A REVIEW ON EFFECT OF CUTTING PARAMETERS ON CUTTING FORCE IN TURNING PROCESS

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Abstract

The purpose of this paper is to study the effect of cutting parameters on cutting force (Fc) & feed force in turning Process. Experiments were conducted on a precision centre lathe and the influence of cutting parameters was studied using analysis of variance (ANOVA) based on adjusted approach. Based on the main effects plots obtained through full factorial design, optimum level for surface roughness and cutting force were chosen depth of cut, and the interaction of feed and depth of cut significantly influenced the variance. In case of surface roughness, from the three levels of cutting parameters considered Linear regression equation of cutting force has revealed that feed, the influencing factors were found to be feed and the interaction of speed and feed. As turning of mild steel using HSS is one among the major machining operations in manufacturing industry, the revelation made in this research would significantly contribute to the cutting parameters optimization.

Keywords ***- rake angle, grooved tools, nose radius cutting force, feed force interaction effect, variable geometry*.**

1. Introduction

An increase in productivity requires involvement of all production operations, technical possibility for full use or activation of all the available manufacturing facilities. In order to involve all the technological operations, optimum technological processes, optimum tool selection, suitable combination of tool-work piece material and determination of optimum cutting variables and tool geometry must be considered. The tool geometry has an important factor on cutting forces and cutting forces are essential sources of information about productive machining. Due to more demanding manufacturing systems, the requirements for reliable technological information have increased. This calls for a reliable analysis in cutting in the cutting zone (cutter work piece chip system). As the mechanics of cutting in this area are very complicated, i.e. various laws continuously interact, it is not possible to make any precise statements about their mutual influences.

2. Cutting tool and cutting parameters

The cutting tests were carried out on a lathe equipped with a Fanuc control system. The cutting speed v was assigned four different levels (40; 50; 60; 80rpm), feed rate f and depth of cut d were kept constant as 0.20 mm/rev and 1.5mm, respectively. The values of cutting parameters selected are recommended by the tool manufacturer for general purpose and finish turning operations of medium carbon steels. Each experiment was carried out with new sharp tools in order to keep the cutting conditions unchanged. The tests were designed according to full factorial design and conducted in dry cutting conditions. Totally, 7 experiments were performed by the combinations of cutting parameters.

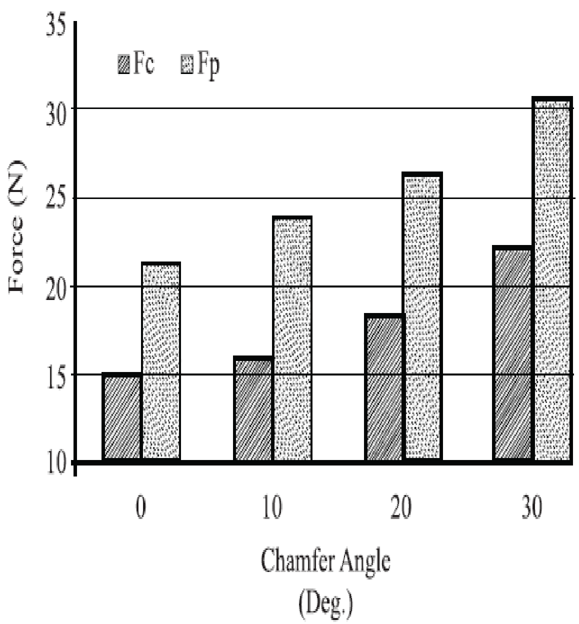

Figure2.1:- Correlation of cutting force and chamfer angle

3. Terminology of cutting tool

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1. **Shank** –It is the main body of tool. The shank used to gripped in tool holder.
2. **Flank**- The surface or surface below the adjacent of the cutting edge is called flank of the tool.
3. **Face**- It is top surface of the tool along which the chip slides.
4. **Base**- It is actually a bearing surface of the toll when it is held in a tool holder or clamped directly in a tool post.
5. **Heel**- It is the intersection of the flank and base of the tool.
6. **Nose**- It is the point where slide cutting edge intersects.
7. **Cutting edge**- It is the edge on face of the tool which removes the material from workpiece. The cutting edges are side cutting edges (major cutting edge) and end cutting edge (minor cutting edge).
8. **Tool angles**- Tool angles have great importance. The tool with proper angle, reduce breaking of tool, cut metal more efficiently, generate less heat.
9. **Nose radius**- It provide long life and good surface finish sharp point on nose is highly stressed, and leaves grooves in the path of cut. Longer nose radius produce chatter.

