019800	2.90	0.116
ap	1	0.006845	0.006845	1.00	0.338
Error	11	0.075027	0.006821		
Lack-of-Fit	9	0.074574	0.008286	36.61	0.027
Pure Error	2	0.000453	0.000226		
Total	14	0.101960			

Table 4. *Model summary of analysis of variance.*

S	R-sq	R-sq(adj)	R-sq(pred)
0.0825870	26.42%	6.35%	0.00%

Table 5. *Coded coefficients of cutting parameter.*

Term	Coefficient	SE coefficient	T-value	P-value	VIF
Constant	0.098	0.226	0.44	0.627	
vc	0.00030	0.00146	0.21	0.841	1.00
f	2.49	1.46	1.70	0.116	1.00
a_p	2.293	0.292	1.00	0.338	1.00

Regression Equation in Uncoded Units
response = 0.098 + 0.00030 vc + 2.49 f + 0.293 ap

RESULT AND DISCUSSION

Presents experimental results of surface roughness criteria Ra for various combinations of feed rate, cutting speed and depth of cut to factorial design. Minimal value of surface roughness criteria Ra=0.259 µm, was obtained at Vc=130 m/min, f=0.1 mm/rev, a_p =0.3 mm. That means increasing of cutting speed with the lowest feed rate and high depth of cut decreasing of surface roughness. It is found that feed rate has the most significant effect on surface roughness, followed by cutting speed and depth of cut.

Maximal value of surface roughness criteria Ra=0.555µm, was registered at f = 0.1 mm/rev, cutting speed Vc =110 m/min and depth of cut.

In order to achieve better surface finish, the highest level of cutting speed, depth of cut, and the lowest level of feed rate should be recommended.

When cutting speed increases, surface roughness decreases and when the feed increases, surface roughness increases.

CONCLUSION

In the Dry valve turning process various level cutting parameter like cutting speed, feed effect on the surface roughness of work piece material, for achieving minimum surface roughness the combination of minimum feed with maximum cutting speed is best suitable. The investigation of this study indicates that when cutting parameter like cutting speed increases and feed decreases the wear on the tool tip is increases.

With the use of dry cutting process the complete elimination of cutting fluid is possible with the help of compress air cooling system; compress air is help to complete reduce the coolant related cost like coolant handling, disposal which alternately reduces the cost of operation.

REFERENCES

[1] Chen L, Stahl JE, Zhao W, et al. Assessment on abrasiveness of high chromium cast iron material on the wear performance of PCBN cutting tools in dry machining. Journal of

Materials Processing Technology. 2018;255:110–20.

[2] Sivaiah P, Chakradhar D. Effect of cryogenic coolant on turning performance characteristics during machining of 17–4 PH stainless steel: A comparison with MQL, wet, dry machining. CIRP Journal of Manufacturing Science and Technology. 2018;21:86–96.

[3] K. Venkatesan, Abhijeet Thakur. A Comparative study on machinability characteristics in dry machining of Nimonic 263 Alloy using coated carbide inserts. Materials Today: Proceedings. 2018;5(5, Part 2):12443–12452. https://doi.org/10.1016/j.matpr.2018.02.224.

[4] Moganapriya C, Rajasekar R, Ponappa K, et al. Influence of coating material and cutting parameters on surface roughness and material removal rate in turning process using Taguchi method. Materials Today: Proceedings. 2018;5(2):8532–8.

[5] He ZH, Zhang XM, Ding H. Comparison of residual stresses in cryogenic and dry machining of Inconel 718. Procedia Cirp. 2016;46:19–22.

[6] Raykar SJ, D'Addona DM, Kramar D. Analysis of surface topology in dry machining of EN-8 steel. Procedia Materials Science. 2014;6:931–8.

[7] Thakur A, Gangopadhyay S. Dry machining of nickel-based super alloy as a sustainable alternative using TiN/TiAlN coated tool. Journal of Cleaner Production. 2016;129: 256–68.

[8] Shalaby MA, El Hakim MA, Abdelhameed MM, et al. Wear mechanisms of several cutting tool materials in hard turning of high carbon–chromium tool steel. Tribology International. 2014;70: 148–54.

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