

Experimental Investigation of Surface Roughness in High Speed Milling of OHNS Steel under MQL Technique using RSM Method

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ABSTRACT: In machining operation large amount of cutting fluids are used for cooling & lubrication purpose. These cutting fluids not only affect on environment but also on the employees health like respiratory disorder, cancer etc. Therefore, there is necessity to use minimum amount of cutting fluid for machining operations. In this work, to achieve that aim, Minimum quantity lubrication (MQL) method was used to reduce the cutting fluid while machining. Response surface methodology (RSM) was used in the experiment. This study investigate the effect of cutting speed, feed rate & constant Depth of cut on surface roughness under MQL on oil hardened non shrinkage steel (OHNS). The result clearly shows that with increasing cutting speed surface finish is improved and when feed rate is increased surface finish is decreased. It is due to effective lubrication in heat generated zone between tool tip & workpiece. The result is not only high productivity but also good surface finish and cost saving.

KEYWORDS: High speed milling, MQL, OHNS steel, Surface roughness.

I. INTRODUCTION

Now a days, the trend of manufacturing industry particularly in advanced machining operation is focusing on using different type of cooling techniques for better machining performance as well as environmental friendly [10]. Lubricants play very important role in machining operation to reduce temperature between tool and workpiece hence product having good surface quality and less wear tool is possible. In conventional cooling method based on the flooding cooling system, large amount of cutting fluid is fed in to tool and workpiece hence negative impact on health due to toxicity of cutting fluid and environment as disposal view [26]. There are more than 100 million gallons of metalworking fluids are used in the U.S. each year and that 1.2 million employees are exposed to them and to their potential health hazards. The U.S. Occupational Safety and Health Administration (OSHA) reported that the permissible exposure level (PEL) for mist within the plant is 0.5 mg/m³[15].

A survey carried out in the German automotive industry by which shows that workpiece related manufacturing costs incurred as a result of the consumption of cutting fluid is 7-17% of total production cost which is relatively higher compared with the 2-4% of total production cost [26]. The possible solution is to use small amount cutting fluid is mixed with compressed air to form mist of oil and air and fed to interface between tool and workpiece to minimise heat generated zone is called as minimum quantity lubrication.

In this paper OHNS steel used as workpiece material basically used for die industry due to it's high strength, high wear resistance and high hardness to experimentally investigate surface roughness under minimum quantity lubrication method by using response surface methodology in high speed milling.

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II. LITERATURE SURVEY

Alper Uysal et al. (2015) In this study the use of nano MoS₂ particles reinforced cutting fluid in MQL milling gave the minimum tool wear and surface roughness due to the lubrication effect of nano MoS₂ particles [1]. Kedare S. B et al. (2014) In this research work, The cutting performance of MQL machining is better than that of conventional machining with flood cutting fluid supply because MQL provides the benefits mainly by reducing the cutting temperature, which improves cooling effect and results in better surface finish [7]. Y.S.Liao et al. (2007) In this paper, End milling experiments under dry cutting, flood coolant, and MQL conditions were conducted. It is shown that MQL proved beneficial at high speed milling when superior heat resistance coated carbide tool and better cooling ability oil are used. The use of MQL leads to the best performance for all three cutting speeds [17]. M.Rahman et al. (2002) this study, Surface roughness obtained in MQL is comparable to that of flood cooling, while it is better than that of dry cutting [20].

III. EXPERIMENTAL DETAILS

In experiment, workpiece material was Oil hardened non shrinkage steel (OHNS- O1) having hardness 51 HRc. The Oil hardened non shrinkage steel having the chemical composition as follows, %C-0.92, %Mn-1.11, %Cr-0.51, %Ni-0.14, %Mo-0.05, %W-0.57, %V-0.16, %S-0.003, %P-0.004, %Si-0.20. A workpiece dimensions was 32×32×17mm. The experiment was conducted on Jyoti px-30 milling machine. The capability of this machine tool was as follows, Maximum feed (Cutting) – 10000 mm/min, Maximum Speed-8000rpm, Maximum distance between table & Spindle-610mm, Maximum load on table- 500kg as shown in Photo No.1. The cutting test was performed by using carbide cutting tool having four flutes with 8 mm diameter.

In this experimentation Minimum quantity lubrication technique was used for lubrication. A precise amount of lubrication was fed in between tool & workpiece. To achieve mist formation Filter, regulator & Lubricator unit i.e FRL unit was used for operation shown in photo no.2. In this unit 6 bar air was regulated by regulator and then mixed with Servo cut lubricating oil to form mist, sprayed by nozzle in between tool & workpiece. The experiment was carried out at three cutting speeds, feed rate & constant depth of cut. The selected cutting speeds were 125,150,175 m/min, selected feed rate were 0.01,0.02,0.03 mm/tooth & selected constant depth of cut was 0.2mm.The experimental design model was made by using Response surface methodology method to investigate surface roughness on OHNS steel under Minimum quantity lubrication as shown in table no.1.



