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Experimental Study on the Thermal Behavior of Multi-Point Cutting Tool in Drilling Machine with Different Parameters

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Abstract:

As we know very well that drilling is used for enlarge the hole and to drill anything. Temperature distribution curve affects both drill bit performance and most important the workpiece properties which is to be obtained. A cemented carbide drill with diameter 10 mm is studied and work piece material is assumed as aluminium die-cast alloy (AISI-1045). The study calculates the trends of temperature with respect to feed rate, cutting speed, radius of cutting tool and duration of cutting. The results are almost similar to the experimental temperature of the drill tip. The study has also calculated the range of parameter in which the model might give accurate result. Conclusion find out is that the experimental temperature and observed in these four cases like feed rate, radius, cutting speed, and cutting time. The experimental temperature and observed temperature is near about to same in context of these three conditions like feed rate, radius and cutting speed buttemperature slightly change in starting case of cutting temperature which is up to 25 sec.

Keywords- drill bit, cutting speed, feed rate, cutting time, temperature, AISI-1045

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I. INTRODUCTION

We know drilling is one of the machining processes that used in manufacturing process to enlarge the hole or to drill something. When a drill tool bit came in contact with work piece the tool tip temperature affects the workpice properties and cutting tool performance due to its different temperature distribution curve obtained by doing tool tip temperature study after performing a statistical approach. Based on the facts of previous studies and experiments of the said problem, the temperature affects most of workpiece, the sensitivity of enlarged hole, surface roughness and even create a tool wear i.e. a major problem. And different cutting parameters like cutting feed, cutting speed, radius of tool bit, and cutting time affects which needs to be studied. So a comparison is put forward for the experimental values that done in numerous previous studies and an observed one.

If the temperature analysis is not done then it is more difficult to calculate in %age how temperature affects most of the tool performances and workpiece properties so it is necessary that an analysis should be done on previous studies and a self-observation should be taken throughout the study so a tool temperature study is performed below.

II. TOOL TIP TEMPERATURE STUDY

The temperature of said tool tip is found out by the temperature equation. The section which summarize the analytical results of temperature equation given by Agapiousand Stephenson (1994), here flank wear if neglected, there are two different sources of metal cutting first one is primary shear zone and second is tool-chip interface. At primary shear zone, plastic deformation takes place and on tool chip interface frictional heating occurs most. Let's divide the cutting edge into N segments where we assume conduction if occurred between them is neglected. At the i_{th} segment which is at a radial distance $r_i$from the axis of drill, the temperature equation from above two said sources is given in the following equation:

$$T_{int}= T_O+\Delta T_f(r)+\Delta T_S(r); \qquad (1)$$

where these are the temperature rising due to ambient, shearing and due to frictional heating where shear zone temperature (T_s) is given by:-

$$\Delta T_s(r) = \frac{R_1(r)\cdot\tau\cdot A_s(r)\cdot V_s(r)}{\delta\cdot c\cdot A\cdot V_s} \qquad (2)$$

And for applying the force to drilling we have must need the following data as possible:-

$$A_s(r) = \frac{t(r)\cdot w}{\sin\phi(r)} \quad (3)$$

$$V_s(r) = \frac{V(r)\cdot \cos\alpha(r)}{\cos[\phi(r)-\alpha(r)]} \quad (4)$$

In the equation 2, the $R_1(r)$is the shear energy proportion

S. No.	Name of constant	Assumed values
1	Density of workpiece material	7.8 (g/cm³)
2	Specific heat of workpiece material	432.6 (J/kg/°C)
3	Thermal conductivity of workpiece	47.7 (W/m/°C)
4	Coefficient of friction	0.64
5	Width of cut	5.83 mm
6	Half web thickness	0.70 mm
7	Helix angle	30°
8	Uncut chip thickness	0.042 mm
9	Half point angle	59°
10	Area of cutting tool	0.585 mm²
11	Shear stress	585 (Mpa)
12	Density of cutting tool material	15 (g/cm³)
13	Specific heat (c) of cutting tool material	203 (J/kg/°C)
14	Thermal conductivity (K) of cutting tool	46 (W/m/°C)

which transported by the chip. As shown by Agapiou and Devries (1990a)[3], equations can be formed by comparing solution for a friction slider on infinite half-space (jaeger, 1943) with the expected temperature rise for bulk heating; for the transient case, the result is:

$$R_1(r) = \frac{1}{[1+B_{ss}(r)]} \quad (5)$$

Where

$$B_{ss}(r) = 1.329\ \frac{\sqrt{K_w\cdot V_s(r)/\delta\cdot C}}{\cos\lambda(r)\sqrt{t(r)\cdot V(r)}\cdot\sin\phi(r)}$$

The temperature rise due to friction $T_f(r)$ is given by:-

$$\Delta T_f(r) = 2\cdot[1 - R_{2t}(r)\cdot Q_{friction}\cdot L_1(r)] \quad (6)$$

