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Experimental Investigation To Study The Effect Of The Cutting Fluid And Carbide Insert Shapes On Machining Of Aisi 4140

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***Abstract*— There are many machining parameters which affects the surface finish of product. One important machining parameter is the shape of the cutting tool and another one is the cutting condition (dry or wet). In this study, the performance of three different shapes of carbide inserts (triangular, round and square shapes) were investigated when turning AISI 4140 under wet conditions. Depth of cut, cutting speed and feed has been selected as the machining parameters for this study. Full factorial design was used for this experimental study. It has been observed that cutting tool shape and conventional cutting fluid has a great role in controlling the surface quality along with the other machining parameters.**

Index terms- Surface roughness, speed, feed, depth of cut and tool shape.

I. Introduction

The machining industries are interested for high material removal rates and high product quality by using greater cutting velocity and feed rates to achieve better productivity. It becomes extremely tough to attain these properties as the high cutting temperature produced in the cutting zone causes premature failure of cutting tools, which results in poor dimensional accuracy. In machining of parts, surface quality is one of the most specified customer requirements. Turning is a widely used machining process in which a single point cutting tool removes material from the surface of a cylindrical work piece. Most of the mechanical energy used to form the chip becomes heat, which generates high temperature in the cutting region. Due to the fact that, higher the tool work piece interface temperature, higher the surface roughness, the use of cutting fluids in machining processes has, as its main goal, the reduction of the cutting region temperature, either through lubrication and reduction of friction wear, and through a combination of these functions.

In today's world there are so many machining parameters controlling the quality of the product. Much attention has been payed to the other parameters such as tool coatings, tool wear and cryogenic cooling etc. But the factors like, tool shape and cutting conditions (dry or wet) has also influence on the surface finish of the work piece. Therefore, in the present study, an attempt has been made to investigate the effect of three different shaped carbide inserts (triangular, round and square insert) on the surface roughness of AISI 4140 under the application of conventional cutting fluid under the different machining conditions.

II. Related Work

Cutting fluids have been used in the machining processes with the purpose to improve the tribological characteristics of the work piece-tool-chip system. Increase in cutting velocity and feed for machining with high productivity is generally restricted by the elevated cutting temperature which causes rapid tool failure. In precision machining also, the major problem was the high cutting temperature, which damage the dimensional and form accuracy of the product, its surface integrity by inducing tensile residual stresses and surface and subsurface cracks.

A.R. Machado and J.Wallbanks (1997) compared the machining of steel under low quantity of lubricants with the traditional flood cooling. The low quantities were applied in a fast flowing air stream. The results showed that surface finish, chip thickness and force variation were all affected beneficially with the low coolant volume compared to flood cooling [1].

Z.Y Wang and Rajkurar K.P (2000) Presented an technique for machining of advanced ceramics with liquid nitrogen (LN2) cooled polycrystalline cubic boron nitride (PCBN) tool, titanium alloys, Inconel alloys, and tantalum with cemented carbide tools. With LN2 cooling, the temperature in the cutting zone was reducing to a lower range and the tool wear reduces significantly under all machining conditions. The surface roughnesses of all materials machined with LN2 cooling were found to be much less than the surface roughness of materials machined without LN2 cooling after the same length of cutting [2].

S.Paul, N.R Dhar and A.B Chattopadhay (2001) experimentally studied the role of cryogenic cooling by liquid nitrogen jet on tool wear and surface finish in plain turning of

AISI 1060 steel at various speed-feed combinations by two types of carbide inserts of different geometric configurations. The results have been compared with dry machining and machining with soluble oil as coolant. The results indicated substantial benefit of cryogenic cooling on tool life and surface finish [3].

R.F. Avila and A.M. Abrao (2001) compared the performance of three types of cutting fluids with dry cutting during continuous turning of the hardened AISI 4340 steel using mixed alumina inserts. The following parameters were evaluated: tool life, surface finish, tool wear mechanisms and chips form. The results indicated that, in general, the emulsions-based fluid (without mineral oil) and dry cutting gave the best results followed by synthetic fluid and emulsion containing mineral oil, both presenting similar results [4]

N.R. Dhar, S. Paul and A.B. Chattopadhyay (2002) investigated the role of cryogenic cooling by liquid nitrogen jet on average chip-tool interface temperature, tool wear, dimensional accuracy and surface finish in turning of AISI 4140 steel under various speed-feed conditions and it was found that surface roughness increases with feed but it was less than obtained with dry machining [5].

