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An Investigation into the Evaluation of Tool and Thermal Characteristics for Optimization of Process Parameters in Machining Tool Steel

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***ABSTRACT*—**Turning is a machining process in which a cutting tool, typically a non-rotary tool bit, describes a helix toolpath by moving more or less linearly while the workpiece rotates.Machining of High Carbon High Chromium steel (HCHCr) is a challenge for production engineers in tool industry. In this research paper, a study on turning HCHCr Steel using tungsten carbide tool inserts is made by varying depth of cut, the cutting and feed rate speed one each at a time and keeping other two constant. The effect on process parameters like surface finish, material removal rate, tool wear, Cutting force, thrust force and temperature distribution on tool tip are discussed.

***Index Terms*—Turning process, HCHCr Steel, Uncoated and Coated Tungsten Carbide Tool inserts**

1. INTRODUCTION

While manufacturing the manufacturers mainly focus on the product dimensional accuracy and surface finish. Early researchers have tried to reduce wear rate of tool by selecting the Feed, The selected input parameters for turning composites are depth of cut and cutting Speed and surface roughness is the output response parameter.[1-2]

Tool wear and surface roughness are the effects of cutting speed and feed rate to optimize in machining conditions for turning the AISI-4140 using for the TiN coated carbide inserts are presented [3-4]

Singh and Kumar et al have studied on optimization of feed force through setting of optimal value of process parameters namely feed rate, cutting speed and depth of cut in turning of EN-24 steel with TiC coated tungsten carbide inserts[5-6]. Taguchi's parameter design have used by the authors [7-8] and concluded that the effect of feed rate and depth of cut in variation of feed force were affected more as compare to cutting speed related to surface finish[9-10].

Dr. Srikantappa. A.S has studied performance evaluation of wire EDM process in cutting HCHCr die steel. [11].

It observed that much research work has not been carried out on turning of HCHCr die steel and optimization of machining conditions from the literature survey. Work experiments have been carried out in this present research with an objective of determining optimum machining Manuscript received August 27, 2018.

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Conditions for turning HCHCr steel by using uncoated tungsten carbide cutting tool inserts.

The authors in this paper have made an attempt to determine the machining characteristics suitable to obtain required characteristics for HCHCr die steel. In modern industry multi point cutting tool inserts are widely used for machining operation in general and turning operation in particular. In this present research work Tungsten carbide tipped tool inserts were used for cutting work material.

2. EXPERIMENTATION

Under dry cutting conditions machining tests are performed by varying depth of cut, cutting speed and feed rate on HCHCr Steel using tungsten carbide tipped and diamond shaped tool inserts. Tool wear, material removal and cutting force and temperature distribution are the effect of these parameters on surface roughness of work material and are analysed.

Figure 1 shows the experimental setup used to conduct machining tests on HCHCr Steel using diamond shaped tipped tool inserts. Lathe tool dynamometer with transducer setup for the measurement of Cutting force and thrust force thermocouple setup for temperature measurement attached to the tool tip is fitted on the lathe to conduct the turning experiments

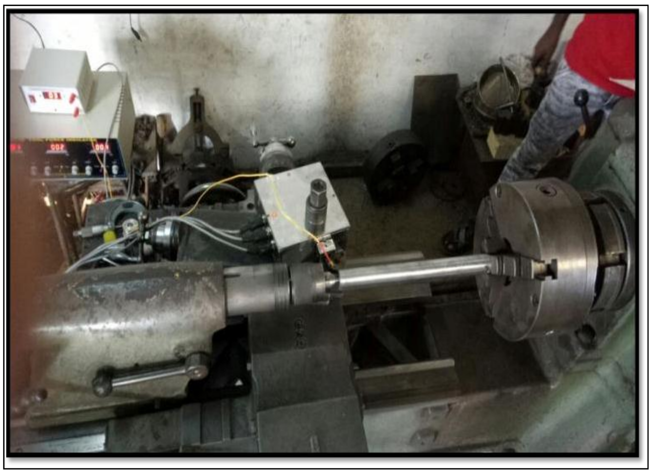

Fig 1. Lathe, thermocouple and lathe tool dynamometer experimental setup.

For conducting the turning experiments HCHCr-High Carbon High Chromium Die Steel is used as the work material. Under different machining conditions such as depth of cut, feed rate and cutting speed we have used 32mm diameter 250mm length bars to conduct turning experiments.

