ERRORS AND ITS REMEDY OF TOOL SETTING IN TURNING OPERATION

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ABSTRACT
All the manufacturing process applications require accurate positioning of tool with respect to machined components i.e. work piece. Such Accuracy is achieved by setting tool exactly at the centre of the work piece. Many key factors like cutting tool and its setting angle, machining conditions, resolution of the machine tool and the type of work piece etc. play an important role in accurate cutting. In this paper, the setting of the tool at the centre of the work piece for turning operation is studied and mathematically demonstrated. Also in this study the errors and its remedy of tool setting on cutting angle has been done through considering and adjusting some factors like height, rake angles, clearance angle, deviation of tool when set, in such a way that there will be no effect on tool and work piece and the greater accuracy of job in turning operation is maintained.

Keywords: tool geometry, tool setting, errors, accuracy.

INTRODUCTION
Cutting tool angle plays a vital role in surface finish and also to get most desirable finish. We should match the centre of work piece with respect to Tool to make concentric. As far as matching of centre concerned, we should have correct data/datum that for what variation, the centre alignment shall be done. Hence how much tool angles should change as per defined in idle condition that also to be considered. Tool wear in hard turning not only modifies the cutting edge geometry but also increase cutting force and cutting temperature significantly, which, in turn, influence the residual stress profile in the machine surface. Therefore, wears in cutting edge is crucial during hard turning and temperature is one of the major factor which influences flank wear.

REVIEW OF LITERATURE
The wear mechanism of tin coated carbide and uncoated cerements tools were investigated at various combination of cutting speed, feed rate, and depth of cut for end milling of hardened AISI H13 tool steel. Hence at low speed, feed rate and depth of cut, SEM (scanning electron microscope) investigation has shown that both inserts experience uniform and gradual wear on the flank face, and diffusion and oxidation have also been observed [1]. Performance of P10 Tin coated carbide tool when end milling AISI H13 tool steel at high cutting speed, feed rate, and depth of cut on the tool life were studied experimentally. Hence the result shows that the tool life is highly affected by the feed rate and depth of cut [2]. Effect of cutting speed on tool performance in milling of B4Cp reinforced aluminum metal matrix composites was investigated with the help of five different cutting speed at constant feed rate of 0.26 mm/Z were used in order to determine the effect of cutting speed on tool wear and tool wear mechanism [3]. Comparison between constant force and constant rate of feed in material graphic cut-off machines, surface quality in relation to cutting speed, force and rate of feed has been studied where this study shows that when cutting work piece of varying shape, the most uniform surface is obtained by using a constant rate of feed and this combined with high cutting speed will produce surface with the least and most uniformed information [4]. The influence of few rate and cutting speed on the cutting forces, surface rough ness and tool chip constant length during face milling has been studied where in the study, three component of the cutting forces developed during face milling AISI 1020 and AISI 1040 steel work piece were measured [5]. The effect of cutting speed and cutting tool geometry on machinability properties of nickel base inconel 718 as per alloy has been investigated. Hence machined with dry cutting condition by using digital controlled computer lathe with ceramic cutting tool in two different geometries and three different material qualities [6] Some effect of cutting edge preparation and geometric modifications when turning INCONEL 718™ at high cutting speeds where this paper evaluates the performance of some inserts subjected to modifications on the edge geometric form and preparation, when turning, at high cutting speed, on a nickel base alloy, INCONEL 718™, hardened by solution and precipitation (44HRc) [7]. Influence of the critical cutting speed on the surface finish of turned steel base have been studies where variable such as feed rate and the tools of nose radius and cutting speed can provide a control on the quality and the surface finish in a given machining process [8]. Effect of federate, work piece hardness and cutting edge on sub surface residual stress in the hard turning of bearing steel using chamfer hone cutting edge geometry has been projected through numerical analysis that hone edge puts chamfer cutting edge and aggressive feed rate help to increase both Compressive residual stress and penetration depth [9]. Effect of cutting speed on the performance of Al2O3 based ceramic was the worst performing tool with respect to tool wear and the best with respect to surface finish. Tin coated Al2O3 + TiCN mixed ceramic tool is the most suitable one for turning modular cast iron, especially at high cutting speed [10]. An experimental study of the effect of cutting speed on chip breaking study concluded that due to the effect of cutting speed on minimum feed for chip-breaking, when machining a continuous chip-forming material, chip-breaker with a wide application range should be selected [11]. The effect of proper tool setting
on tool cutting angle with respect to work piece, provides greater accuracy of work [12]