In equation (6) where $R_{2t}(r)$ is the proportion of then shear energy transported L_1 is the length of cutting tool and L_2 is the length of workpiece.

$$L_1(r) = \sqrt{t_1(r)/\pi\cdot K_t\cdot \delta t\cdot C_t}$$

$$L_2(r) = \sqrt{L_c(r)/V_c(r)\cdot K_w\cdot \delta w\cdot C_t}$$

$$R_{2t} = \frac{L_1(r) - \Delta T_s(r)/\,2Q_{friction}}{L_1(r) + L_2(r)}$$

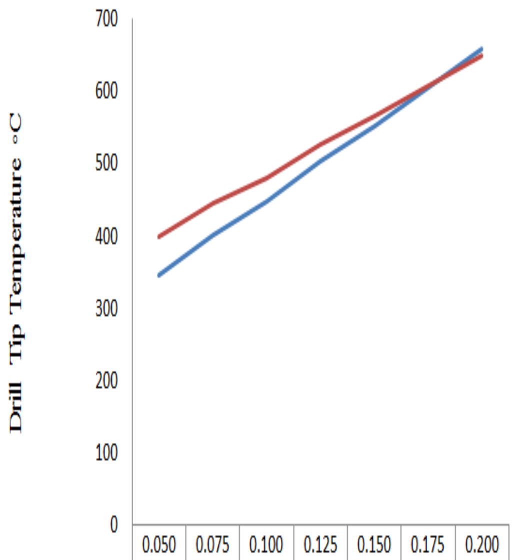
To solve the temperature equation, we consider some constant parameters of work piece and cutting tool in the following table;

III. RESULTS AND ANALYSIS

In this research work, thermal analysis of multipoint cutting tool in drilling machine for (feed rate, cutting speed, radius and cutting time) have been carrying out. The mathematical equation is solved in MATLAB, for thermal analysis of drill tool. The program is executed for above mentioned problem. The result is obtained and they are compared with the experimental results. The temperature is also calculated at 5 to 10 points lie at different radial distance form center of the tool. The results are also compared at 5% significant level with the help of Chi-square test. The study also identify the range in which this analytical model wok accurately.

Drill tip temperature variation withfeed:-

Figure 1 belowshows the experimental temperature and calculated temperature is linearly increases with the feed rate. Both the graph is almost conside with each other. There is a very small difference between the experimental temperature and calculated temperature for a particular feed rate. At some instant both the graph gives same temperaturevalue.

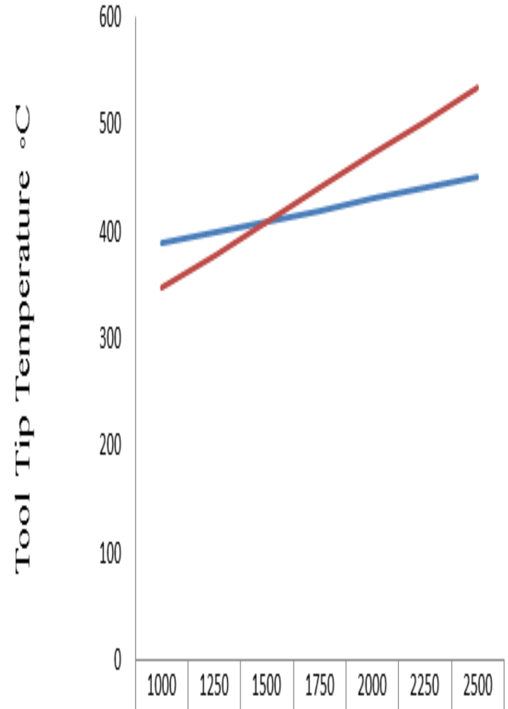


	0.050	0.075	0.100	0.125	0.150	0.175	0.200
Observed Temperature	345.18	400.35	447.58	502.85	553.13	606.34	658.66
Experimental Temperature	400	444.65	481.3	525.95	565.13	608.15	649.8

Fig. 1:- Variation of drill tip temperature with feed rate

The experimental temperature be start to rise at 350°C to 600°C at constant cutting speed 1000 rpm, cutting time 150 seconds, radius 5mm and feed rate varying from 0.05mm/revto 0.2 mm/rev and calculated temperature is also raise at the same cutting parameter near about 400°C to 610°C.