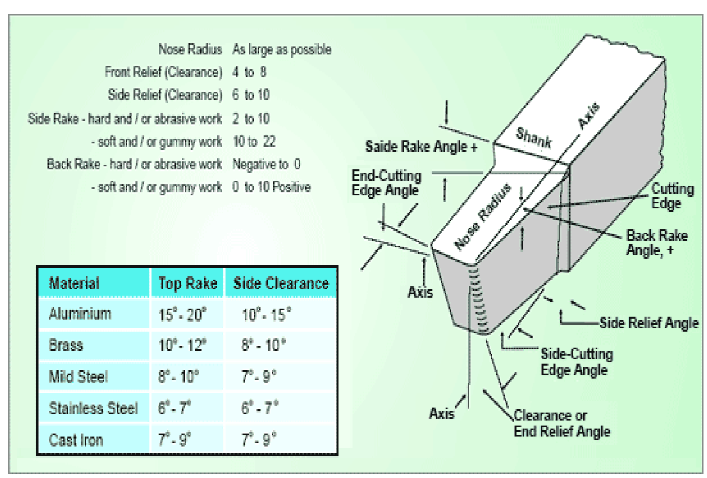

Figure3.1:- Tool geometry

4. The effect of entering angle on main cutting force and tool tip temperature

The main cutting edge approaches the work piece with entering angle. In large entering angle, the cutting forces are distributed over a shorter section of the cutting edge. Since the main cutting edge enters and leaves the cutting zone suddenly at 90 degree of entering angle it is subjected to maximum loading and unloading. Therefore, the optimum entering angle has been obtained as 60-75degree.At 45degree entering angle with the same cutting speed and depth of cut, the effective cutting edge length increased greatly comparing to the 90degree. As a result, the chip thickness becomes smaller. The entering angle affects the axial and radial components of the cutting forces. Generally, a large entering angle produces a large feed force and also smaller thrust force. The entering angle also affects the direction of chip flow.

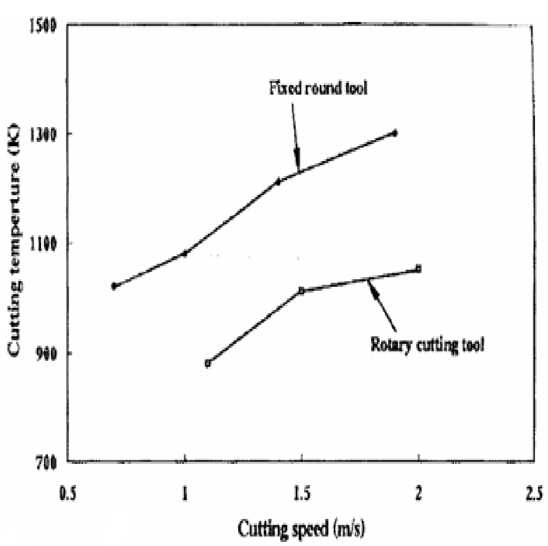

Figure4.1:-. Cutting temperatures

5. The effect of rake angle on main cutting force and tool tip temperature

Rake angle has an important effect on all the cutting force components and also on the tool tip temperature. By increasing positive rake angle, the cutting forces were decreased as the tool can plunge into the work piece easily. But, in contrast, the tool tip temperature was increased in high rake angles due to the increased chip contact length. Positive rake angle produces higher shear angle; therefore, it leads to reduction of cutting forces. It also leaves a better surface finish since it assists the chip to flow away from the work piece. But, excessive rake angle weakens the tool, thus causes to tool breakage. As a result, as the cutting forces and temperature were reduced considerably.

