EXPERIMENTAL INVESTIGATION OF CUTTING FORCE AND ANALYSIS OF AXMT 0903 TUNGESTEN CARBIDE END MILLING INSERTS USING FINITE ELEMENT ANALYSIS

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ABSTRACT

In this paper, design and finite element modeling of tungsten carbide end milling insert with prediction of deformation, stress and deflection in the presences of insert edge. Machining parameters are speed, feed and depth of cut and output responses is cutting force is studied. The insert designed CATIAV5 and analysed through ANSYS11 softwares. Model is tested and force prediction in end milling insert of AA 6082T6 aluminum.

Keywords: End milling, Insert, Tungsten carbide, CATIA, ANSYS, Stress.

1. Introduction

Milling machines are the most versatile and functional machine tools due to their capabilities to perform a variety of operations. Milling is the process of machining curved, flat, regular and irregular surfaces by feeding the work piece against a rotating cont a number of cutting edges. The milling machine consists of a motor driven spindle, which mounts and revolves the milling cutters, and a reciprocating adjustable work piece. Mainly milling machines have self-contained electric drive motors, coolant systems, inconsistent spindle speed, power-operated and feeds. These machines are also classified as ram-type, knee-type, manufacturing or bed-type and planar-type. It is used for wide-ranging purpos operations. Column and knee type of milling machines are the most common milling machines. The spindle to which the milling cutter is may be horizontal (slab milling) or vertical (face milling and end milling).

Chaintanya and Kaladhar [1] developed an indiscriminate model of special shaped milling cutter made of high speed steel material for the purpose of predicting stress and deformation. Ratnakumar and Tippa et.al [2] proposed a design aspects of plain milling cutter is analysed. They are concluded stress and deformation are decreased with increase of speed.

Virginija and Vytautas [3] studied the force acting on a single cutting tool insert to accomplished by transforming cutting force signals from coordinate system of Kistler dynamometer into milling tool coordinate system. Atan [4] proposed a methodology for simulating the cutting process in flat end milling operation and predicting the chip flow, cutting forces, tool stresses and temperatures using Finite Element Analysis (FEA). The method concluded that the highest tool temperatures were predicted at the primary cutting edge of the flat end mill insert. Sai [5] presented a numerical analysis to predict temperature distribution in a 3D model describing at a ball end milling operation. The different cutting conditions as cutting speed, feed rate and tool rotation angle are studied. The results shows, temperature increases when increasing of cutting parameters. Kadirgama and Bakar [6] studied the stress distribution of nickel based super alloy and HASTE alloy C-2000 in end milling operation. The result shows stress had lower values under the cutting edges.

Samhan [7] analysed thermal stresses in adhesive bonded carbide tip face milling cutters using numerical analysis. He concluded that thermal stresses decreased while applying of coolant. Li [8] analysed the force density function and stress on the rake face of H-slot blade. Dmitry et.al [9] developed a 3-D model of an end mill tool using solid works. Tugrul Ozel [10] developed a finite element model of macro/micro end milling process with predictions of forces, stresses and temperature distributions in the presence of tool edge are presented. All above work were limited to design and prediction of deformation, stress and deflection using FEA by method. In this work prediction of deflection, deformation and stress of various cutting condition has been made using FEA technique.

2. Experimental procedure

To conduct the experiment on knee type milling machine (UF-1, 1200 x 900 Bed size) with maximum spindle speed. Fig.1 shows the experimental set up of end milling for machining of AA6082T6 (workpiece) with tungsten carbide inserts in single side. The design of the experiments has an effect on the number of experiments required. Therefore, it is important to have a well-designed experiment to minimize the number of trails which often are carried out randomly. The machining parameters speed as a constant (constant speed, 1000 rpm), the other parameters are feed and depths of cut are changed and cutting force is measured. The cutting force vales measured with Kristler dynamometer with different machining condition. The values are tabulated in Table 1.