In the literature survey it has been observed that no work been carried out related align the centre of work piece with respect to tool and what variation in centre alignment, how much tool angles should change as per defined in idle condition (Concentric). Hence a mathematical demonstration has been shown for the same to obtain most desirable finish.

MACHINE SPECIFICATION

Machine name
MAZAK QUICK TURN 15 N, 3 AC - 415V, 50/60HZ

Size (Height): 1810 mm
Floor Space Required (Width x Length): [2360 x 2570] mm
Machine weight: 4400 kg
Shape of bed: Horizontal

Bed width: 340 mm
Positioning Accuracy: 0.008 mm[X - axis]
0.013 mm[Z - axis]
Reparative Positioning Accuracy: ± 0.002 mm [X - axis] ± 0.003 mm [Z - Axis]

Cutting Speed (CS) is measure in surface meter/minute = (Diameter in mm * π) * RPM / 1000; cutting speed required for Lathe operations without using a cutting fluid.

Cutting speed and feed is influenced by
- Cutting tool material
- Work piece material
- Tool Geometry.
- Use of chip breaker
- Desired tool life
- Cutting fluid used
- Type of the cut (Rough/Finish)
- Rigidity of m/c and tool with respect to work.

Turning and boring operation parameters

<table>
<thead>
<tr>
<th>Material to be machining</th>
<th>Roughing</th>
<th>Finishing</th>
<th>Screw-thread cutting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-carbon steel 0.05 to 0.30% C m/min</td>
<td>27</td>
<td>30</td>
<td>10-12</td>
</tr>
<tr>
<td>High-carbon steel 0.06 to 1.7% C m/min</td>
<td>15</td>
<td>21</td>
<td>6-8</td>
</tr>
<tr>
<td>Brass</td>
<td>45</td>
<td>91</td>
<td>15-18</td>
</tr>
<tr>
<td>Aluminum</td>
<td>60</td>
<td>105</td>
<td>15-21</td>
</tr>
</tbody>
</table>

Tool angle for high-speed steel tool and various materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Side clearance angle, degrees</th>
<th>Side clearance angle, degrees</th>
<th>Back rack angle, degrees</th>
<th>Front clearness angle, degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel 1020</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Medium steel 1035</td>
<td>10</td>
<td>14</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Medium C. steel 1090</td>
<td>10</td>
<td>12</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Screw steel X I 112</td>
<td>12</td>
<td>22</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Cost iron</td>
<td>10</td>
<td>12</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Aluminum</td>
<td>12</td>
<td>15</td>
<td>35</td>
<td>8</td>
</tr>
<tr>
<td>Brass</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Monal metal</td>
<td>15</td>
<td>14</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>Plastic</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Fiber</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
</tbody>
</table>

Carbide Tool require slightly greater cutting angle those shown in the above Figure because of the brittleness of the material. Side-Cutting-Edge angle of 5 to 20 degrees are recommended for those cutters.

As we know that cutting tool angle plays a vital role in surface finish and also to get most desirable finish. We should match the centre of Work Piece and tool i.e. to make concentric. As far as matching of centre is concerned, we should have data / datum that for “what variation”, in centre alignment, how much tool angles should change as per defined in idle condition (concentric).