The experiments are conducted by varying the machining parameters such as speed, the feed and depth of cut for turning the HCHCr die steel and the process parameter like material removal rate surface finish, tool wear, and tool temperature are determined as follows.

- Forces acting on the cutting tool inserts are recorded with the help of lathe tool dynamometer.
- Surface finish is measured using Perthometer.
- Tool wear viz flank wear is measured using tool maker's microscope.
- By dividing the weight of metal removed by machining time the material removal rate (MRR) is found out.
- Tool tip temperature is measured using thermocouple setup.

3. RESULTS AND DISCUSSION

The experimental results obtained are plotted and analysed.

Machining processes generate a wide variety of irregularities on the surface of work piece. These irregularities are in the form of finely spaced marking (pattern) left by the cutting tool on the work piece surface. In the simple words, the finish obtained on the work piece surface after machining is not perfectly smooth. The term surface finish, or texture or surface roughness is used to indicate the local deviations of a work surface from the perfectly flat ideal face. The Perthometer used to measure the surface finish of the work material after turning. The surface finish is measured in microns.[12]

From Figure 2 it is seen that the surface finish improves with increased depth of cut at higher feed rates conditions at the cutting speed of 11.46m/min.. The surface finish deteriorates with increased depth of cut at moderate feed rate conditions. The surface finish is constant at lower depth of cut for moderate feed rate conditions.

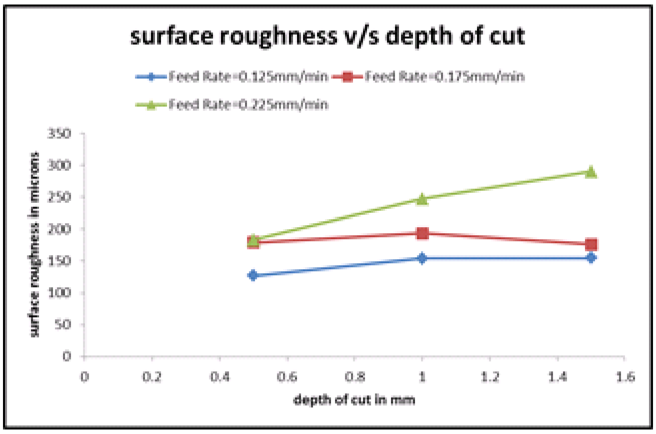

Fig. 2. Variation of Surface Finish with depth of cut for cutting speed of 11.46m/min.

Figure 3 shows that the surface finish improves at higher depth of cut and remains constant at lower depth of cut conditions at lower feed rate conditions at the cutting speed of 20.10 m/min. The surface finish improves with increased depth of cut at higher feed rate conditions. The surface roughness increases at lower depth of cut but remains constant at higher depth of cut conditions for moderate feed rate conditions.

Figure 4 gives the variation of material removal rate increase in depth of cut for different feed rate conditions at the cutting speed of 11.46m/min. Material removal rate increases gradually with increase in the depth of cut for lower feed rate conditions. At higher feed rate the material removal rate will increases at higher rate with increased depth of cut.

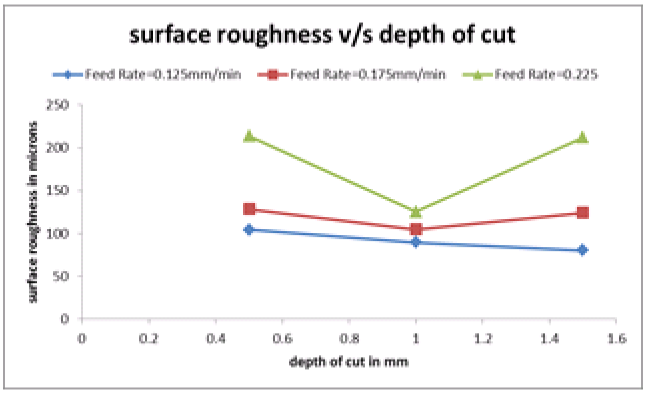

Fig. 3. Varying depth of cut of cutting speed 20.10m/min by variation of surface roughness.

