Effects of Cutting Fluids and Machining Parameter on Turning of Mild Steel

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Abstract— The purpose of this paper is to study the effect of machining parameters like spindle speed, feed rate and depth of cut under the dry and wet machining condition. The experiment was conducted in centre lathe for different machining conditions with dry and two types of cutting fluids. For the experimentation the machining is done with two cutting tool (HSS and Carbide tip tool) with mild steel (AISI 1018) as working material. The selection of proper machining parameters with proper cutting fluids will increase the tool life and will result in good surface finish on the material. Hence the temperature of tool tip-work piece interface was examined at different spindle speed, feed rate and depth of cut with soluble oil and palm oil as cutting fluid. Here in the experiment, an attempt is made to analyse the tool tip temperature at different machining condition by using fluke infrared thermometer with dry and wet machining.

Keywords— Mild Steel, Spindle Speed, Depth of Cut, Feed rate, Cutting Fluids, Tooltip Temperature.

I. INTRODUCTION

Machining process is versatile process, have vital role in engineering industry. The mild steel AISI1018 find wide application in manufacturing, like to manufacture Nut and bolts, Axels of automobiles, shafts, gears-pinions etc. Lathe machine is a traditional machine used to produce the shafts, bearing, threading from cylindrical part. The cost effectiveness all machining process is essential for the growth of industry, which affects on the selection of suitable machining parameters like spindle speed, feed rate, depth of cut, cutting tool, work piece material and also proper cutting fluids. Selection optimum machining parameter resulting in longer tool life, higher material removal rate and good surface finish.

The main factor during the machining process is friction which will be developed between tool-work piece and chip- cutting toll interface, resulting in high temperature and produce large heat. This results in poor machining quality of work and also reduces the toll life. These condition is more prominent when use of hard material or material which is difficult to machine. There are several methods are reported to reduce the tool- work piece interface temperature or to reduce the heat generation. This can be achieved by choosing coated cutting tool, but which is expensive. Due to this reason the cutting fluids are used to reduce the heat generation between the tool- work piece interfaces. This also helps to carry the chips along with it and cause higher material removal rates, increase the tool life. If the machining is involved with dry condition, the surrounding air will not able to carry the heat away in case of large speed and depth of cut. Hence a proper cutting fluid is used to reduce the heat generation.

The important requirement of good cutting fluid is to provide the proper lubrication to reduce the friction between tool and work piece and also to prevent the thermal damage like cracks. For higher machining operations, cooling is the main function of cutting fluid, hence fluid with good cooling property must be selected. In this experiment an attempt is made to determine the tool tip temperature at different machining condition. The temperatures are recorded at different spindle speed, different depth of cut and different feed rate. The machining operation carried at dry and wet condition by using soluble oil and palm oil as coolant. The temperature at the cutting tool- work piece were analysed with two tool, High Speed Tool and Single point Carbide tip tool by using fluke infrared thermometer.

Considerable heat is generated at the cutting edge of the tool due to friction between tool and work, and the plastic shearing of metal in the form of chips, when the tool is machining metal on a machine tool. The heat is evolved in three zones as shown in Fig 1.

![Fig 1 Evolution of heat at three zones](image-url)
practically all of this heat is carried away by the chip as machining is rapid and continuous process. Avery minor portion of this heat (5-10%) is conducted to work piece. In friction zone, the heat is generated mainly due to friction between moving chip and tool face and partly due to secondary deformation of the built up edge. In work-tool contact zone, the heat is generated due to burning friction and the heat in this zone goes on increasing with time as the wear land on the tool develops and goes on increasing. It will be noted that each of these three zones leads to rise of temperature at the tool chip interface and it is found that the maximum temperature occurs slightly away from the cutting edge, and not at the cutting edge.

II. METHODOLOGY/ EXPERIMENT SET UP

For the Experimentation, two of the cutting fluids (Palm oil and soluble oil) with the cutting tools (Tungsten carbide and HSS) and the work piece (mild steel) were obtained from the workshop. The experiment was carried out on a center lathe machine. The work piece was placed into the 3-jawchuck and the jaws were tightened by chuck key until the jaw start to grip the work piece. The HSS Tool was tightly clamped in the tool holder for the machining the work piece. The angle of the tool holder was adjusted so that the tool was almost perpendicular to the side of the work piece. The cutting speeds were set to 285, 460, 725 rpm. The feed rate is adjusted in the lathe for 0.22 mm/rev and 0.35mm/rev. The process was repeated continuously until a certain diameter for the workpiece was reached. The diameter of the workpiece was also determined using a vernier caliper. These steps were repeated for different depth of cut and subsequent cutting fluids. The same machining is carried out with tungsten carbide tip cutting tool. The cutting temperatures were also taken at regular interval of cutting in fluke infrared thermometer. The experimental set up is shown in fig 2.

A. Work piece material

The present investigation mild steel of initial diameter Ø30mm and length 100mm is used in plain turning

- Mild Steel is a type of steel that contains only a small amount of carbon and other elements. It is softer and can be shaped more easily than higher carbon steels.
- Some mild steel properties and uses:
  - Mild steel has a maximum limit of 0.2% carbon. The proportions in mild steel is of 1.65% manganese, 0.6% copper and 0.6% silicon are fixed, while the proportions of cobalt, chromium, niobium, molybdenum, titanium, nickel, tungsten, vanadium and zirconium are not.
  - A higher amount of carbon makes steels different from low carbon mild-type steels. A larger amount of carbon makes steel stronger, harder and stiffer than low carbon steel. However, it reduces the machine ability.
  - Mild steel is the cheapest and most common form of steel and serves all application which requires a bulk amount of steel.