O.Cakir and M. Kiyak (2004) Studied the effects of cutting fluid, some gases applications and dry cutting on cutting forces, thrust forces, surface roughness, friction coefficient and shear angle in turning of AISI 4140 steel material. Nitrogen, oxygen and carbon dioxide gases instead of cutting fluid have been used and compared to wet and dry machining processes. Experiments have been performed at constant cutting speed for three different depths of cuts and feeds. The values of surface roughness were slightly closed [6].

C.Bruni, et. al. were focused on the effects produced by cutting operations on work piece surface finish and tool wear. Turning of AISI 420B stainless steel was carried out under wet, minimum quantity of lubricant and dry cutting conditions, using both conventional and wiper technology inserts. The work piece surface finish and tool wear versus cutting volume were measured and the results showed that the MQL technique generates the surface of good quality compared to traditional flood cooling technique and dry turning. The wiper inserts showed the best surface finish [7].

N.R. Dhar, M. Kamruzzaman and Mahhiudin Ahmed (2006) experimentally studied the role of MQL on tool wear and surface roughness in turning of AISI-4340 steel at different speed-feed combinations by uncoated carbide insert. The results include significant reduction in tool wear rate and surface roughness by MQL mainly through reduction in the cutting zone temperature [8].

N.R. Dhar, M.T. Ahmed and S. Islam (2007) Compared the mechanical performance of MQL and dry lubrication for the turning of AISI 1040 steel based on experimental measurement of cutting temperature, chip reduction coefficient, cutting forces, tool wears, surface finish and the dimensional deviation. Results indicated that the use of near dry lubrication leads to lower cutting temperature and cutting force, favorable chip-tool interaction, reduce tool wears, surface roughness and dimensional deviation [9].

M.Anthony Xavior and M.Adithan (2008) experimentally studied the effect of different lubricant environments during turning of the 6061 aluminum alloy with diamond-coated carbide tools. The effect of dry machining, minimum quantity of lubricant (MQL), and flooded coolant conditions were analyzed with respect to the cutting forces, surface roughness of the machined work-piece and tool wear. It was found that MQL condition proved better alternative than the flooded coolant/lubricant and dry turning conditions [10]

M. Anthony Xavior and M. Adithan (2009) investigated the influence of cutting fluids on tool wear and surface roughness during turning of AISI 304 with carbide tool. Further the influence of coconut oil in reducing the tool wear and surface roughness during turning process was studied, the performance of coconut oil was also being compared with another two cutting fluids namely an emulsion and a neat cutting oil. The results indicated that in general, coconut oil performed better than the other two cutting fluids [11].

B. Dilip Jerold and M. Pradeep Kumar (2011) compared the turning of the AISI 1045 steel under cryogenic carbon dioxide, dry and traditional cooling environment. Cutting temperature, cutting forces, chip disposal and surface roughness were the parameters analysed. The experimental results showed that the application of cryogenic Co_2 as the cutting fluid is an efficient coolant for the turning operation [12].

It is clear from the above mentioned literature that much work have been conducted on the surface roughness during dry turning and wet turning but few were reported to see the effect of turning of steel with different shaped carbide inserts under the presence of conventional cutting fluid. Therefore, in this research work, the effect of conventional cutting fluid during turning of AISI 4140 with three different shape carbide inserts has been studied.

III. EXPERIMENTATION

Experiments have been conducted to determine the effect of conventional cutting fluid on the surface roughness produced during turning of AISI 4140 steel. Three types of inserts shape were taken for experimentation keeping different cutting conditions and comparison is made between performance of three tool inserts (round, triangular and square). Turning tests were performed on LB-17 model HMT lathe machine. The work piece material AISI 4140 was heat treated to 25-30 HRC. The diameter and length of work piece were 80 mm and 600 mm respectively. This material has wide applications in manufacturing of axles, conveyor parts, sprockets etc. The chemical composition of the AISI 4140 is shown in table 1.

Table 1: Chemical composition of AISI 4140 (%)

C%	Si%	Mn%	P%	S%	Cr%	Mo%	Ni%
0.425	0.269	0.644	0.14	0.18	1.31	0.251	0.050

The cutting tools used in the present study were round insert (RNMA160408S01225), triangular insert (TNMA160408S1525) and square insert (SNMA1608S01525). The tool holders (WIDAX, 9B, PBGCR) were used in the study. In this study four input parameters and one output parameters were taken.

Input paramaeters:

- Cutting Speed (m/min) – 35 to 88.
- Feed (mm/rev) - 0.1 to 0.15.
- Depth of cut (mm) – 0.5-2.5.
- Length of Cut (mm) – 20.

Output parameter:

- Surface roughness (µm)

The surface roughness of workpiece was measured with mutitoyo type surface roughness tester at three different locations and a average value of surface roughness was taken. The experimental set up is shown in Fig. 1.