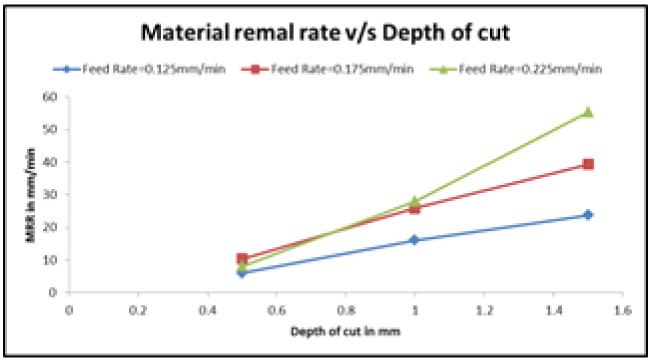

Fig. 4. Varying depth of cut at speed of 11.46m/min by variation of material removal rate .

The material removal rate is measured by recording the weight of the work material before and after machining with respect to time. Weighing scale compares masses by balancing the weight due to the mass of an object against the weight of one or more known masses.

The weight is noted. Similarly for different trails the weight is measured by which the weight of the work piece is measured before the machining and after the machining,.

The increase in material removal affects on the surface obtained on the turned work surface and the flank wear of the tungsten carbide tipped tool insert used for turning HCHCr Steel. The physical contact between the tool tip and the work piece causes friction and generation of temperature in the interface in the turning operation,. This will affect on the properties of the work material and results in nonlinear behavior of the material in turning.

Figure 5 gives the variation of the material removal rate increase in depth of cut for different feed rate conditions at the cutting speed of 20.10m/min. The Material removal rate increases by gradually increase in the depth of cut. At higher feed rate the material removal rate will increases and also for lower the feed rate slow increase in material removal rate for different depth of cuts.

Figure 6 gives the variation of tool wear by increase in depth of cut for different feed rate conditions at the cutting speed of 11.10m/min. As depth of cut increases which increases temperature therefore tool wear also increases. For higher feed rate tool wear will increases till the moderate depth of cut and gradually decreases.[13]

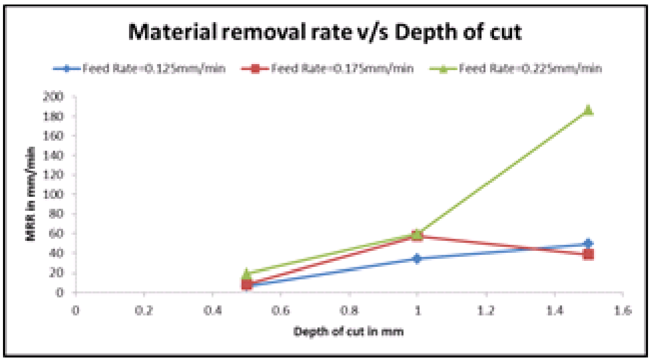

Fig. 5. Variation of material removal rate by varying depth of cut at 20.10m/min.

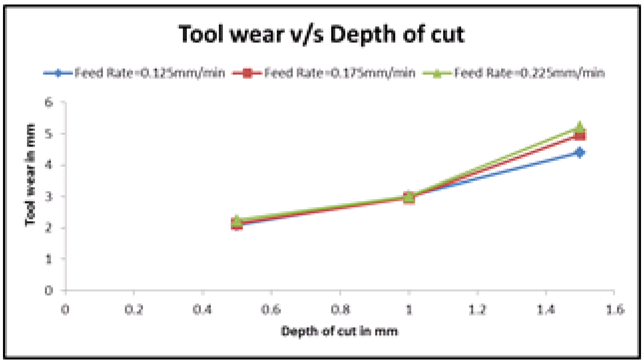

Fig. 6. Variation of Tool wear by varying the depth of cut at 11.46m/min.

The variation of tool wear by increase in depth of cut for different feed rate conditions at the cutting speed of 20.10m/min is given by Figure7. For the higher feed rate tool wear will increases till the final depth of cut. Depth of cut and temperature mainly depends on tool wear, by graph we found that tool wear is also depends on feed rate. Some conditions of material the properties are changes so tool wear also changes.

To measure the flank wear of the Tungsten Carbide Tool inserts we have used tool makers microscope in our experiment. The turning of the HCHCr Work material leads to wear on flank side of tungsten carbide tool inserts. In order to measure the length of the flank wear the tool maker's microscope is a versatile instrument that measure by optical means with no pressure being involved, thus very useful for measurement on small and delicate parts.