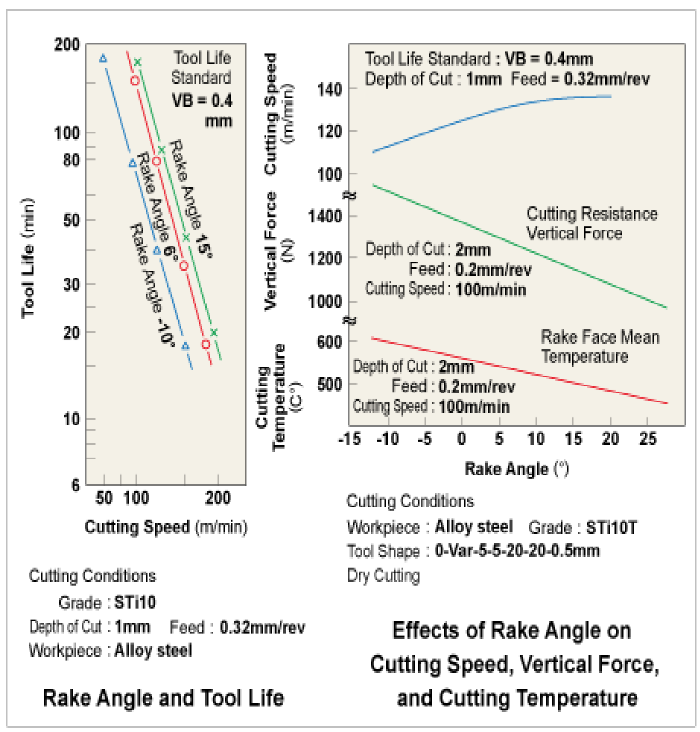

Figure5.1:-.Rake angle and its effect on cutting parameter

6. Force analysis

Turning is the machining operation that produces cylindrical parts. In its basic form, it can be defined as the machining of an external surface: With the work piece is rotating. With a single-point cutting tool, and with the cutting tool feeding parallel to the axis of the work piece and at a distance that will remove the outer surface of the work. Among the force components, cutting force and Feed force prominently influences power consumption and the most common equation available for the estimation of Cutting force is given by (equation 1)

$$Fc = kc \times DOC \times f$$

Where, DOC = Depth of cut (mm), f = feed (mm/rev), kc = Specific cutting energy coefficient (N/ mm2)
According to equation 1, cutting force is influenced by the depth of cut, feed, and specific cutting energy coefficient. A lot of work is in progress to study this influence and construct the models for different tool and work force material so as to optimize the power consumption. Another important parameter of research interest is Surface roughness of the work piece produced, as an optimum surface finish would influence performance of mechanical parts and cost of manufacture2-7. The surface finish of any given part is measured in terms of average heights and depths of peaks and valleys on the surface of the work piece8. But there are basically two streams of arguments on the influencing factors of surface roughness. A popularly used model for estimating the surface roughness value is as follows (eqn. 2)

$$R_a = 0.0321 f^2 / r$$

Where, Ra = ideal arithmetic average (AA) surface roughness (μm), f = feed (mm/rev), r = cutter nose radius (mm).

