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Research Paper

Analysis of Cutting Forces for Different Work Materials and Tool Material: Effect of Rake Angle in Turning Process

Engineering

KEYWORDS : Orthogonal turning, lathe machine, dynamometer.

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ABSTRACT

The aim of this work is to study experimentally the influence of tool rake angle, work piece material type and tool material on the main cutting force during a turning process. EN 31, MS, Aluminum specimens have been used as work piece materials, High Speed Steel and Carbide tools are used as tool materials. The experiments have been obtained with constant cutting speed (550 rpm), depth of cut and feed rate with five different tool rake angles (0^0-16^0).

For the estimation of the material type influence on the main cutting force, the experiments have been performed with the same cutting conditions, tool characteristics on the three work piece materials and two tool materials.

The effect of the tool rake angle on the main cutting force depends on the type of work piece material, i.e. for EN 31, M.S. specimens the main cutting force has a decreasing trend as the rake angle increases from 0^0 to 16^0 but for the Aluminum specimen the main cutting force was increased as increasing the tool rake angle.

The experimental results show that main cutting force has the maximum value at the EN 31 specimen, average value at the MS specimen and the lower value at the Aluminum specimen. In this experiments HSS and Carbide tool have been used, the value of cutting force is more in carbide tool than HSS tool for same cutting conditions.

Introduction

Turning is a machining process to produce parts cylindrical in shape by a single point cutting tool on lathes. The tool is fed either linearly in the direction parallel or perpendicular to the axis of rotation of the work piece, or along a specified path to produce complex rotational shapes. The primary motion of cutting in turning is the rotation of the work piece, and the secondary motion of cutting is the feed motion.

In turning process the work piece material is rotated and the cutting tool will travel, removes a surface layer (chip) of the work piece material, producing three cutting forces components, i.e. the tangential force (Fy), which acts on the cutting speed direction, the feed force (Fx), which acts on the feed direction and the radial force (Fz), which acts on the direction normal to the cutting speed

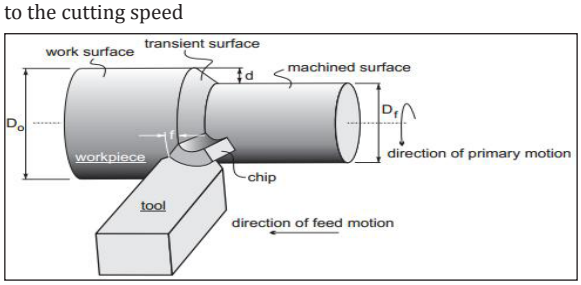

Figure 1 Schematic illustration of the basic turning operation

LITERATURE REVIEW

During literature review, it has been observed that ,many researches has been done in the area of metal machining

Experimental Studies on Tool Geometry-

The paper is about the effect of rake angle and feed rate on the cutting forces in an orthogonal turning process. A hollow cylindrical EN8 work piece was turned using HSS tools for 6 different rake angles (0^0, 4^0, 8^0, 12^0,16^0, 20^0) During the experimentation, the forces were measured Using a 4-component piezoelectric dynamometer. The experimental results show that the feed force (Fx) is greater than the tangential force (Fy) and the longitudinal force (Fz) is least in magnitude irrespective of the tool rake angle.(1)

The paper is about experimentally the influence of cutting depth, tool rake angle and work piece material type on the main cutting force and chip morphology during a turning process. AISI 1020, Aluminum 2014 and UNS C23000 specimens were used as work piece materials.(2)

The paper is about the work investigates the effect of cutting speed, feed rate, depth of cut, and rake angle on main cutting force during the cylindrical turning of mild steel, brass, and aluminum rod, using high speed steel cutting tool and palm-kernel oil as cutting fluid. The impact of lubrication on the coefficient of friction between the chip and rake face during turning operation, assuming a negligible friction between the flank and cut surface is measured. [3]

The paper is about by measuring the cutting forces the effect of the tool shape and qualifications (sharp and worn cutting tools of both vee and knife edge profile) and cutting conditions (depth of cut and cutting speed) in the turning operation on the tool deflection and cutting force is investigated. The work piece material was mild steel and the cutting tool was made of high speed steel. Cutting forces were measured by a dynamometer. (4)

The paper is about model based on finite deformation was developed to predict the forces in orthogonal turning operations. [5]

The paper is about power consumption in turning EN-31 steel (a material that is most extensively used in automotive industry) with tungsten carbide tool under different cutting conditions was experimentally investigated(6)

Work and Cutting tool materials (7-11)

Experimental Studies on work tool interface parameters-(12-14)

Methodology

In this work the effect of rake angle on the cutting forces in an orthogonal turning process will be experimentally determine. cylindrical work pieces of three different materials such as EN 31, MS, Aluminum to be turned using HSS(Miranda) and Carbide cutting tools for different rake angles (0, 4, 8, 12, 16 degree). During the experimentation, the forces will be measured by dynamo meter In this work the cutting forces were measured by mechanical dynamometer.