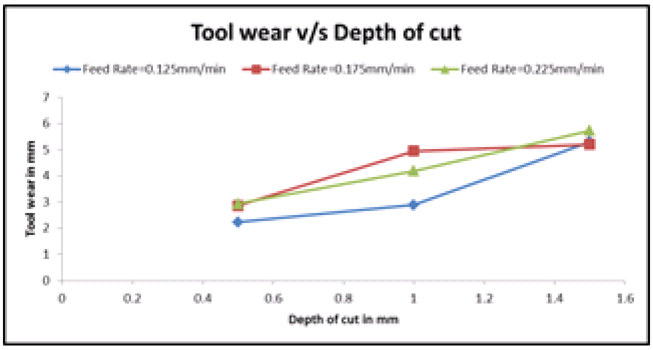

Fig.7. Variation of Tool wears by varying the depth of cut at 20.10m/min.

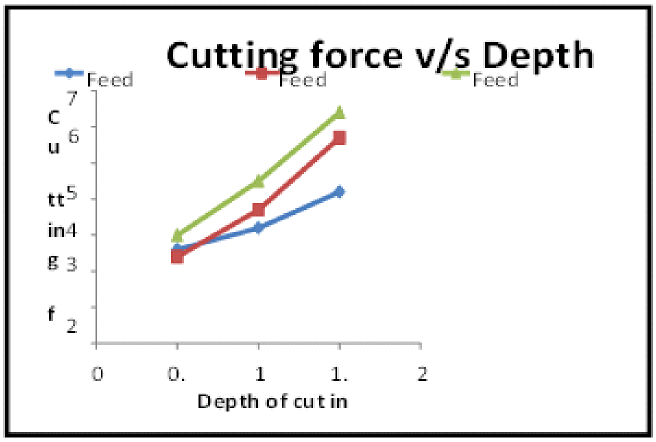

Fig. 8. Variation of cutting force by varying depth of cut at 11.46m/min.

The resultant cutting force acting on the tool tip may be resolved into three components, they are Feed force acting in horizontal plane, but in the direction opposite to the feed, then thrust force acting in the direction perpendicular to the generated surfaces, and main force called cutting force acting in the direction of the main cutting motion. The largest in magnitude to the vertical force which in turning is about 2 or 3 times larger than thrust force and from 4 to 10 times larger than the feed force. The force acting on the chip in orthogonal cutting are shear force which acts on shear plane. It is the resistance to the shear of metal in forming the chip, normal force is normal to the shear plane. This is the backup force on the chip provided by the work piece and Frictional resistance of the tool acting downward against the motion of the chip as it moves upwards along the tool force.

The variation of cutting force by increase in depth of cut for different feed rate conditions at the cutting speed of 11.46m/min is given in Figure 8. Cutting force will be more for higher feed rate, similarly for lower feed rate cutting force will be low. By increasing depth of cut for a material cutting force increases.

The variation of cutting force by increase in depth of cut for different feed rate conditions at the cutting speed of 20.10m/min is given in Figure 9. Cutting force will be more for higher feed rate, similarly for lower feed rate cutting force will be low. Cutting force increases by increasing depth of cut for a material.

Different feed rate conditions at the cutting speed of 11.10m/min is given in Figure 10.

When the depth of cut increases the Temperature also increases gradually. For higher feed rate temperature will be higher at tool tip. For exact value of an temperature at the time of machining wait for few feed rate.

The variation of temperature increase in depth of cut for different feed rate conditions at the cutting speed of 20.10m/min is given in Figure 11. Temperature increases gradually by increase in the depth of cut, at final depth of cut there will be a decrease in temperature for all feed rates. For feed rate 0.175mm the temperature will be higher at tool tip.

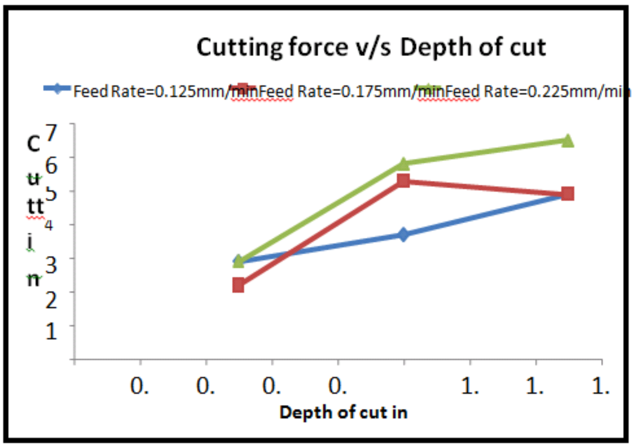

Fig. 9. Variation of cutting force by varying depth of cut at 20.10m/min.