B. Cutting Tool (HSS and Tungsten Carbide Tip Tool)

The term ‘high speed steel’ was indicates that it capable of cutting the metal at a much higher rate than carbon tool steel and continues to cut and retain its hardness even when the point of the tool is heated to a low red temperature. Tungsten is the major alloying element but it is also combined with molybdenum, vanadium and cobalt in varying
amounts. Even in carbide tip tool can be cut at higher depth of cut than the HSS tool. In this paper mild steel is used as work piece and single point HSS and carbide tip tool is used to turning operation on a lathe machine having different lathe speed taken into account.

The machining conditions are given below in the tables.

Table: 1 Experimental conditions

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed(rpm)</td>
<td>285, 460, 725</td>
</tr>
<tr>
<td>Depth of cut(mm)</td>
<td>0.5, 0.7, 0.9, 1.1, 1.3</td>
</tr>
<tr>
<td>Feed(mm/rev)</td>
<td>0.22, 0.35</td>
</tr>
</tbody>
</table>

Table: 2.2 Cutting Variables

<table>
<thead>
<tr>
<th>Cutting fluid used</th>
<th>Soluble oil, vegetable oil(palm oil)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material used</td>
<td>Mild Steel</td>
</tr>
<tr>
<td>Cutting Tool</td>
<td>Single point HSS, Tungsten Carbide tip tool</td>
</tr>
</tbody>
</table>

III. RESULTS & DISCUSSIONS

Fig 4. Graph of temperature variation during cutting using HSS cutting tool (Depth of cut=0.9mm)

Fig 5. Graph of temperature variation during cutting using HSS cutting tool (Depth of cut=1.3mm)

Fig 6. Graph of temperature variation during cutting using Tungsten carbide tool (Depth of cut=0.9mm)

Fig 7. Graph of temperature variation during cutting using Tungsten carbide tool (Depth of cut=1.3mm)

Fig 8. Graph of temperature variation during dry machining with 285 rpm

Fig 9. Graph of temperature variation during dry machining with 460 rpm
The hardness of HSS tool will start to reduce after 250°C. The maximum working temperature of HSS is about 500°C. Currently, HSS produced by powder metallurgy (HSS-PM) offers a higher content of alloy elements and a combination of unique properties: higher toughness, higher wear resistance, higher hardness and higher hot hardness. However, for machining of tempered steels and very difficult-to-cut alloys HSS is not the first choice; tungsten carbide is a more recommended tool material. Heat and oxidation resistance - Tungsten-base carbides perform well up to about 700°C in oxidizing atmospheres. Thermal Conductivity - Tungsten carbide is in the range of twice that of steel and carbon steel.

As from the graphs, it can be seen that the cutting tool temperature reduced by using cutting fluids. From fig 4, it is shown that the maximum temperature of 327°C is recorded in dry machining at 725 rpm, 0.35 mm/rev feed rate and 0.9 mm depth of cut which reduce the tool life as its hardness becomes less after 250°C. This machining leads burnt chips and effects on the surface roughness of the work material. With use of cutting fluid the temperature is reduced to 184°C in soluble oil and 186°C in palm oil hence this machining can be preferred. From the fig 3.2, the dry machining at 720rpm leads to 368°C temperature and even use of soluble oil given 272°C and 460rpm are preferred as the temperature at the tool tip-work piece interface is less than 250°C. From fig 4 and fig 5 it is observed that the soluble oil be the good cutting fluid compare to the vegetable palm oil as it gives the less temperature than at palm oil.

From the fig 6 and fig 7 the dry machining with carbide tip tool had given higher temperature in both 0.9mm and 1.3mm depth of cut. Even though carbide tip performs well till 700°C, the machining with 460rpm and 725rpm, with 0.9mm and 1.3 mm depth of cut results in poor surface finish on the work piece due to deformation of material. Whereas use of soluble oil as cutting fluid results in greater reduction in temperature at all the speed and depth of cut due to higher thermal conductivity of carbide tip tool material which conducts heat through the cutting fluids, when compare to HSS tool. With carbide tip tool, two types of fluids the material can be machined at all speed (285rpm, 460rpm, 725rpm) and 0.9mm and 1.3 mm depth of cut with 0.35 mm/rev feed rate as it gives cutting tool temperature less than 200°C. Comparing with HSS and Tungsten Carbide tip with cutting fluids, while machining the carbide tip shows good tool life at higher rpm and higher depth of cut.

Fig 8 shows the dry machining at 285rpm with 0.22mm/rev and 0.35mm/rev feed rate with different depth of cut, and these machining is preferable as the
temperature less than 200 °C and will not affect much on the tool life, while in fig 3.7, 725 rpm is not recommended as the temperature cause work piece roughness and tool tip become burnt during the turning operation. From fig (9, 10, 11) it is observed that the tungsten carbide with soluble oil and palm oil as coolant would given less temperature hence be recommended for all the machining parameter mentioned above.

IV. CONCLUSIONS

The following conclusions could me made on the basis of experiment

- This paper provides us information about the effect of temperature using various cutting parameters like different speed, feed rate and depth of cut.
- This paper provides us information about the effect of temperature using dry machining, machining with soluble oil and palm oil.
- The maximum temperature reduction is obtained with Soluble oil at all the cutting parameters compared to palm oil and dry machining.
- The selection of cutting fluids for machining processes generally provides various benefits such as longer tool life, higher surface finish quality and better dimensional accuracy. These results also offer higher cutting speeds, feed rates and depths of cut.

REFERENCES

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