Effects on Cutting Forces in Shaping Operation

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ABSTRACT

In this paper, the effect of tool rake, tool shape, tool radius and tool material on the cutting forces was investigated when machining mild steel work piece material. The machining tests were carried out on a shaper. For cutting force measurement, a test setup that was designed and constructed for cutting force measurement was used. The beam type load cells were used to construct the setup and cutting force measurement readings were recorded on a computer during the tests. The MINITAB15 software is used to draw main effect plots and interaction plots between parameters. In the measurement of the cutting forces, elastic defections of the cutting tool due to the cutting forces were measured by means of the load cells located suitable position on the cutting tool .The effect of process parameters like feed, cutting speed, depth of cut, tool material, tool shape and tool geometry is seen on the cutting forces.

Key words: Cutting & Thrust Force, shaping operation

INTRODUCTION

In metal cutting, a cutting tool is used to remove excess material from a work piece in order to convert the remaining material into the desired part shape. Proper selection of tool materials, cutting parameters, and tool geometry and machine tools is essential to produce high-quality products at low cost. Therefore, many attempts have been made to reduce cost and improve quality through the understanding of the cutting process. A considerable amount of these investigations has been directed towards the measurement and prediction of the cutting forces during machining. That is because, knowledge of the cutting forces is important as they have a direct influence on the generation of heat, and thus on tool wear, quality of machined surface and accuracy of work piece. They are also used in the design of machine tools, cutting tools and fixtures [6-9].

Due to the complex tool configurations/cutting conditions of metal cutting operations and some Unknown factors/stresses, theoretical cutting force calculations failed to produce accurate results and therefore experimental measurement of the cutting forces became unavoidable. In the literature, there are many studies concerning the cutting force measurement. Many dynamometers have been developed for this purpose. However, these are mainly for turning and milling operations. No work dealing with the measurement of the cutting forces during machining with linear motion as in shaping has been reported in the literature. Although shaping is one of the oldest single-point machining processes and it has largely been replaced by milling and broaching [12].

In this study, in order to investigate the effect of speed ,feed ,depth of cut ,tool shape, tool material, tool geometry on the main cutting force (F_p) and thrust force (F_t) during the machining with linear motion a test setup has been designed and manufactured [1-5]. Beam type load cells were used in this setup and the cutting force values were recorded automatically on a computer during the tests. In the measurement of cutting forces experimentally it was aimed to determine the deflection of the cutting tool due to the cutting force by means of load cells located in suitable positions on the cutting tool. Data have been analyzed by using MINITAB 15 software and draw the main effect plots, interaction plots between parameter.

EXPERIMENTAL SET UP

In the experimental set up a dynamometer for measuring the cutting force & thrust force is designed and developed. The beam type load cells were used to construct the setup and cutting force measurement readings were recorded on a computer using the RS 232 data logger during the tests.

Fig.1Experimental Set-Up for Force

Fig.2 Position of Load Cell

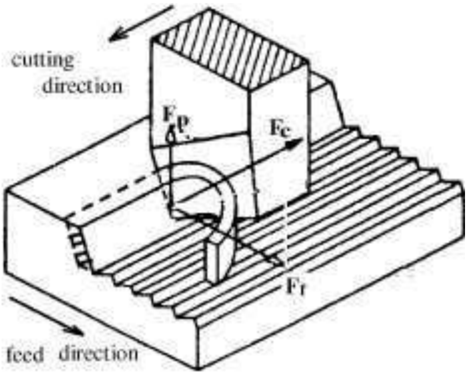

Fig. 3 Mechanism of Shaping Operation [15]

Fig. 4 Calibration Process

Although shaping is one of the oldest single-point machining processes and it has largely been replaced by milling and broaching [12], it may be still important in examining the effect cutting force and thrust force on tool. Experiments have been planned and data were analyzed and results were different from turning operation. In this study, in order to investigate the effect of feed, speed, depth of cut, tool materials, tool geometry, tool shape on the cutting force (Fp) and thrust force(Fq) during the machining with linear motion a test setup has been designed and manufactured [3-5]. Beam type load cells were used in this setup and the cutting force values were recorded automatically on a computer during the tests. Experiments are aimed to determine the defection of the cutting tool due to the cutting force by means of load cells located in suitable positions on the cutting tool.

