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DESIGN AND THERMAL ANALYSIS OF SINGLE POINT CUTTING TOOL

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ABSTRACT

Temperature at tool-chip interface of a single point cutting tool is determined, generated in different speed machining operations.Specifically, three different analyses are comparing to an experimental measurement of temperature in a machining process at slow speed,medium speed and at high speed. In addition, three analyses are done of a High Speed Steel and of a Carbide Tip Tool machining process at three different cutting speeds, in order to compare to experimental resultsproduced as part of this study. An investigation of heat generation in cutting tool is performed by varying cutting parameters at the suitable cutting tool geometry. The experimental results reveal that the mainfactors responsible for increasing cutting temperature are cutting speed (v) and depth of cut (d) respectively. Various researches have been undertaken in measuring the temperatures generated during cutting operations. Investigators made attempt to measure these cutting temperatures with various techniques during machining.

KEY WORDS: ***Single Point Cutting Tool, HSS tool and Carbide tip tool, Centre lathe,Fluke IR Thermal Imager, Finite Element Analysis, Solid Modelling***

INTRODUCTION

A large amount of heat is generated during machining process as well as in different process where deformation of material occurs. The temperature that is generated at the surface of cutting tool when cutting tool comes in contact with the work piece is termed as cutting tool temperature. Heat is a parameter which strongly influences the tool performance during the operation. We know the power consumed in metal cutting is largely converted into heat. Temperature being developed during cutting it is of much concern as a result heat are mainly dependent on the contact between the tool and chip, the amount of cutting force and the friction between the tool and chip. Almost all the heat energy produced is transferred into the cutting tool and work piece material while a potion is dissipated through the chip.During machining the deformation process is highly concentrated in a very small zone and the temperatures generated inthe deformation zone affect both the work piece and tool. Tool wear, tool life, work piece surface integrity, chip formation mechanism are strongly influenced at high cutting temperatures and contribute to the thermal deformation of the cutting tool,which is considered as the largest source of error in the machining process.There has been a considerable amount of research devoted to develop analytical and numeric models in order to simulate metal cutting processes to predict the effects of machining variable such as speed, feed, depth of cut and also tool geometry on deformations of tool.Especially,

numerical models are highly essential in predicting Chip formation, computing forces, distributions of strain, strain rate, temperatures and stresses on the cutting edge and the machined work surface. Advanced process simulation techniques are necessary in order to study the influence of the tool edge geometry and cutting conditions on the surface integrity especially on the machining induced stresses. The objective is to analyse the temperature distribution on a tool of different materials at various machining parameters using analysis software ANSYS

DESIGN OF EXPERIMENT

In randomized complete block design, it is possible to reduce error variance by forming blocks such that the experimental units within the blocks are relatively more homogeneous with respect to the dependent variable of interest to the experimenter. The primary objective of creating the blocks is to eliminate from the experimental error the variation due to the differences between the blocks. The experimental units or the subjects correspond to plots and block comprises of k subjects that are fairly homogeneous with respect to a given variable. Here, each block will consist of k subjects matched on a given variable. Thus, the subjects within any block will be more homogeneous than the subjects that are selected at random. The objective of this local control is to create homogeneity within each of the r blocks and consequently heterogeneity between the blocks. The variation due to block differences is eliminated from the experimental error

DESIGN OF EXPERIMENT FOR HSS TOOL

In our case, experimental results are the temperature formed at the cutting tool tip face when machining at different speed and depth of cut. Here we analyse the error using the temperatures obtained for HSS tool at a time 10 seconds after machining starts. The analysis carried out for a significance level of 0.01.

LOAD AND BOUNDARY CONDITIONS

Structural loads and boundary conditions are applied as usual. Here we have four conditions.

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1. Cylindrical support for work piece
2. Longitudinal displacement of tool (63.7 mm)
3. Tangential displacement of tool (0.1 mm, 0.4 mm, 0.7 mm)
4. Speed of rotation of work piece (150 rpm, 420 rpm, 710 rpm)

4.7 PERCENTAGE DIFFERENCE BETWEEN MAXIMUM TEMPERATURES OBTAINED THROUGH EXPERIMENT AND FEA FOR HSS TOOL

Sl No	Feed (mm per rev)	Speed (rpm)	Machining Time (sec)	Depth of Cut (mm)	Max Expt Temp (°C)	Max FEA Temp (°C)	Percentage Difference (%)
1	0.52	150	49	0.1	67.6	69	2.03
2				0.4	104.4	108	3.33
3				0.7	152.4	155	1.68
4		420	17.5	0.1	78.4	77	1.79
5				0.4	109.6	112	2.14
6				0.7	158.6	160	0.875
7		710	10	0.1	81.6	84	2.85
8				0.4	124.6	127	1.89
9				0.7	167.6	170	1.41

Table 4.41 Percentage difference between max temperatures obtained for HSS tool

4.8 PERCENTAGE DIFFERENCE BETWEEN MAXIMUM TEMPERATURES OBTAINED THROUGH EXPERIMENT AND FEA FOR CARBIDE TOOL

Sl No	Feed (mm per rev)	Speed (rpm)	Machining Time (sec)	Depth of Cut (mm)	Max Expt Temp (°C)	Max FEA Temp (°C)	Percentage Difference (%)
1	0.52	150	49	0.1	75.4	77.02	2.10
2				0.4	111.8	115.03	2.81
3				0.7	159.4	162.05	1.64
4		420	17.5	0.1	82.8	85.025	2.62
5				0.4	119.2	117.04	6.36
6				0.7	167.6	169.06	0.86
7		710	10	0.1	86.8	90.027	3.58
8				0.4	127	129.04	1.58

Table 4.42 Percentage difference between max temperatures obtained for Carbide tool

FINITE ELEMENT ANALYSIS OF TOOL

Finite element analysis of single point cutting tool is carried out by using ANSYS, a powerful general purpose finite element analysis package. Ansys is a finite element analysis package to numerically solve a wide variety of mechanical, structural and non-structural problems.These problems include static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid problems as well as acoustic and electromagnetic problems. In this project we carried out thermal analysis of a single point cutting tool using Ansys. Thermal analysis is used for determining the temperature distribution and quantities such as thermal distribution, amount of heat loss or gain, thermal gradient, thermal fluxes etc. The problem analysing here is basically a multiphysics coupling (structural thermal). Usually, physics coupling is ignored or simplified. Simulation engineers are usually using single-physics. Because coupled analyses are more computationally intensive. However, coupled analyses provide more realistic results. ANSYS Workbench is designed to make it easier to simulate multiphysics coupling.

CONCLUSION

1. Using ANOVA table, the speed is the most significant parameter followed by depth of cut for rising the temperature during machining.The percentage contribution obtained for HSS tool and Carbide tool as, HSS tool - Speed: 70.25%, Depth of cut: 28.88% Carbide tool - Speed: 69.86%, Depth of cut: 29.75%
2. Compared the results obtained from experiment and finite element analysis, the results were validated.The difference in temperature obtained for HSS tool and Carbide tool as, HSS tool - not more than 4% Carbide tool - not more than 7%
3. It can be observed that an increase of the cutting speed produces an increase of the cutting temperature. This result is due to the fact that an increase of the cutting speed

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