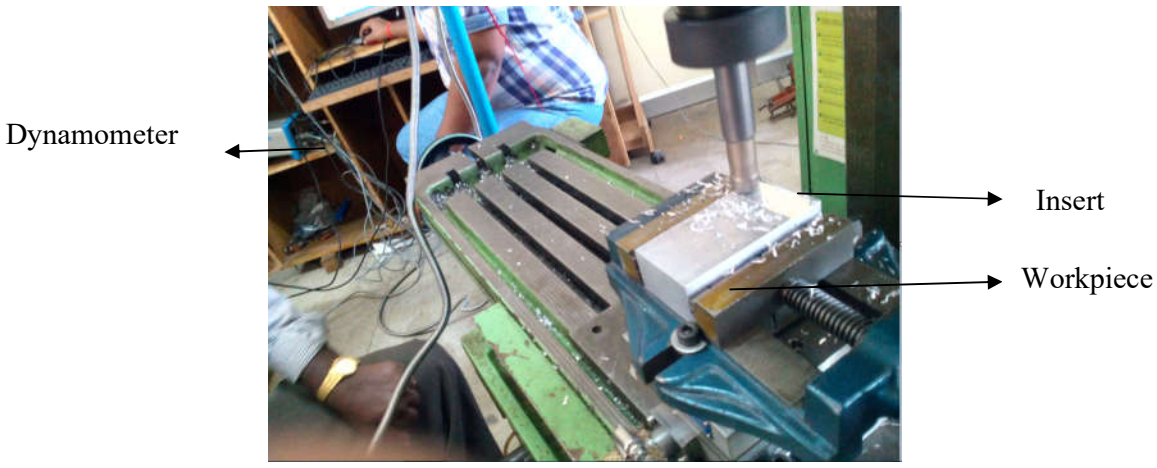

Fig. 1 Knee type milling machine

Table 1 Cutting Force

Cutting speed (m/min)	Feed (mm/min)	Depth (mm)	Tangential Cutting force F_z (N)
1000	40	0.5	19.42
1000	40	0.75	22.69
1000	40	1	24.05
1000	63	0.5	24.33
1000	63	0.75	25.27
1000	63	1	26.97
1000	100	0.5	27.02
1000	100	0.75	27.94
1000	100	1	28.06

3. Modelling of tool insert

The AXMT 0903 PER-EML insert is made up of tungsten carbide, the machining is carried out in dry condition. The milling insert geometry is shown in Table 2 and Fig 2 . The CAD models of insert geometry shown in Fig 3.

Table 2 Insert Geometry Values

D	d_1	A	T	R
Mm				
9.5	6.198	1.245	6.608	0.508

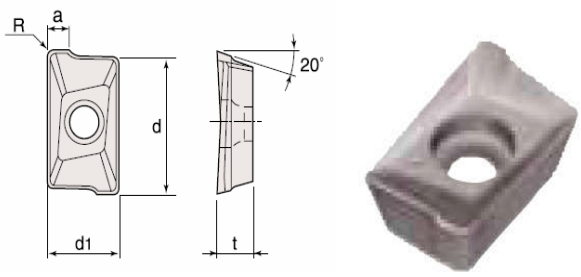

Fig. 2 Insert Shape and Geometry

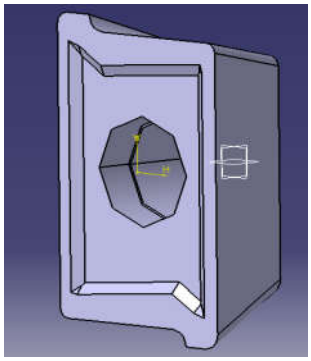

Fig.3 CAD modelling of milling inserts

4. Analysis of Insert Using ANSYS

The model is created with help of cad software and various cutting forces are applied in the tip of the insert. The analysis is carried out in ansys11 software and analysed the deformation, stress and deflection values. The values are shown in Table 3. Stresses and deformation distributions are shown in Fig 4 and 5.