Case 1:
A mathematical demonstration is being shown here, that is why we align the centre and also to keep the centre at certain height what change in angles should be done, so that we will get same result (approximately). [But cutting force is different.]
Let \( h \) = height of deviation from centre 
\( a \) = angle of deviation

Then from \( \Delta OAB \), we get,
\[
\sin a = \frac{h}{r} 
\]
\[
\therefore a = \sin^{-1} \left( \frac{h}{r} \right) 
\]

It is obvious that change in clearance = previous clearance – \( a \) [given, \( a = \sin^{-1} \left( \frac{h}{r} \right) \)]

and new rake= previous rake + \( \sin^{-1} \left( \frac{h}{r} \right) \)
So, \( \sin \alpha = \frac{h}{R} \)

Here we are seeing that clearance angle is decreasing by \( \alpha \) amount as rake, increasing by same amount. Here tool is being set at certain height \( h \) from the centre of the Work Piece. So after composing work-piece and tool with respect to new top rake angle will be equal to previous top rake plus amount of angle formed at the centre of work-piece, when tool is being deviated towards top direction. But clearance angle will be decreasing by the same amount as top rake increasing because clearance angle is always measured at the tangent, where tool tip point rest at the work-piece.

Let \( h \) be the height of deviation of the tool from centre of work-piece \( \alpha \) is the angle formed at the centre of work-piece. As per construction \( \alpha = C \) and correspondence angle, the amount reduce in clearance angle will be equal to \( 'C' \), where \( 'D' \) is the old top rake angle. So, new top rake angle will be equal to \( (C + D) \). Now previous clearance is \( 'C' \). So, new clearance will be previous clearance \( (Q - C) \) - Increase in top rake angle. i.e., \( (Q - C) \).

Hence, finally it is obvious that if clearance angle decreases then tool face will be in contact with Work Piece, then rubbing will start and surface finish will be deteriorated.

For \( h \) amount (height from centre) and angle \( \alpha \), tool clearance angle should be

\[
\begin{align*}
\text{New clearance or required clearance, } \theta' &= \theta + \alpha \\
\theta' &= \theta + \sin^{-1}\left(\frac{h}{R}\right) \\
\beta' &= \beta - \sin^{-1}\left(\frac{h}{R}\right)
\end{align*}
\]

Case 2: Errors in Tool Setting

The tool should be set exactly at the centre of the work piece, for proper cutting. If the tool is kept below or above the workpiece, the tool geometry gets affected, as shown in the fig.1, for example, if the tool is set at a position below the workpiece centre by a distance \( h \), then the expected changes are \( R = \sqrt{r^2 - h^2} \) where, \( R \) is the actual radius of the component produced and \( r' \) is the radius set. \( \alpha = \sin^{-1}(r/h) \).

Tool Setting Errors

The above angle decreases the actual rectangle \( \alpha \), while the clearance angle increased by the same amount. Thus, the cutting focuses increase because of the reduction in the rack angle in the case of setting the tool above the centre cause the rack angle to increase while the clearance angle reduces. This causes rubbing to take place in the flank face.

The following example shows the magnitude of error that is involved in a cutting tool setting.

While turning of bar diameter of 90mm, the turning tool is set below the centre line by an amount equal to 5 mm. Find the change in the effective cutting tool geometry

\[
\alpha = \sin^{-1}(r/h) = \sin^{-1}(5/45) = 6.37937^\circ
\]
If the actual back rake angle is 10°, the effective rake angle = (10-6.38°)=3.62°, and the clearance angle is 5°, the effective clearance angle = (5-6.38°)=-1.38°. Hence, if the tool is set at a point above the centre line, these would be a corresponding increase in the rake angle by the same amount. While the clearance angle would be (5-6.38°) =-1.38° which would cause rubbing (interference) with the workpiece.

CONCLUSIONS

Hence, to avoid inaccuracy in manufacturing processes like turning operation the accuracy of height should be maintained and deviation of the tool angles should be changed accordingly to get the greater accuracy of the products. So it is concluded that, the tool should be set exactly at the centre of the work piece for turning operation, otherwise an error will occur and manufacturing process is not accurate and reliable.

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