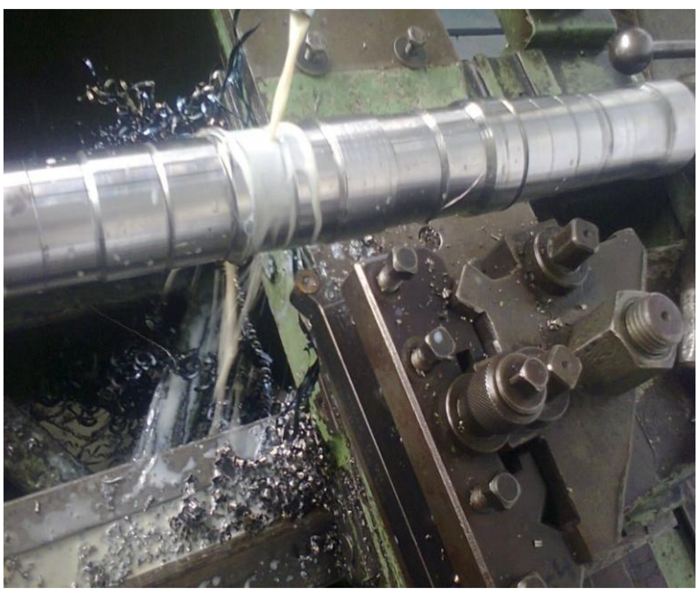

Figure 1

iv. RESULTS AND DISCUSSION

The main goal of the work presented in this paper was to study the effect of conventional cutting fluid during machining of AISI 4140 material with three different shaped carbide inserts. The observations obtained when turned at various depths of cuts, speeds and feeds were shown in Table 2, Table3 and Table 4, same were plotted on Fig.2, Fig.3 and Fig.4.

Table 2: Machining of AISI 4140 with Triangular insert

Run No.	Depth of cut (d) (mm)	Cutting speed (v) (m/min)	Feed (f) (mm/rev)	Surface roughness (R_a) (µm)
1	0.5	55	0.125	1.45
2	1.0	55	0.125	1.32
3	1.5	55	0.125	1.10
4	2.0	55	0.125	1.0
5	2.5	55	0.125	0.98
6	1.5	35	0.125	1.65
7	1.5	44	0.125	1.89
8	1.5	55	0.125	1.77
9	1.5	70	0.125	1.65
10	1.5	88	0.125	1.63
11	1.5	55	0.1	0.85
12	1.5	55	0.113	0.90
13	1.5	55	0.125	1.10
14	1.5	55	0.138	1.32
15	1.5	55	0.15	1.47

Table 3: Machining of AISI 4140 with square insert

Run No.	Depth of cut (d) (mm)	Cutting speed (v) (m/min)	Feed (f) (mm/rev.)	Surface roughness (R_a) (µm)
1	0.5	55	0.125	2.26
2	1.0	55	0.125	1.52
3	1.5	55	0.125	1.11
4	2.0	55	0.125	0.92
5	2.5	55	0.125	0.85
6	1.5	35	0.125	4.81
7	1.5	44	0.125	3.78
8	1.5	55	0.125	3.16
9	1.5	70	0.125	1.28
10	1.5	88	0.125	0.68
11	1.5	55	0.1	1.18
12	1.5	55	0.113	1.15
13	1.5	55	0.125	0.98
14	1.5	55	0.138	0.76
15	1.5	55	0.15	0.65

Turning was carried out under different cutting conditions; results obtained after turning are shown in table 2 which was plotted in Fig 2. It is clear from Table 2, Table 3 and Table 4 that surface roughness decreases 68% when machined with triangular insert with the increase of depth of cut from 0.5mm to 2.5 mm. Same trend was obtained when machined with square insert (62% decrease in surface roughness) and when machined with round insert surface roughness decreases by 87%. As change in depth of cut does not contribute to the change in height of surface irregularities and hence the surface roughness but this behavior of decreasing surface roughness with increase of depth of cut may be attributing to large nose radius.

The surface roughness decreases 1% with triangular insert, 86% with square insert and 77% with round insert when cutting speed increases from 35m/min to 88m/min as shown in Fig. 3. It may be due to the properties of metals are influenced by the deformation velocity. The higher the velocity, the less Significant the plastic behavior will be, lesser the lateral plastic flow and thus less additional increase in the peak-to-valley height of the machined surface roughness. Moreover, with the increase in cutting speed there was reduction in the cutting forces that leads to the minimal vibration during machining and there was decrease in surface roughness value.

The effect of feed was obvious on surface roughness as seen in Fig.4, for the triangular and square insert. Surface roughness greatly increased by rising feed because feed was directly proportional to the square of surface roughness, but in case of round insert surface roughness decrease 48% , this behavior may be due to the large nose radius of round insert as compared to the other two's.