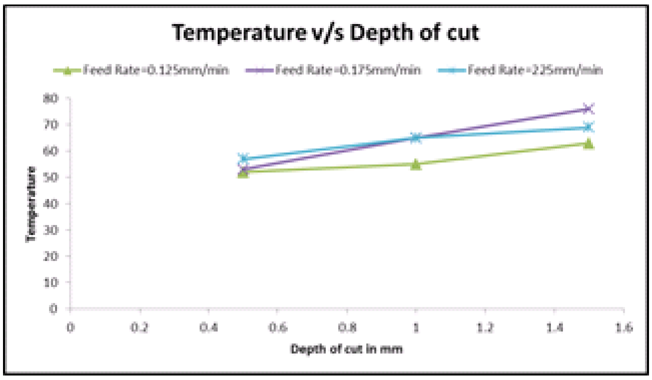

Fig. 10. Variation of Temperature by varying depth of cut at 11.46m/min.

The Tool-Work thermocouple was used to measure. The temperature at the cutting point of the tool. The objective of this experiment was to compare the temperature generated during machining at uncoated tungsten carbide cutting tool. The machining tests were conducted by varying the cutting speed, depth of cut and feed rate. In this experiment, turning insert and work piece were insulated from the lathe machine by using holders.

A thermocouple is an electrical device consisting of two dissimilar electrical conductors forming an electrical junction. The main limitation with thermocouples is accuracy; system errors of less than one degree Celsius (°c). The varying temperature of the tool inserts is read by connecting the thermocouple.

A digital thermocouple instrument is used to measure the tool tip temperature during turning operation. A wire from the instrument is connected to the tip of the Tungsten carbide tool insert. The temperature rise in the tool during turning operation is recorded for different machining conditions and analyzed.

The variation of temperature increase in depth of cut for

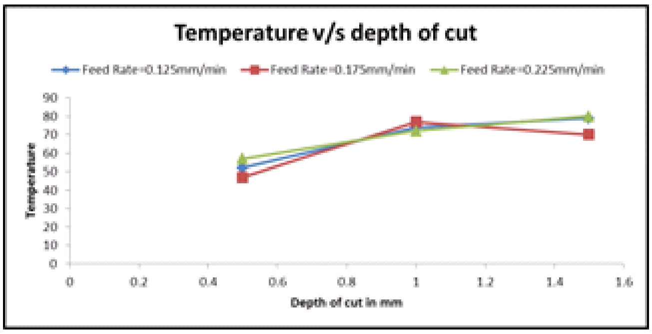

Fig. 11.Variation of Temperature by varying depth of cut at 20.10m/min.

4. CONCLUSIONS

The following conclusions are made from the evaluation of the experimental results.

The surface finish improves with increase in depth of cut and remains same at higher depth of cut conditions. The surface finish quality will be good with increase in cutting speed.

The material removal rate increases gradually at lower depth of cut conditions but increases rapidly at higher depth of cut conditions. The increase in feed rate will increase the material removal rate.

The temperature at the tool tip increases with increase in depth of cut and feed rate conditions. The rate of temperature raise is minimum at higher cutting speed conditions.

The flank wear of the tungsten carbide tipped tool increases with increase in depth of cut. The rate of flank wear will be lower at higher feed rate conditions. The tool wear rate will be minimum at higher cutting speed condition.

The cutting force exerted on the tool tip increases with increase in depth of cut. The rate of increase in cutting force increases with increased feed rate at higher depth of cut conditions.

The thrust force increases with increase in depth of cut at lower cutting speed conditions but remains constant at higher cutting speed conditions. The rate of thrust force increases with increased feed rate.

For better surface finish with higher material removal and lower tool wear the machining conditions can be obtained from the thorough analysis of the experimental results plotted for different depth of cut, feed rate conditions under varying cutting speed conditions of the tool material used for turning HCHCr steel.

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Dr. Srikantappa A S was honoured by Taluk Kannada Sahitya Parishat Srirangapatna recognising his services in the field of education and Honoured with Best Teacher Award by District Kannada Sahitya Parishat Mandya recognising his services in the field of education.

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