DIFFERENT TOOL USED FOR EXPERIMENTS

A Different shapes: V- shape, parting tool and curved shape.
B Different nose radius: 1 mm, 2mm and 4mm
C Different tool material: HSS, K20 and P30
D Different Rake angle: 0º, 3º and 5º.

Different Tool Shapes
(1. V- Shape, 2. Parting and 3.Curved Shape, Material HSS)

Fig. 5 Different Tool Materials& Shapes

Table -1 Table for run 1-8

Run	V(m/min)	f(mm/stroke)	d(mm)	Fp(kg)	Fq(kg)
1	5.34	0.30	0.5	9.25	3.99
2	11.63	0.30	0.5	7.46	2.96
3	5.34	0.30	1.0	20.48	7.50
4	11.63	0.30	1.0	15.84	5.02
5	5.34	0.35	0.5	9.78	4.94
6	5.34	0.35	1.0	21.13	7.92
7	11.63	0.35	0.5	9.31	3.77
8	11.63	0.35	1.0	16.13	5.42

RESULTS & DISCUSSION

Main Effect Plots For Fq (Thrust Force)

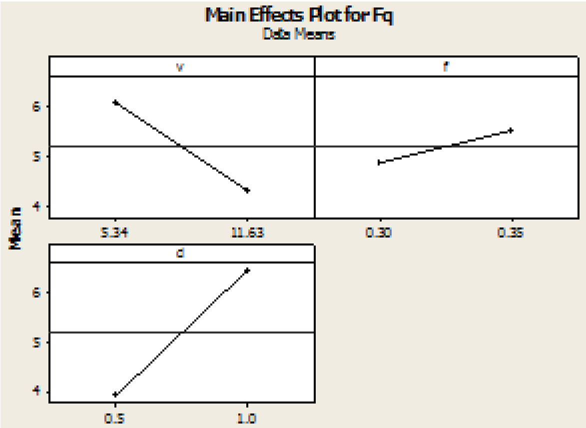

Fig. 6Thrust Force V/S Speed, Feed and Depth of Cut

Main Effect Plots For Fp (Cutting Force)

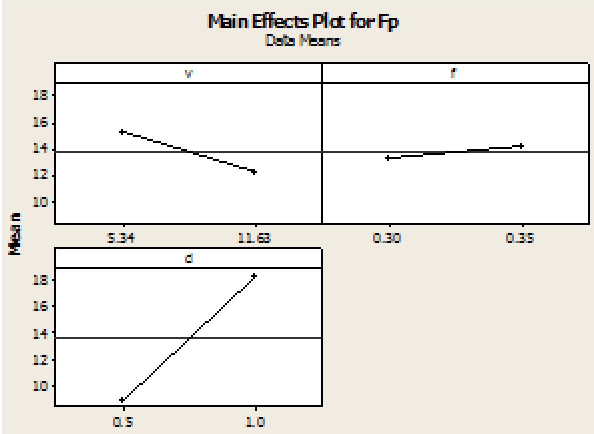

Fig. 7 Cutting Force V/S Speed, Feed and Depth of Cut

Interaction Plot for Fq (Thrust Force)

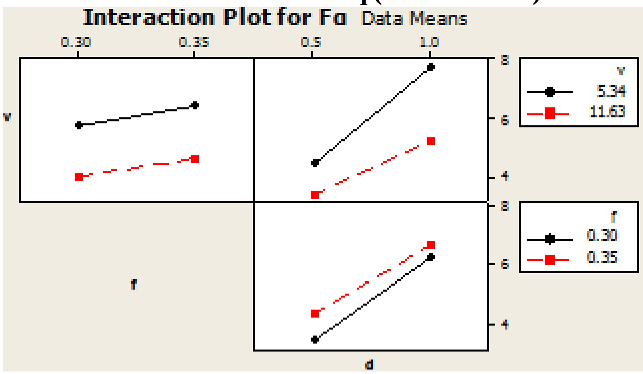

Fig. 8 Interaction Plot for Thrust Force Among Speed, Feed and Depth of Cut

Interaction Plot for Fp (Cutting Force)

