Influence of Lubricant Conditions on Surface Roughness (Ra) for Hard Turning Of AISI 4340 Steel

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Abstract:

In this article during the turning the AISI 4340 steel the effect of Dry, Wet and Solid lubricant is compared for average roughness (Ra). For solid lubricant boric acid is used and for liquid lubricant water and vegetable oil is used. Main purpose of this study is to find out the best lubricant for turning of AISI 4340 steel. The result of this experiment work shows that very less surface roughness is achieved in solid lubricant. It is also analysis that at cutting speed 100m/s, feed rate 0.12 and depth of cut 0.3 mm best finish is achieved with solid lubricant (boric acid in powder form).

Keywords: average Surface Roughness (Ra); Response Surface Methodology.

1. Introduction

Hard turning is a process in which hard material which have hardness above 45 HRC is machined with the help of single point geometrical tools [1]. To overcome the cost, is a challenge to the manufacturer of those components and manufacturer of goods. Grinding is a process which is used in industries but it involves expensive machinery and lengthy setup times, high manufacturing time, costly equipment's. In hard turning material removal rate is high that is why it is a fast process as compare to grinding hard turning process. [2].Hard turning is generally a replacement of grinding which is mostly used in automotive industries. As compared to grinding process the machining process preferred for good surface finish. CBN cutting tool insert, PCBN, Ceramic insert, coated carbide, etc. which is capable of machining the high strength materials with properly defined cutting edge. For hard turning the CBN insert recommended generally. because the CBN tools show toughness high as compared to other tools. During the ceramic phase the hardness and toughness loses in some CBN inserts grades and gain chemical phase. Chamfer angle is provided generally in these inserts for strengthen the cutting edge and avoid chipping and breakage [22].

2. LITRATURE

Diniz and Micaroni [2] used AISI 1045 steel bars with an average hardness 96 HRB along with the vegetable oil as cutting fluid with 6% water concentration. Cutting fluid used at different flow rates, (91 and 111 min^{-1}) and pressure 0.04 Mpa. Due to lubricant application on tool, the tool life improves as compare to dry cutting and also reduce the temperature formed during turning. In this [3] they used graphite and molybdenum disulphide in powder form having 2 µm average particle sizes as solid lubricants. It was found that the molybdenum disulphide used maximum time due to better results than graphite. Surface roughness value decreased 8% to 10% when graphite is used and 13% to 15% decreased due to molybdenum disulphide. Cutting forces were reduced when lubricants were applied from 1gm/min. to 2gm/min flow rate. Krishna et al. [4] concluded the insert defects and surface finish with powder form lubricants Graphite & boric acid. Kang He and Xu (2014) developed modeling technique for predicting surface roughness with the use of new HMM-SVM model based on Bayesian in hard turning. Steel with high hardness value are used as the work piece. Beatricea et al. (2014) discussed about the surface roughness with the use of cutting fluid solid form or liquid form through the ANN model in hard turning. cutting fluid parameters used, pressure at injector is 100 bar , rate of cutting fluid application 8ml/min. , composition of cutting fluid - 20% oil in water and frequency - 500 pulses/min. When the feed rate was 0.05 and cutting velocity was 115, the experimental result was 1.45 µm and according to ANN prediction 1.35 µm, the % error was 6.89. In this study, According to ANN model the accuracy is possible with smaller number of turning data. Shihab et al. (2014) AISI 52100 work material is used to investigate the cutting parameters in hard turning with the use of RSM (response surface methodology) and multilayer coated carbide insert. RSM (response surface methodology) is used for data collection and analysis. shows that, optimized value of cutting temperature from 566.593 ºC - 592.028 ºC at particular parameters. Cutting speed and feed rate are the major parameters for increasing the cutting temperature.

Bordin et al. (2014) investigated the effects of process parameters on surface integrity with longitudinal turning (hard turning) under dry conditions. The CoCrMo alloy with PVD coated TiAIN carbide tool were used for the study. For finished surface low feed rate is required. When cutting speed is 60 m/min. then the uniform surface profiles resulted. P. Paul et al. (2014) studied the tool wear with the use of magneto rheological fluid with minimal fluid application. Hard steel was used as material with is used in air craft engine, gear shafts etc. Viscosity of fluid increases as strength of magnetic field increases. It was found that the tool wear is reduced due to magneto rheological fluid with 75 µm size Ferro particles. Cutting forces also reduced up to 22.3% and 44.4 % improvement in surface finish.Ventura et al. (2015) used steel in dry machining with hardness 60 ± 2 HRC and length 200mm machined. The cutting edge analysis of high content CBN insert in hard turning was experimentally done. Tool performance with different edge geometries was discussed. The area contacted between cutting edge and work piece was minimum.

