Analysis of Single Point Cutting Tool

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Abstract - *Temperature at tool-chip interface of one purpose cutter is set, generated in numerous speed machining operations. Specifically, 3 completely different Associate in analyses are comparison to an experimental mensuration of temperature during a machining method 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 results produced as part of this study. An investigation of thermal energy generation in cutter is performed by varied cutting parameters at the acceptable cutter pure mathematics. The experimental results reveal that the most factors to blame for increasing cutting temperature are cutting speed (v) and depth of cut (d) severally.

Various researches have been undertaken in measuring the temperatures generated during cutting operations.

Investigators created arrange to live these cutting temperatures with varied techniques throughout machining.

"Fluke IR Thermal Imager" is employed for mensuration temperature at tool-chip interface. Single point cutting tool has been solid modelled by using SOLIDWORKS 2013 and Finite Element Analysis carried out by using ANSYS Workbench 15. By varied parameters the result of these on temperature are compared with the experimental results and FEA results.

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

1. INTRODUCTION

A large quantity of warmth is generated throughout machining method additionally as in numerous method wherever deformation of fabric happens. 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 could be a parameter that powerfully influences the tool performance throughout the operation.

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 area unit extremely 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 method simulation techniques area unit necessary so as to review the influence of the tool edge pure mathematics and cutting conditions on the surface integrity particularly on the machining iatrogenic stresses.

The objective is to analyse the temperature distribution on a tool of different materials at various machining parameters using analysis software ANSYS.

2. OBJECTIVE OF STUDY

- Study and comparison of temperature distribution on a single point cutting tool of different materials at various machining parameters.
- Modelling and finite element analysis of single point cutting tool.
- Comparison of experimental data with finite element analysis data for the tool.

There are different materials used for cutting tool such as HSS, cemented carbides, diamond etc. and the various machining parameters associated with the tool are cutting speed, feed and depth of cut. So in order to study the temperature distribution on the single point cutting tool we select different cutting tool materials and various machining parameters.

For carrying out the finite element analysis on the single point cutting tool Firstly we modelled the single point cutting tool using suitable modelling software. There are different modelling software are available such as AutoCAD, CATIA, SolidWorks, Pro/E etc. After modelling is done, this modelled single point cutting tool is imported into suitable finite analysis software such as ANSYS. So by providing suitable boundary conditions the finite element analysis of single point cutting tool is done. After finite element analysis, we compare the results obtained with experiment and finite element analysis data for the tool.

3. PROJECT METHODOLOGY

Since there are a large number of variables controlling the process, some Experimental models are required to represent the process. In order to achieve the, FEA analysis of the experimental results will have to be proceed using the analysis (ANSYS). ANSYS is a computational technique that enables the estimation of the relative contributions of each of the control factors to the overall measured response. In the present work, only the significant parameters are used to develop relation between temperature and various parameters like speed, depth of cut and feed. These models are great use during the optimization of the process variables.

Table -1: Experiment results for HSS tool

Speed (rpm)	Depth of Cut (mm)			Total Sum
	0.1	0.4	0.7	
150	34	70	115	937
	33	72	116	
	32	70	114	
	35	70	115	
	34	72	116	
420	73	96	148	1451
	72	94	146	
	73	95	145	
	71	94	146	
	72	95	145	
710	81	123	165	2144
	82	125	169	
	83	125	168	
	80	124	169	
	82	126	167	
Total Sum	1098	1565	1869	**4532**

The computation procedures of the design of experiment for HSS tool are given below:

i. Correction Term, C = (4532)2/45
= **456422.76**

ii. Total sum of squares, SS_{total} = (34)2 + (33)2+……… + (167)2 – C
= 526056 – 456422.76
= **69633.24**

iii. DOC sum of squares, SS_{DOC} = (1098)2/15 + (1565)2/15 + (1869)2/15 – C
= 476532.67 – 456422.76
= **20109.91**

iv. Speed sum of squares, SS_{Spd} = (937)2/15 + (1451)2/15+ (2144)2/15 – C
= 505340.4 – 456422.76
= **48917.64**

v. Speed*DOC sum of squares, $SS_{DOC*Spd}$ = (168)2/5 + (361)2/5 + ……+ (838)2/5 - C - SSDOC–SS_{Spd}
= 526010 - 456422.76 - 20109.91 - 48917.64
= **559.64**

vi. Error sum of squares, SS_{error} = SS_{Total} - (SS_{DOC} -SS_{Spd}- $SS_{DOC*Spd}$) = 69633.24- (20109.91+48917.64 + 559.69)
= **46**