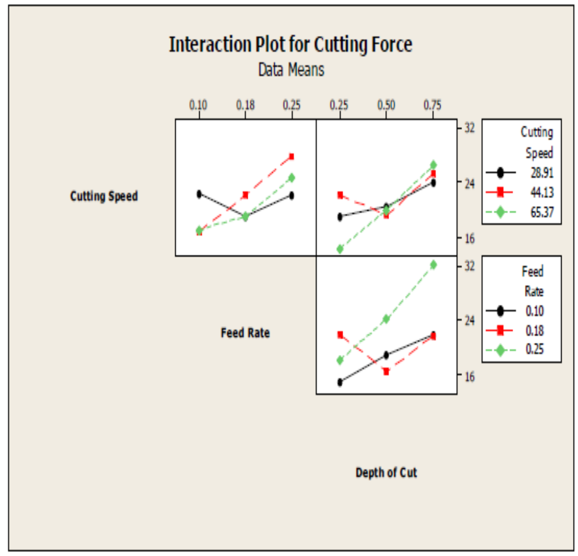

Figure6.1:-Interaction plot for cutting force in plain turning

Result and discussions

In the course of this study, the cutting forces and averaged tool tip temperature were measured in turning and the measured results were also compared with their calculated values. On the other hand, the effects of cutting speeds and tool geometry including entering angles and rake angles on cutting forces were evaluated. The following conclusions and observations can be drawn from these investigations.

Cutting force & feed force increases almost linearly with the increase in depth of cut from 0.25mm to 0.75mm.Optimum conditions are achieved for a feed rate value of 0.18 mm/rev and a DOC value of 0.5mm., which is the main effects plot for cutting force indicates that cutting force is influenced significantly by depth of cut, feed rate, interaction effect of feed and depth of cut and interaction effect of speed, feed and depth of cut, whereas, speed has an insignificant influence on cutting force which is shown in table - 4. Further, the model adequately explains the total variance in cutting parameters and it is also reasonably a good fit R-Sq = 81.53% R-Sq(adj) = 76.19% It can also be noted through ANOVA that Cutting force is not significantly influenced due to the interaction between speed and feed, however, there is an indication that at higher feed rate the influence may be significant.

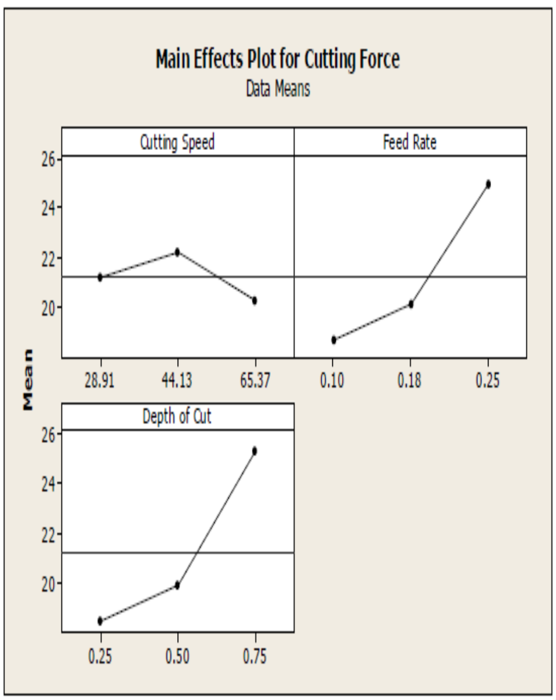

Figure: - Main effects plot for cutting force in plain turning.

Conclusions

- When the cutting speed was raised, the cutting forces were reduced but the temperature was increased. For the increased positive rake angle, the cutting forces were decreased, which means less force/power is required.

- Although some theoretical methods and empirical approach have been developed, the measurement of cutting forces is an essential requirement. Since metal cutting mechanic is quite complicated, it is very difficult to develop a comprehensive model which involves all cutting parameters affecting cutting forces. Under the cutting conditions used in this investigation, the cutting [6] Y. Mustafa and T. Ali Determination and optimization of the effect of cutting parameters and workpiece length on the geometric tolerances and surface roughness in turning operation International Journal of the Physical Sciences Vol. 6(5), pp. 1074-1084, 4 March, 2011

- Forces and the averaged temperature on the tool tip were measured and also compared with the calculated results. Due to the confusing chip flow, the radiation sensor was not able to penetrate into the rake surface and, therefore, it could not be taken as real temperature. But, these temperature results were used to analyze the effects of cutting parameters.

- Since the main cutting edge enters and leaves the cutting zone suddenly at 90degree of entering angle, it is subjected to maximum loading and unloading. If the cutting tool has an entering angle different then 90degree, the cutting edge enters and leaves the work piece gradually, thus the impact of load is not exerted on it. Therefore, the optimum entering angle was obtained.

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