2. Experimental Detail

This chapter includes the material and methodology employed for the hard turning process of selected material. The experimental procedures and experimental data generated during the turning of AISI 4340 steel with cuszsed in details in this chapter. The selection of input parameters with their working range, cutting conditions, and details of instruments used in experimental process presented in this part of the thesis. Machining variables such as cutting force and surface roughness are influenced to a large extent by cutting parameters, as well as fixed geometric parameters such as approaching angle, rake angle and nose radius with different lubricant conditions. In order to minimize the machining time and hence the cost of machining in an industrial Environment there is a need for optimization of cutting parameters and cutting conditions.

In this study the AISI 4340 Steel with hardness 60 HRC is used for experimental work. There were three cutting parameters cutting speed, feed and depth of cut used with three cutting conditions dry condition, wet lubricant condition and solid lubricant condition. Design of experiments is based upon central composite designed by RSM methodology. In total twenty numbers of experiments have been conducted with one center experiment for each of the selected condition. Analysis of the machining variables under different cutting conditions has been carried out for material. Further, a comparison of various selected condition has been carried out with regard to machining variables by varying one or more than one cutting parameter at a time. Final results were analyzed by using analysis of variance (ANOVA).

2.2. Heat Treetment Process

Material is heated up to 830° C Temperature and quenched in an oil tank. After quenching process tempering process done to maintained the hardness 60 HRC. Tempering is done to avoid the cracks or stresses in material formed during the heating procces

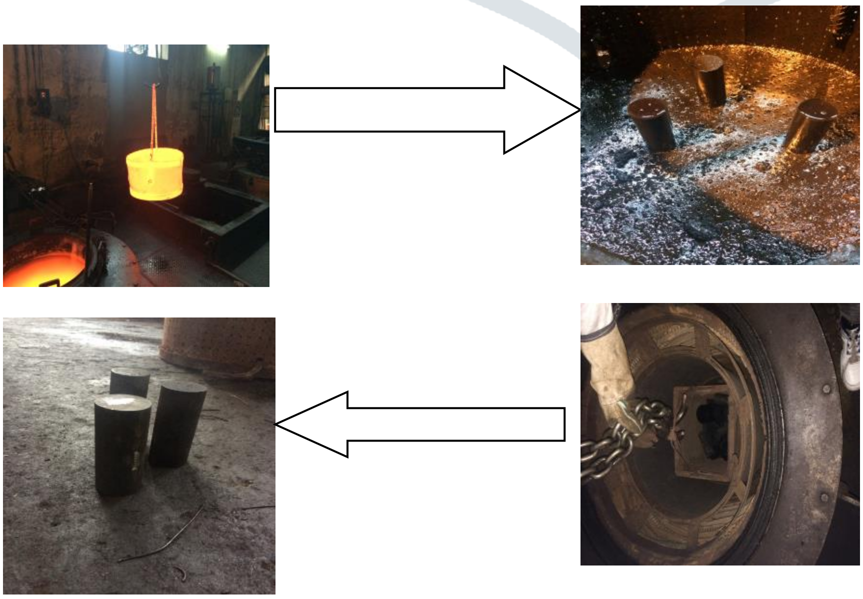

Figure 1. Hardening Process

2.3 Cutting Tool

Cutting insert used for this experimental work was CBN insert with specification CCMT0908. It is selected according to machine specification and tool holder. Tool specification is given in table 4.3.

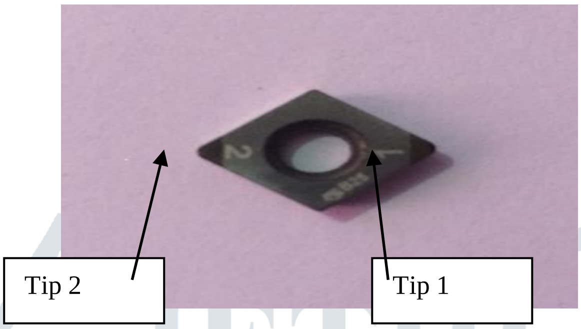

Figure 2 Cutting insert

Table 1. Cutting Tool Details

Insert type	CBN (cubic born nitride)
Insert shape	Rhombic
Insert specification	CCMT09
Nose radius	0.8 mm

2.4. Surface Roughness Analysis

The experiments were carried out according to the cutting conditions and cutting parameters. To specify the experiments Face-Centered Central Composite Design (FC-CCD) was used in Design Expert software (Version 8.0.).