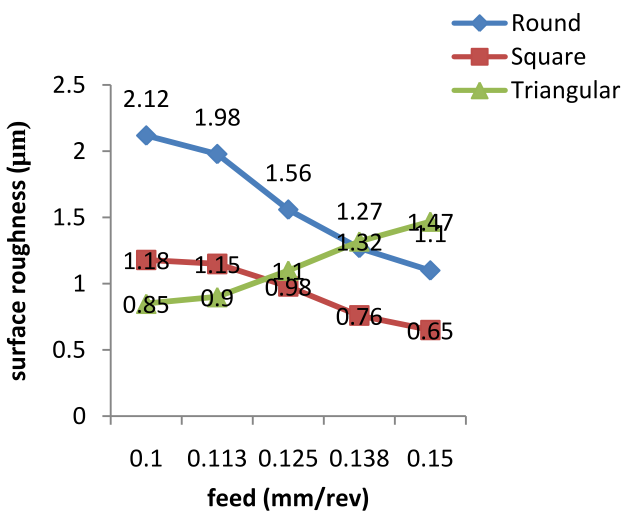

Figure2: surface roughness vs.feed.

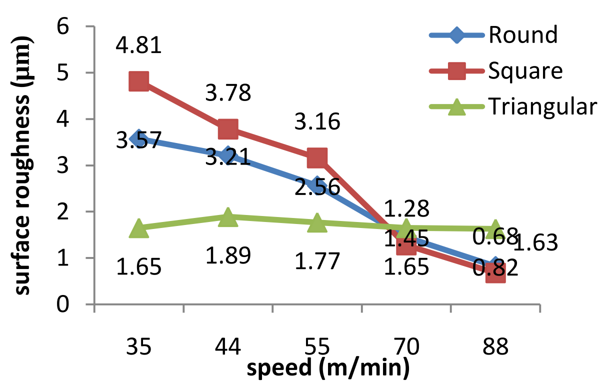

Figure 3: surface roughness vs. speed 1

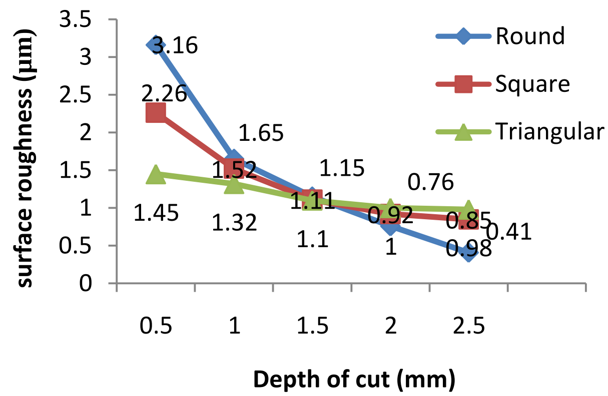

Figure 4: Surface roughness vs. DOC

Table: Machining of AISI 4140 with round insert

V. Conclusions

Run. No.	Depth of cut (d) (mm)	Speed (m/min)	Feed (mm/rev.)	Surface roughness (R_a) (μm)
1	0.5	55	0.125	3.16
2	1.0	55	0.125	1.65
3	1.5	55	0.125	1.15
4	2.0	55	0.125	0.76
5	2.5	55	0.125	0.41
6	1.5	35	0.125	3.57
7	1.5	44	0.125	3.21
8	1.5	55	0.125	2.56
9	1.5	70	0.125	1.45
10	1.5	88	0.125	0.82
11	1.5	55	0.1	2.12
12	1.5	55	0.113	1.98
13	1.5	55	0.125	1.56
14	1.5	55	0.138	1.27
15	1.5	55	0.15	1.10

Increase in cutting velocity and feed for machining with high productivity is generally restricted by the elevated cutting temperature which causes rapid tool failure. In precision machining also, the major problem was the high cutting temperature, which impairs the dimensional and form accuracy of the product, its surface integrity by inducing tensile residual stresses and surface and subsurface cracks. Cooling and lubrication in machining are important in reduction the severity of the contact processes at the cutting tool-work piece interface. Following conclusions withdrawn from experimentation studies:

1. Higher feed rates lead to generation of higher surface roughness with triangular and square insert but it decreases with round insert may be due to large nose radius of round insert.
2. When cutting speed increases, surface roughness decreases in every case due to the fact that more cutting speed leads to the less plastic deformation and less cutting forces.
3. Higher depth of cut leads to less surface roughness may be due to the more nose radius of triangular, square and round insert.

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Author Profile

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