Drill tip temperature variation with cuttingspeed:

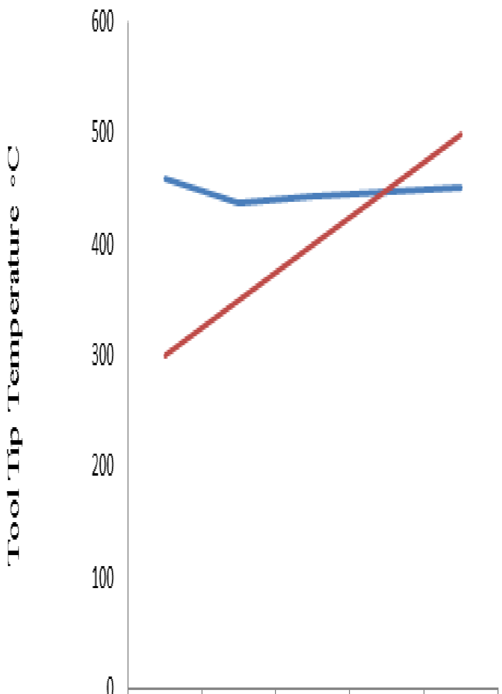


	1000	1250	1500	1750	2000	2250	2500
Observed Temperature	389.08	399.63	410.1	420.5	430.89	441.25	451.8
Experimental Temperature	347.5	378.75	410	441.25	472.5	503.7	535

Fig. 2:- Variation of drill tip temperature w.r.t. cutting speed

Figure shows above that the experimental temperature and observed temperature is continuously linearly increases with the cutting speed. Both the temperatures are making a little difference between them at the beginning of the graph but the difference is incessantly decreases and cross each other. After that the experimental temperature and observed temperature over again made some difference due to increase of cutting speed. As shown in graph observed results are precise to the experimentalresults. The experimental temperature starts rising at 347.5°C to 535°C at constant feed 0.2 mm/rev, cutting time 150 seconds, radius 5mm and cutting speed vary 1000 rpm to 2500 rpm and calculated temperature also rises at the same cutting parameter near about 389.08°C to 451.8°C.

Drill tip temperature variation with radial distance:



	1	2	3	4	5
Observed Temperature	458.8647	436.8655	442.7468	447.61	451.19
Experimental Temperature	300	350	400	450	500

Fig. 3:- Variation of drill tip temperature with radial distance

Shows the experimental temperature and observed temperature is continuing linearly increases with the radial distance. Both the temperatures are make a few differences between them at begin of graph but the difference is incessantly decreases and they cross each other. After that the experimental temperature and observed temperature over again made some difference due to increase of radial distance. As show in graph observed results are precise to the experimental results. The experimental temperature starts rising at 300°C to 500°C at constant feed 0.2 mm/rev, cutting time 150 seconds, cutting speed 1000 rpm and radius of cutting too vary from 1mm to 5mm and calculated temperature also rises at the same cutting parameter near about 458.86°C to 451.19°C

Drill tip temperature variation with cuttingduration (t):-

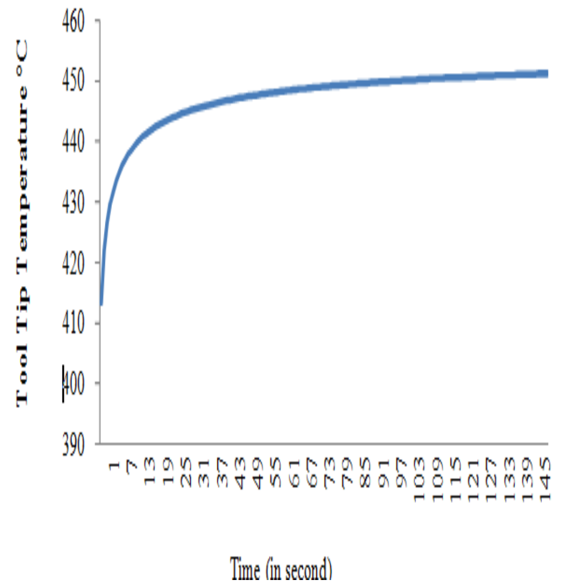


Fig. 4:- Variations of drill tip temperature wrt. Cutting duration

Similarly we found the relationship of tool tip temperature with time. Fig above shows the observed temperature rapidly increases from 413.22°C to 443.19°C at 1-25 seconds. After 443.19°C the tool tip temperature slightly increases with time and reach to its maximum temperature 450°C. All these calculations are found out at the constant cutting speed of 2300 rpm, feed rate 0.1 mm/rev and radius5mm.

IV. CONCLUSIONS

The experimental temperature and observed temperature continuously increases at 350°C to 600°C or 400°C to 610°C with the feed rate and the calculated value & experimental temperatures are similar in the range of 0.08 to 0.2 mm/rev of feed rate.

The experimental temperature and observed temperature continuously increases at 347°C to 535°C or 380°C to 451°C with the cutting speed and the calculated value & experimental temperatures are similar in the range of 1150 to 1950 rpm.

The experimental temperature and observed temperature continuously increases at 300°C to 500°C or 444°C to 455°C with the radius and the calculated value & experimental temperatures are similar in the range of 3.1 to 4.7 mm.

The calculated temperature increases from 413.22°C to 443.19°C at 1 second to 25 second after 443.19°C temperature time curve is constant. All these calculations are find out at the constant cutting speed 2300 rpm, feed rate 0.1 mm/rev and radius 5mm.

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