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Design & Thermal Analysis of Single Point Cutting Tool by Using Ansys Workbench

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Abstract: *At numerous operational cutting speed of lathe, temperature of the tool-chip interface is decided experimentally and modelled. Specifically, Analyses are done of High Speed Steel and of a Carbide Tool tip machining technique at three varying cutting speeds, so as to examine to experimental outcomes produced as part of this study. Heat generation during cutting operation at tool chip interface is investigated by varying cutting parameters at the suitable cutting tool geometry. The experimental readings shows that the elements which can be accountable for increasing cutting temperature are cutting speed, depth of cut and feed respectively. Various methods can be used to calculate those cutting temperatures generated all through machining. "Infrared Thermometer" is mostly used for measuring temperature at tool-chip interface. Single point cutting tool has been modelled and analyzed with the help of ANSYS.*

Key Words: *HSS Tool, Carbide Tool, Thermal Analysis, Ansys etc.*

1. INTRODUCTION:

A great amount of heat is generated during machining process and also in different process where deformation of material occurs. The temperature generated at the surface of cutting toolwhen cutting tool comes in contact with the work piece is cutting tool temperature. Heat is a factor which greatly influences the tool performance of the tool during the operation. The power consumed in metal cutting is mostly converted into heat. Temperature that generated during cutting process is mainly dependent on the contact between the tool and chip, cutting force and friction between the tool and chip. Largely all of the generated heat is transferred to the cutting tool and workpiece material and a cutting portion is dissipated through the chip. During machining the temperatures generated in the deformation zone affect both the work piece and tool. The biggest supply of mistakess withinside the machining technique happens at excessive temperatures and contributes to the thermal deformation of the cutting tool and highly impacts tool wear, toollife, work piece surface integrity, chip formation mechanism.

Many researcher works are devoted to develop analytical and numeric models to simulate metal cutting processes and the effects of machining variable such as cutting speed, feed and depth of cut. Numerical models are relatively vital in predicting forces, chip formation, strain distributions, strain rate, temperatures and stresses at the cutting edge. To study the influence on the tool edge geometry and cutting conditions on the surface integrity especially on the machining induced stresses advanced simulation techniques are used.

2. LITERATURE REVIEW:

Joao Roberto Ferreira [1] studies the heat influence in cutting tools considering the variation of the coating thickness and the heat flux. K10 and diamond tools substrate with TiN and Al_2O_3 coatings were used. The numerical methodology utilizes the ANSYS CFX software. Boundary conditions and steady thermo physical properties of the solids involved withinside the numerical analysis are known. To validate the proposed methodology an experiment is used.

M. Hameedullah [2] developed first and second order mathematical models in terms of machining parameters by using the response surface methodology on the basis of the experimental results. The experiment was turning of EN-31 steel alloy with tungsten carbide inserts using a tool-work thermocouple technique. The results are analysed statistically and graphically.

P.D. Kamble [3] studied the processes for modelling the turning technique for EN-24 kind of steel. In this study, a Finite Element Analysis software Deform 3D is used to study the effects of cutting speed, feed rate, and type of alloy steel in temperature behavior. The work-piece is modelled as Elastic-plastic material to take thermal, elastic, plastic effect. Work-piece is represented by a liner model with different length for each condition.

Shreepad Sarange [4] provided a method with the intention to determine cutting tool forces and temperatures to be used in finite element simulations of metal cutting processes. From the experimental set up, it's actually determined that as depth of cut increases, the temperature generated withinside the cutting tool on the tool tip additionally increases. It is likewise determined that, as the depth of cut increases, cutting forces are also increases. It is main reason of tool failure.

Mohd. Razik [5] conducted three analyses using a High Speed Steel and of a Carbide Tip Tool at three different cutting speeds, in order to compare the experimental results produced. The experimental outcomes reveal that the primary elements accountable for increasing cutting temperature are cutting speed (v), feed rate (f), and depth of cut (d), respectively.

3. OBJECTIVES:

Heat is a factor which exceedingly impacts the overall tool performance in the course of the operation. So the knowledge of temperature distribution on the tool is required for improving machining operation. Thus the main objectives of project are as follows:

1. To study and compare the temperature distribution on a single point machining tool made of different materials at different parameters.
2. To model the single point machining tool.
3. To compare of experimental data.

Different types of materials are used for cutting tools which includes HSS, cemented carbides, diamond etc. and different parameters associated with these tools are cutting speed, feed and depth of cut. So we can select various materials and parameters to study the temperature distribution on the single point machining tool. Also thermal analysis can be carried out by modeling the single point machining tool and analysis in ANSYS and then comparing the results with the experimental data.