4.1 Material Properties for Tungsten Carbide

The properties of tungsten carbide, Young's modulus = 627 GPa, Poisons ratio = 0.3. The stress value and deformation values of 19.42N shown in below figures. The red colour shows the maximum stress and deflection of the insert. The lower value is shown in blue colour.

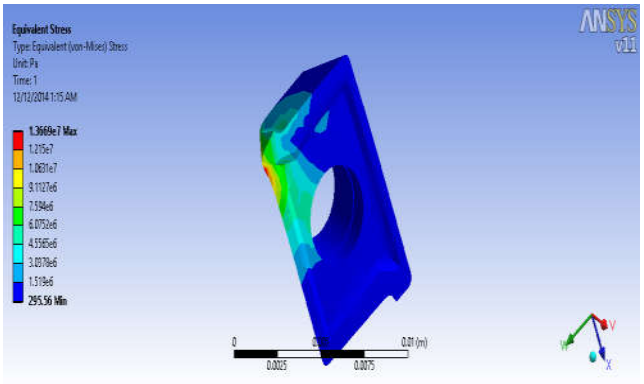

Fig. 4 Result of Stress

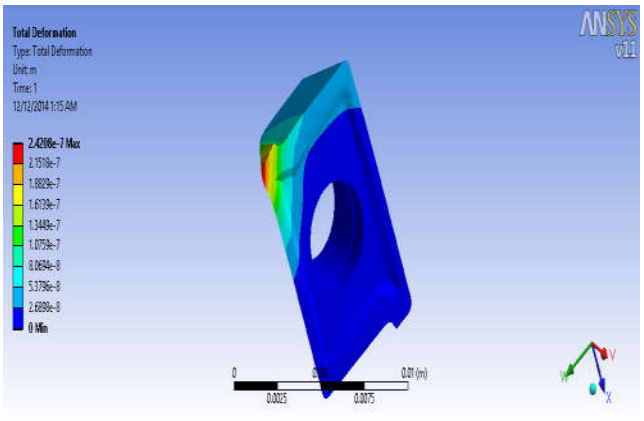

Fig. 5 Result of Deformation

Table 3. Values of deformation, stress and deflection

Deformation (mm)	Stress (N/mm^2) (ANSYS Results)	Deflection (mm)
2.4E-07	1.3669E7	2.6E-07
2.8E-07	1.597E7	3E-07
3E-07	1.692E7	3.2E-07
3.1E-07	1.5717E7	3.5E-07
3.2E-07	1.7786E7	3.6E-07
3.4E-07	2.0602E7	3.7E-07
3.4E-07	1.1839E7	3.9E-07
3.5E-07	1.6569E7	4E-07
3.8E-07	1.7639E7	4.2E-07

5. Regression equations

Regression model is used to generate the relation between input and output valus. The input values are machining parameters (speed, feed and depth of cut) and output values (deformation, stress and deflection). The linear regression models are shown in Equations 1, 2, 3 and 4.

Cutting force =14.816+0.00000*speed+0.090316*feed+5.54000*depth of cut -------- (1)

Deformation =1.75E-07+0.000*speed-1.7E-10*feed+1.67E-07*depth of cut --------- (2)

Stress =9970777+0.000*speed-9426.09*feed+9291333*depth of cut ---------- (3)

Deflection =1.86E-07+0.000*speed-1.8E-10*feed+1.87E-07*depth of cut -------- (4)

6. Result and Discussion

The model of the insert is designed in CATIA and analysis is carried out in ANSYS. The machining carried out in different machining levels and calculates the outputs of deformation, stress and deflection. The varies forces are applied in insert tip and values are identified. The average deformation, stress and deflection are plotted as a graph shown in Fig 6. Graph shows feed increases the cutting forces increased. Depth of cut increases average cutting force also increased. Cutting force is increased while increasing the feed and depth of cut because of softening of the work material and hardness of the tool. The Fig 7, 8 and 9 shows the deformation, stress and deflection values.