Under the action of the cutting force, say Fc in turning, the tool or tool holder elastically deflects as indicated in figure 4.2. Such tool deflection, δ is proportional to the magnitude of the cutting force, Fc, simply as,

$\delta = Fc(L3/3EI)$ .....(1.1)

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where, L = overhang or equivalent projected length of the cantilever type tool (holder)
E = physical property (Young's modulus of elasticity of the beam)
I = size (plane moment of inertia) of the beam section.

Result-
The research topics of this study focus on the experimental influence of tool rake angle, work piece material type and tool material type on the main cutting force during the turning process.

During the experimental procedure, the main cutting force Fc was measured, on three different work piece materials i.e. EN31, MS and Aluminum 2014 with two cutting tool materials i.e. HSS and Carbide.

Table 1.1 Effect of rake angle on AL, MS, EN 31 with HSS tool

HSS tool			
Rake angle	EN-31	M.S.	Aluminum
0	147	84	50.4
4	172.2	105	63
8	117.6	71.4	63
12	126.6	67.2	67.2
16	100.8	84	67

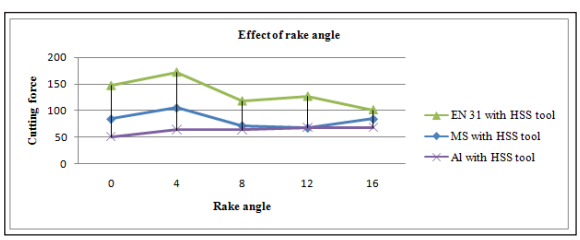

Figure 1.1 Effect of rake angle on AL, MS, EN 31 with HSS tool

Table 1.2 Effect of rake angle on AL, MS, EN 31 with Carbide tool

Carbide tool			
Rake angle	EN-31	M.S.	Aluminum
0	204	113.3	68
4	226	136	85
8	158.6	102	85
12	170	90.6	96.3
16	158.6	85	102

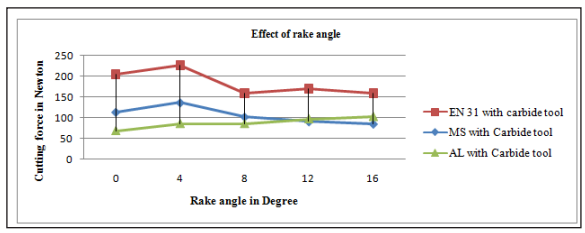

Figure 1.2 Effect of rake angle on AL, MS, EN 31 with Carbide tool

From the figure 1.1 and 1.2 the effect of tool rake angle on main cutting force for EN 31and Mild Steel specimen decreasing trend as the rake angle increases from 0^0 to 16^0 on the other hand, for the Aluminum material the main cutting force is increased as the tool rake angle increases.

CONCLUSION

The results obtained in this study has been drawn from experimental data evaluation. The findings are as follows:-

1. The effect of tool rake angle on main cutting force for EN 31and Mild Steel specimen decreasing trend as the rake angle increases from 0^0 to 16^0. On the other hand, for the Aluminum material the main cutting force is increased as the tool rake angle increases.
2. The experimental results correlation of the three different work piece material types shows that the main cutting force has it's maximum value for the EN 31 material with carbide tool, average value for the Mild Steel material and the lower value for the aluminum material.
3. In this experiments HSS and Carbide tool have been used, the value of cutting force is more in carbide tool than HSS tool for same cutting conditions.

FUTURE SCOPE

1. Consider also thrust force and radial force with main cutting forces for analysis.
2. We can also consider effect of temperature and speed on tool life and work surface.
3. By this experiment we can consider other parameters of tool geometry (clearance angle, nose radius,side cutting edge angle, end cutting edge angle).

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