4. METHODOLOGY:

4.1 Experimental Setup

The experiment was conducted under dry conditions on a three jaw centre lathe. Lathe gets rid of undesired portion of material from a rotating work piece in the form of different shape of chips with the assist of cutting tool that is traversed throughout the workpiece and may be fed deep into the workpiece. A hole was drilled on the face of work piece to allow it to be supported at the tailstock.

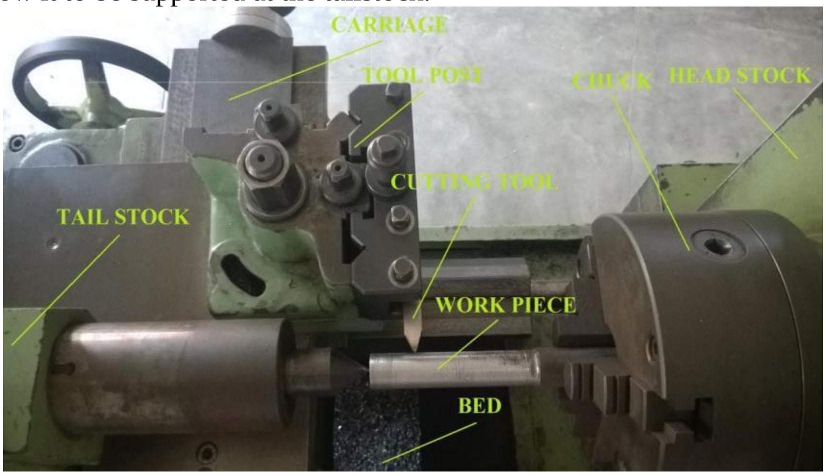

Figure 1. Experimental setup

The work piece used as cylindrical soild rod of Mild Steel as a diamension of (Ø23*63.7 mm).The cutting tool used as High Speed Steel and Carbide Tip Tool (13*101.98 mm). The machining is carried out at different speed and depth of cut. Feed may be kept as constant. The settings ofthe main machining parameters are summarized in Table

Tabel 1. Machining Parameter & Values

Parameters	Value
Feed (mm/rev)	0.5
Speed (rpm)	150, 420, 710
Depth of cut (mm)	0.1, 0.4, 0.7

4.2 Design of experiments 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.The table of subjects of the design of experimentfor HSS tool.

Table 2. Design of Experiment of 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**

4.3 Design of experiments for carbide tool

Table 3. Design of Experiment of CarbideTool

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**

5. DESIGNE & ANALYSIS OF CUTTING TOOL:

5.1 Modelling of Cutting Tool

The single point cutting tool has been solid modelled by using SOLIDWORKS, a solid modelling computer aided design software. Solidworks software is a soild modeller, and makes use of parametric feature -based approach to create different models and assemblies.

1. Modelling of HSS Tool

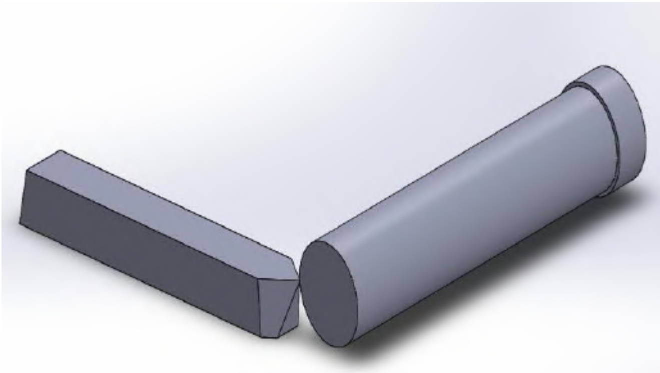

Fig. 2 Modelling of HSS Tool

2. Modelling of carbide tool

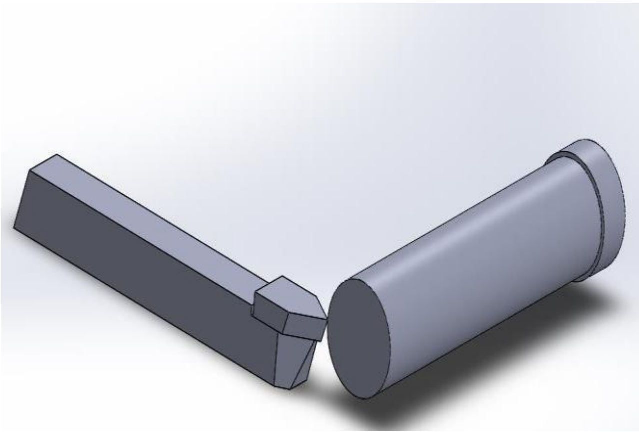

Fig. 3 Modelling of Carbide Tool

5.2 Finite element analysis of HSS Tool

The geometry is modelled using SOLIDWORKS and then it is imported into ANSYS WORKBENCH