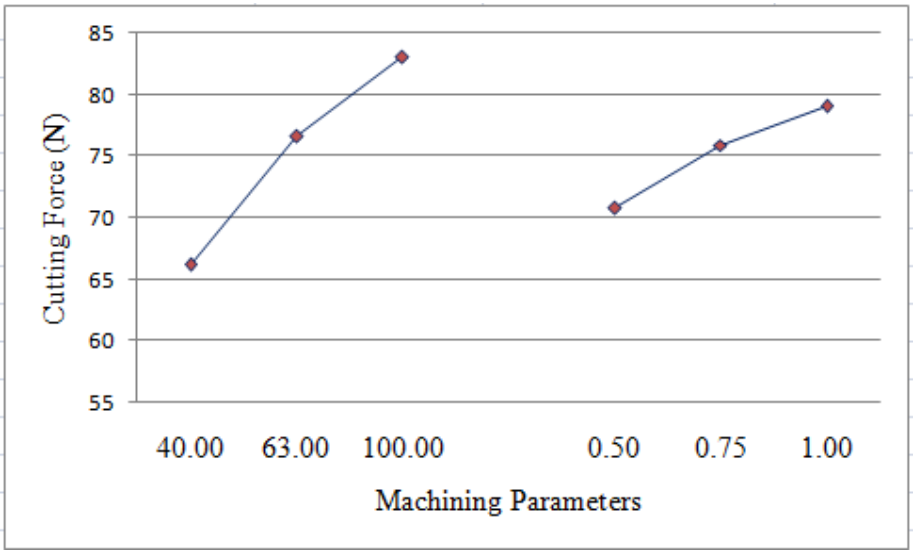

Fig 6. Depth of cut, feed and average cutting force

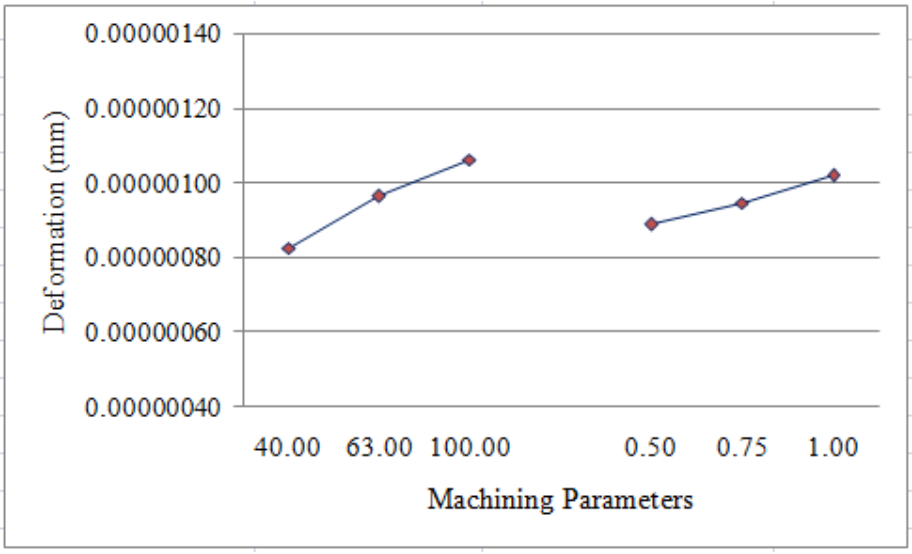

Fig 7. Machining parameters and deformation

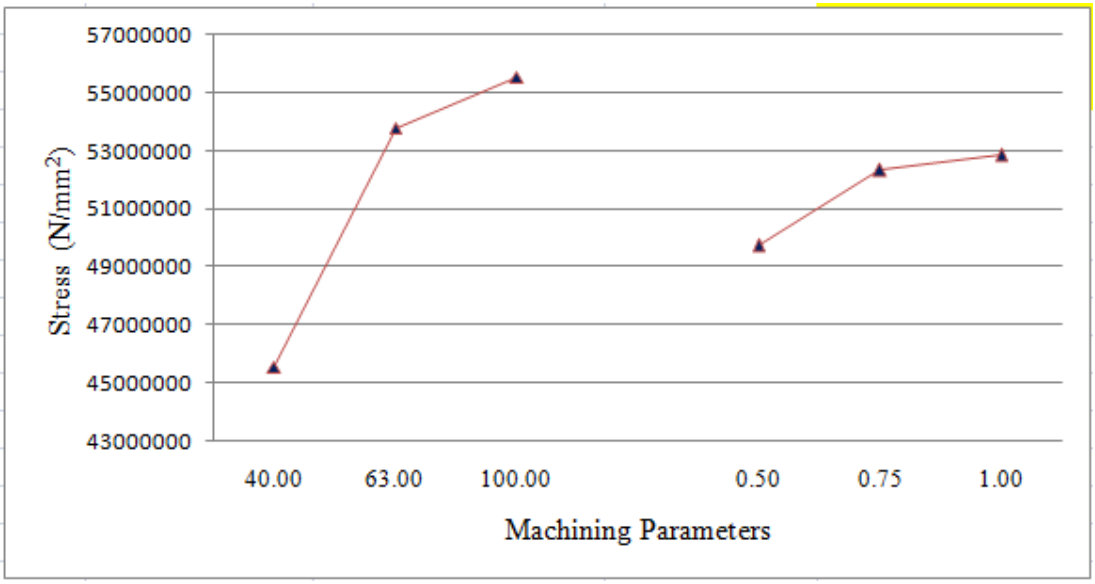

Fig 8. Machining parameter and average stress

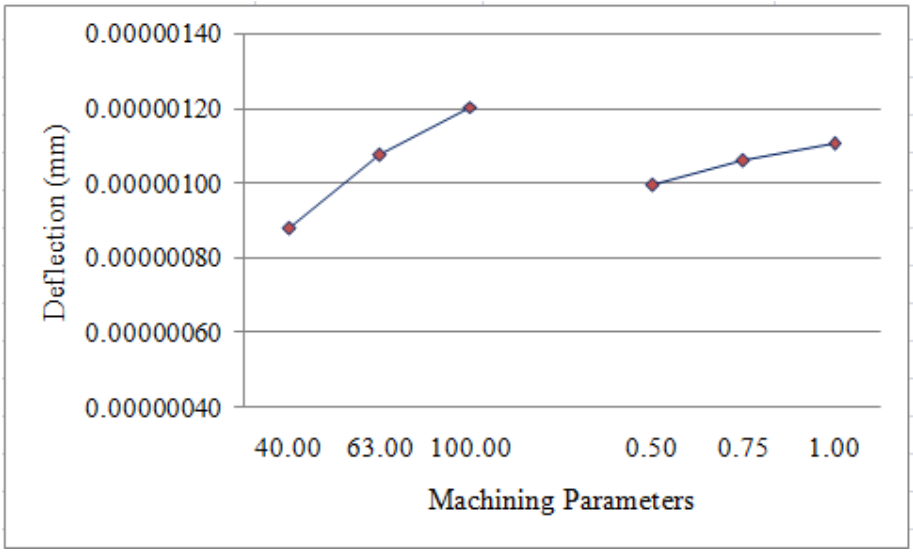

Fig 9. Machining parameters and deflection

6. Conclusions

This paper introduces an experimental and modeling study for end milling of AA 6082T6 aluminium alloy. The experimental measured forces are presented for various feed and depth of cut conditions. The cutting force, stress, deformation and deflection are observed at very low feed rate and depth of cut. Large force, deformation, stress and deflection are observed at high feed rate and depth of cut. A CATIA model created and analysed for end milling insert. The results are found to extend thermal FEM model to investigate end milling insert as future work.

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