2.5 Design Matrix for average Surface Roughness (Ra)

Table 2. Matrix for different cutting condition and average roughness with different lubricant

Sr. No.	Cutting Speed mm/s	Feed rate (mm/rev.)	Depth of cut (mm)	Average roughness at Dry Condition	Average roughness at Wet Lubricant	Average roughness at Solid Lubricant

1	100	0.04	0.1	0.22	0.25	0.21
2	100	0.04	0.3	0.57	0.66	0.5
3	100	0.08	0.2	0.44	0.52	0.38
4	100	0.12	0.1	0.45	0.51	0.41
5	100	0.12	0.3	0.88	1.1	0.68
6	125	0.04	0.2	0.32	0.38	0.28
7	125	0.08	0.1	0.25	0.3	0.22
8	125	0.08	0.2	0.39	0.47	0.33
9	125	0.08	0.2	0.39	0.46	0.33
10	125	0.08	0.2	0.39	0.47	0.33
11	125	0.08	0.2	0.39	0.47	0.33
12	125	0.08	0.2	0.39	0.47	0.33
13	125	0.08	0.2	0.39	0.47	0.33
14	125	0.08	0.3	0.58	0.66	0.52
15	125	0.12	0.2	0.62	0.71	0.55
16	150	0.04	0.1	0.18	0.19	0.19
17	150	0.04	0.3	0.49	0.56	0.44
18	150	0.08	0.2	0.37	0.44	0.32
19	150	0.12	0.1	0.35	0.44	0.28
20	150	0.12	0.3	0.71	0.78	0.66

3. Results and discussion

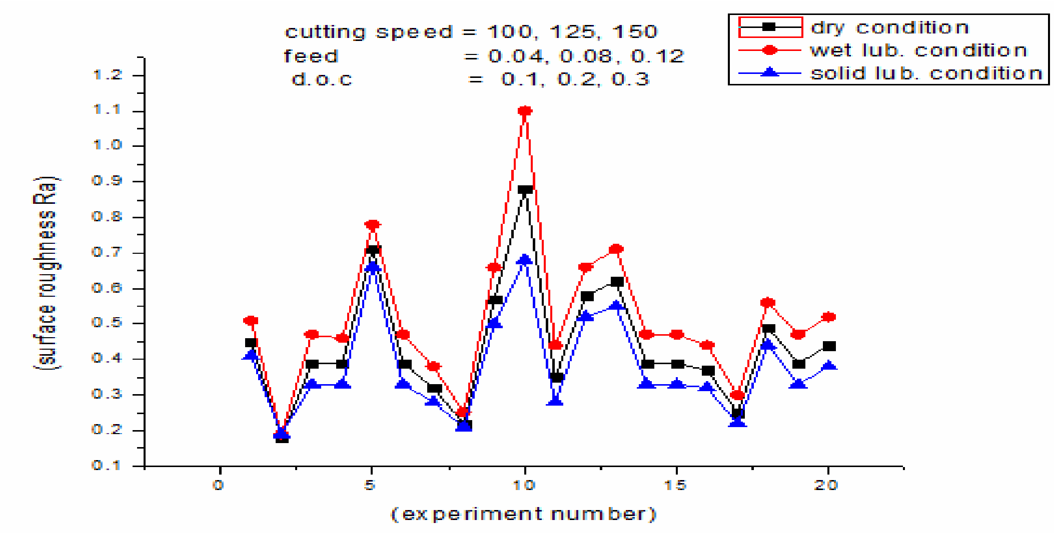

Figure 3. Surface roughness (Ra) dry, wet and solid lubricant conditions

As noticed in comparison plots the results shows hard turning in solid lubricant condition found better as compared to wet lubricant condition & dry condition. Due to the batter contact with cutting tool solid lubricant from very well in this experiment. According to study, powder form of solid lubricant, cutting forces reduced between work piece and cutting tool reduced during the turning operation as measured with Lathe tool dynamometer with software (XKM 2000). The material removes easily when boric acid as a solid lubricant used. During dry machining friction is increase very high due to that hindrance in the travel of cutting tool occur that produce uneven fracture of the chip and further roughness in increased . In wet lubricant cooling of the chip occur very past due to that thermal softening in reduce in the chip. This process again produces difficult fracture, due to that again roughness is increased.

4. Conclusion

surface roughness studied with the help of Surface Roughness Tester with Probe/Stylus. In this work the different lubricant conditions used (wet lubricant, solid lubricant). AISI 4340 Steel was used for study and cutting insert was double tip CBN (Cubic Boron Nitride). A comparison study done between dry cutting condition, wet lubricant and solid lubricant condition . The result of this experiment work shows that very less surface roughness is achieved in solid lubricant. It is also analysis that at cutting speed 100m/s, feed rate 0.12 and depth of cut 0.3 mm best finish is achieved with solid lubricant (boric acid in powder form).

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