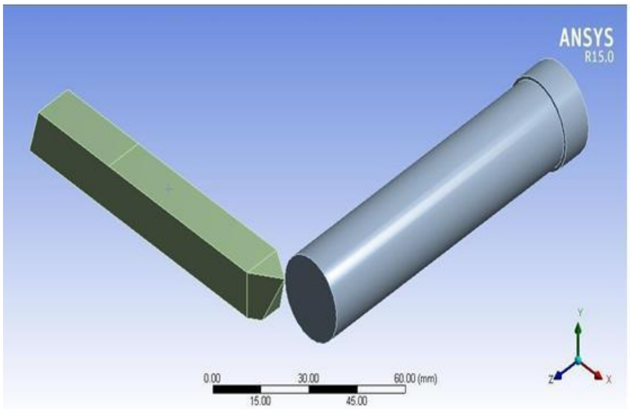

Fig.4. Geometry of HSS tool

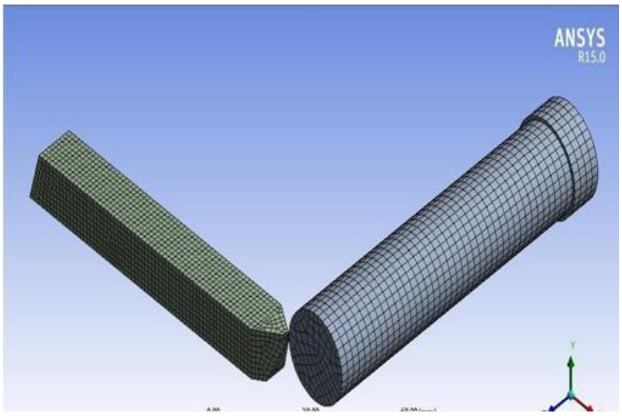

Fig.5 Meshed Geometry of HSS tool

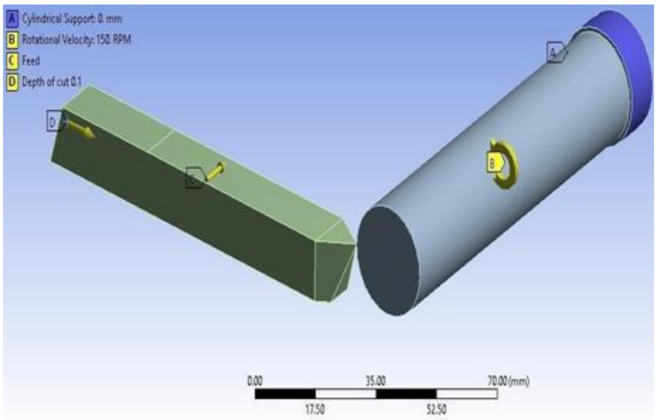

Figure.6 Load and boundary conditions for HSS tool

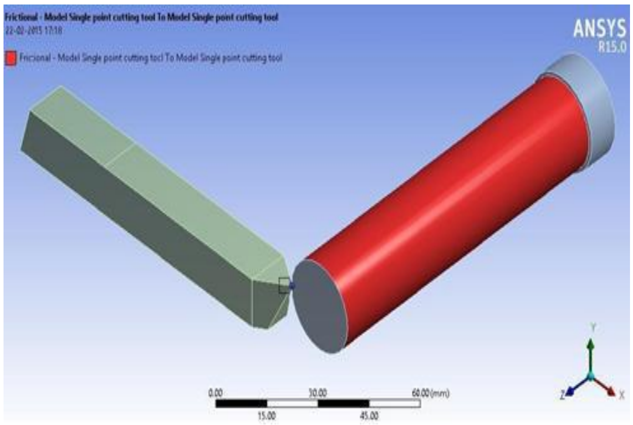

Fig.7 Frictional model of HSS tool

Basically the cutting material used in this project work as T15 super high speed steel. The temperature dependent properties of tool are summarised below in Table.4

Table.4 Temperature depedent properties of HSS Tool

Sr 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

5.3 Finite element analysis of Carbide Tool

The geometry is modelled using SOLIDWORKS and then it is imported into ANSYS WORKBENCH