Table -2: Experiment results for Carbide tool

Speed (rpm)	Depth of Cut (mm)			Total Sum
	0.1	0.4	0.7	
150	37	71	118	1006
	39	71	119	
	40	72	120	
	39	73	119	
	38	72	119	
420	75	102	153	1509
	76	102	153	
	77	103	154	
	75	104	153	
	76	104	155	
710	87	127	176	2239
	88	128	175	
	86	127	176	
	86	128	174	
	87	127	175	
Total Sum	1147	1662	1945	**4754**

The computation procedures of the design of experiment for Carbide tool are given below:

i.Correction Term, C = (4754)2/45
=**502233.69**

ii. Total sum of squares, SS_{Total} = (37) + (39)2+……… + (175)2 – C = 575588N–502233.69
= **73354.31**

iii. DOC sum of squares, SS_{DOC} = (1147)2/15 + (1662)2/15 +(1945)2/15 – C = 524058.53 – 502233.69
= **21824.84**

iv. Speed sum of squares, SS_{Spd} = (1006)2/15 + (1509)2/15+ (2239)2/15 – C = 553487.52 – 502233.69
= **51248.84**

v. Speed*DOC sum of squares, $SS_{DOC*Spd}$ = (193)2/5 + (359)2/5 + ……+ (876)2/5 - C - SS_{DOC}–SS_{Spd} = 575560.4 – 502233.69 –21824.84 – 51248.84
= **253.03**

vi. Error sum of squares, SS_{error} = SS_{Total} - (SS_{DOC} -SS_{Spd}- $SS_{DOC*Spd}$) = 73354.31- (51248.84+ 21824.84+ 253.03) = **27.6**

4. 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 analyzing here is basically a multi-physics coupling (structural thermal).

Table -3: Main Dimension of Tool and Workpiece

	Cutting Tool	Work piece
Material	High Speed Steel Tungsten carbide	Mild Steel
Cross-section	13*101.98 mm Side and end cutting edge angles: 30 ° End relief angle: 20°	Ø23*63.7 mm

4.1 Material of HSS Tool

- The cutting material used is T15 super high speed steel.
- The temperature dependent properties of tool are summarized below and the other properties are also given below.

Table -4: Properties of T15 Super High Speed Steel

S l No.	Temperature (°C)	Density (kg/m³)	Thermal Conductivity(w/mK)	Specific Heat(J/kgK)
1	0	8190	19	418.68
2	50	8186	20	420
3	75	8183	22	425.36
4	100	8179	23	430.45
5	120	8177	25	436.25
6	175	8172	26	442.57
7	200	8168	28	445.68
8	220	8162	30	448.35

4.2 Material of Carbide Tool

- The cutting tool tip material used is C20 Tungsten Carbide.
- The temperature dependent properties of tool are summarized below and the other properties are also given below.

Table -5: Properties of C20 Tungsten

Sl No	Temperature (C)	Density (g/cm³)	Thermal Conductivity (w/mK)	Specific Heat(J/kgK)
1	0	14.90	84	210
2	50	14.70	84.5	212.3
3	75	14.67	85	213.5
4	100	14.62	85.5	214
5	150	14.58	87	215.8
6	175	14.55	87.4	216.8
7	200	14.45	87.8	217.3
8	230	14.40	88.2	218

5. RESULT

Table -6: Percentage difference between max 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 -7: Percentage difference between max 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
9				0.7	175.2	174.06	0.65

6. CONCLUSION

1. Using ANOVA table, the speed is the most important parameter followed by depth of cut for increasing 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 data 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 too - not more than 7 % produces an increase of the cutting forces. More energy is needed to remove the material away increasing the cutting temperature.

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.

4. It can be observed that an increase of the depth of cut produces an increase of the cutting temperature. When a material is plastically deformed, most of the energy is turned into heat since the material is subject to extremely severe deformations; being the elastic deformation the ones that represents a small part of the total deformation. Hence, the increase of depth of cut represents a bigger compression in the tool-work piece interface this will increase the energy supplied to the system during the cut of the material.

5. In both experiment and finite element analysis, the temperature formed during machining is more in carbide tool than in HSS tool. So the chances for tool wear or tool failure is more in carbide tool than in HSS tool at same cutting conditions.

7. REFERENCES

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