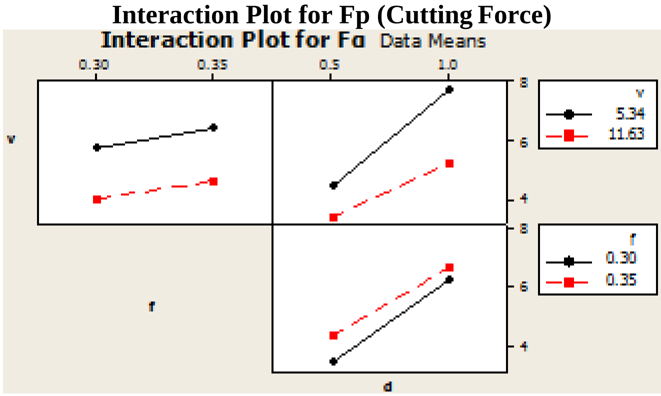

Fig. 9Interaction Plot for Cutting Force among Speed, Feed and Depth of Cut

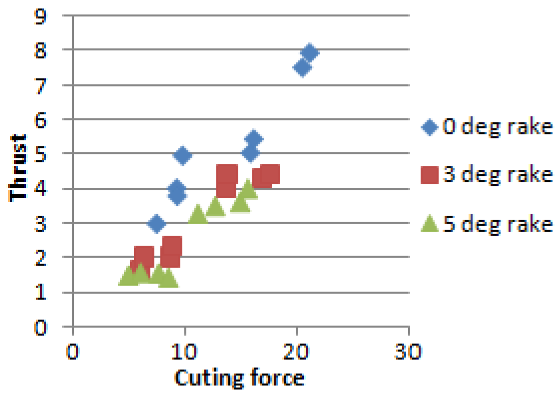

Fig. 10Effect of Tool Rake on Cutting & Thrust Force

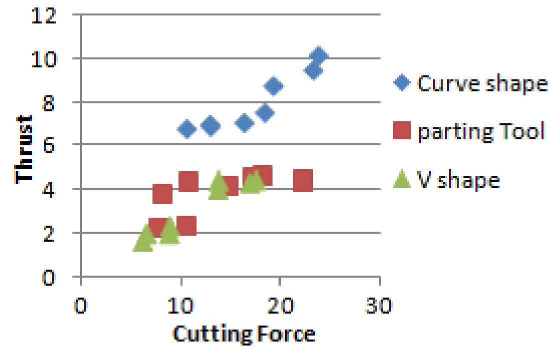

Fig. 11Effect of Tool Shape on Cutting &Thrust Force

Fig. 12Effect of Tool Material on Cutting & Thrust Force

CONCLUSION

By using the designed and constructed dynamometer, the effects of cutting speed, feed, depth of cut, tool material, tool shapes, tool geometry on cutting forces during machining these parts with linear motion can be evaluated. From the present work, following conclusion can be drawn:

• The main cutting force and thrust force increased with increasing depth of cut followed by feed rate and decrease with cutting speed during shaping operation.

• The main effect of radius tool is more on cutting and thrust force followed by parting tool and v shape tool.

•The main effect of tool material HSS is more on forces followed by P30 and k 20 with 4 mm nose radius. i.e hardness of k20 is larger than P30 and HSS that's why the cutting force and thrust force is very less with the K20.

• By increasing the rake angle the force are in decreasing manner.

• By using the MINITAB 15 data were analyzed and draw the main effect plots and interaction effect between parameters. Analysis show that effect of depth of cut in more on cutting and thrust force increase followed by feed and decrease with speed. This is different from turning. That's why effect of cutting parameter in shaping operation need to study.

• This system can be used reliably to measure cutting forces during shaping.

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