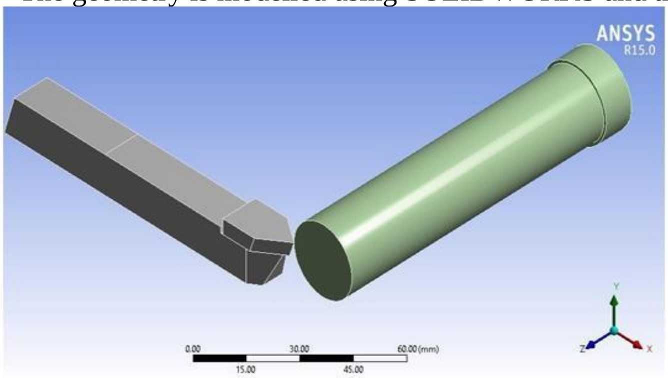

Fig.8. Geometry of Carbide tool

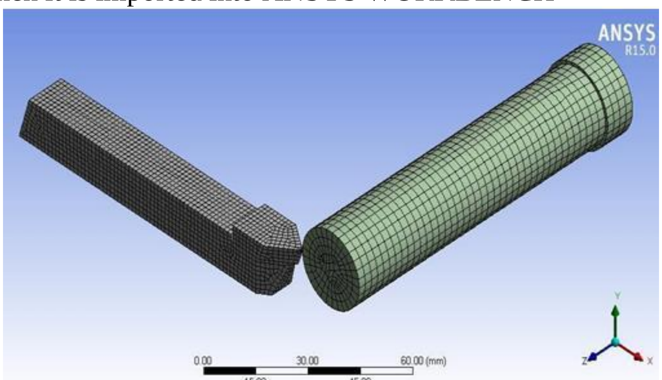

Fig.9 Meshed Geometry of Carbide tool

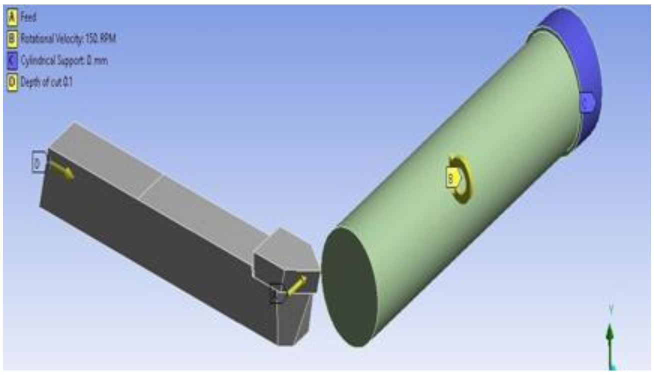

Figure.10 Load and boundary conditions for Carbide tool

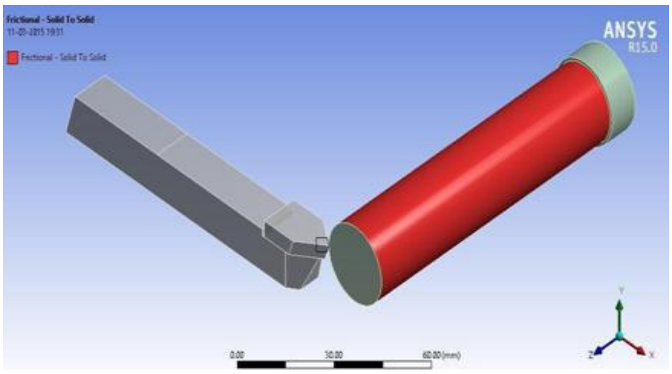

Fig.11 Frictional model of Carbide tool

Basically the cutting tool tip material used is C20 Tungsten Carbide. The temperature dependentproperties of tool are summarised below in Table 5

Table.5 Temperature depedent properties of Carbide Tool

Sr 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& DISCUSSION:

Percentage difference between maximum temperatures obtained through experiment and FEA (Finite Element Analysis) for HSS Tool

Sr 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

Percentage difference between maximum temperatures obtained through experiment and FEA (Finite Element Analysis) for Carbide Tool

Sr 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

From the ANOVA table, it is clear that speed is the most significant parameter followed by depth of cut. However the interaction of speed*depth of cut has least effect.

8. CONCLUSION:

8.1 Summary

Temperature at tool-chip interface of a single point cutting tool of High Speed Steel and Carbide Tip is determined, generated in a machining process at slow speed, medium speed and at high speed. Fluke IR Thermal Imager is used for measuring temperature at tool-chip interface. Single point cutting tool has been solid modelled via way of means of the usage of SOLIDWORKS 2013 and Finite Element Analysis carried out by using of ANSYS Workbench 15. By varying speed and depth of cut, the effect of those on temperature are compared with the experimental results and FEA results. After comparison nearly 7% variation is found in between the results. Also the results display that the primary elements responsible for increasing cutting temperature are cutting speed (v) and depth of cut (d) respectively.

8.2 Conclusion

1. 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. Comparing 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%

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