Photo No.1 CNC Milling Machine



Photo No.2 FRL unit

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IV. RESULT AND DISCUSSIONS

By using detail experimental model cutting speed, feed rate & depth of cut was set on the JYOTI px-30 Machining centre. The Minimum Quantity Lubrication Set up was fixed on CNC Milling machine and 6 bar air was supplied to FRL Unit which forms the mist of air & oil at outlet of FRL unit. Mist is forwarded to interface between tool and workpiece by using nozzle. The nozzle is set at an angle & took fourteen trials on OHNS work piece, by using end mill cutter slots was cut on OHNS steel and checked surface roughness values.

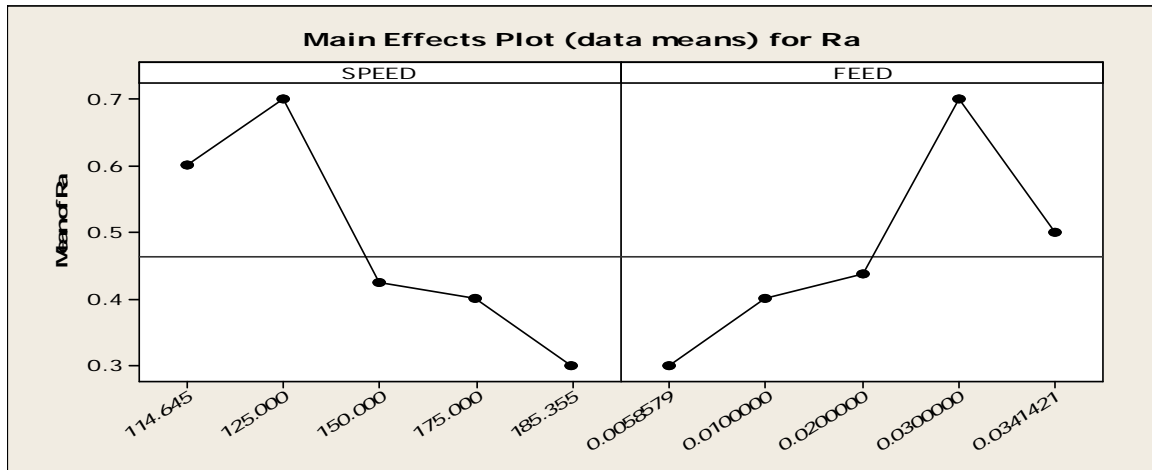
Sr. No	Speed (M/Min)	Feed (mm/Tooth)	Depth of cut (mm)
1	125	0.01	0.2
2	125	0.03	0.2
3	175	0.03	0.2
4	150	0.02	0.2
5	150	0.02	0.2
6	150	0.02	0.2
7	175	0.01	0.2
8	150	0.03414	0.2
9	150	0.02	0.2
10	114.64	0.02	0.2
11	150	0.02	0.2
12	185.35	0.02	0.2
13	150	0.02	0.2
14	150	0.005	0.2

Table No.1Experimental Design Model

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Graph No.1 Main Effects plot for Ra

As concern in machining with high speed milling the effect of MQL on OHNS Steel, a graph no.1 shows mean surface roughness value for different cutting speed and feed rate. When cutting speed is lower i.e. 114.64 m/min, surface roughness was 0.6 μm then it increases up to cutting speed 125 m/min. As cutting speed was increased up to 185 m/min the surface roughness was reduced. As per feed rate is concern in machining in high speed milling, as feed rate was increased then surface roughness was increased up to 0.03 mm/tooth then it decreased at feed rate of 0.034 mm/tooth.

Source	Df	Seq SS	Adj SS	Adj MS	F	P
Regression	5	0.33113	0.33113	0.066225	8.68	
Linear	2	0.22857	0.22857	0.114283	14.98	0.004
Square	2	0.01256	0.01256	0.00628	0.82	0.002
Interaction	1	0.09	0.9	0.09	11.8	0.473
Residual Error	8	0.06102	0.06102	0.007627		0.009
Lack-of-Fit	3	0.04768	0.04768	0.015894	5.96	
pure Error	5	0.0133	0.01333	0.002667		0.042
Total	13					

S = 0.08733 R-Sq = 84.4% R-Sq(adj) = 74.7%

Table No.2 Analysis of Variance for Ra

Analysis of variance (ANOVA) is employed to test the significance of developed models. The analysis of variance of model for surface roughness was shown in Table no.2. The ANOVA have been performed to check the adequacy of the models as well as significance of the individual model coefficients. The ANOVA table for surface roughness is presented here, the ANOVA table for individual model coefficients where it can be seen that there are five main effects with a P-value less than 0.05 which means that they are significant at 95 % confidence level. These significant effects

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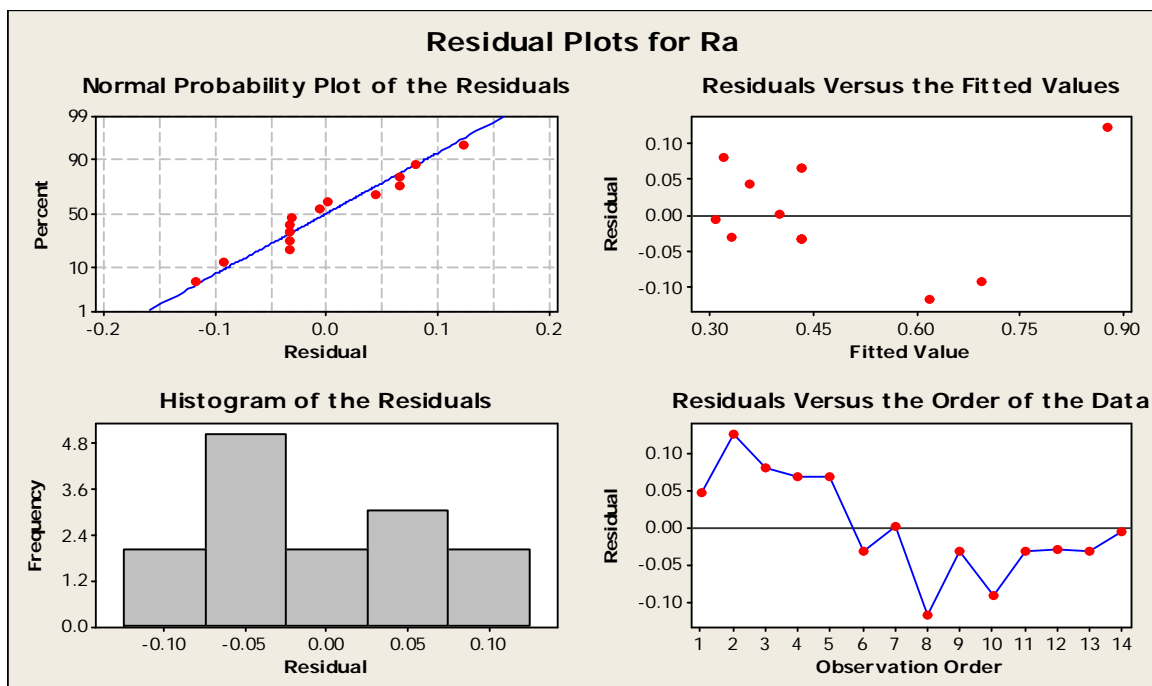
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are surface roughness. P-value for surface roughness is very close to 0.05, thus it may be concluded that Speed, feed & multiplication of speed & Feed are significant

Regression equation:-

The final linear regression equation for the surface roughness of OHNS- O1 Steel when tested on MQL set up under various cutting speed & feed rate can be expressed as follows:-

$$Ra = 0.664202 - 0.0121219 * \text{speed} + 95.2022 * \text{feed} + 6.33E-05 * (\text{Speed})^2 + 145.834 * (\text{Feed})^2 - 0.6 * (\text{Speed} * \text{feed})$$



Graph No.2 Residual Plot for Ra

The graphical method characterizes the nature of residuals of the models. A residual is defined as the difference between an observed value and its fitted value. In the normal probability plot of the residuals shown in Graphs No.2, the data were plotted against a theoretical normal distribution in such a way that the points should form an approximate straight line, and a departure from this straight line would indicate a departure from a normal distribution, which was used to check the normality distribution of the residuals. It is reasonable that the assumptions of normality were satisfied for the data. The plots of residuals versus the order of the data indicated no obvious pattern, implying that residuals of the models were randomly distributed. As well, the histogram of residuals has shown the normal distribution for Ra.

V. CONCLUSION

This work has demonstrated the experimental investigation on high speed milling of OHNS Steel under MQL Technique using RSM Method. In this work servo cut oil was used as a lubricant under Minimal quantity lubrication

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condition. It is found that cutting speed & Feed rate have significant effect on roughness parameters considered in the present study. The following conclusions were obtained:

- a) When the cutting speed increases the surface roughness decreases above 150 m/min in high speed milling under MQL technique.
- b) From statistical analyses, it is clear that the process parameters, Cutting speed & feed rate have significant effects on the roughness parameter values.
- c) MQL Technique plays an important role to improve surface roughness on OHNS Steel.
- d) High speed milling was done under MQL Condition, maximum oil is saved which reduced the overall product cost

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