Reducing the Temperature of Machining Tool by using Heat Pipe

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ABSTRACT

Tool wear of machine tools and large usage of lubricants is the major problems in machining process during manufacturing. Tool life and temperature have an inversely proportional to each other, namely that the lower the temperature at the tool-chip interface is, the higher the tool life will be, and vice-versa. This paper investigates the performance of a cutting tool implanted with and without heat pipe on reducing cuttingtemperature and surface roughness of work piece. The temperature of a tool plays an important role on surface finish of work piece and accuracy of workpiece, as well as life of tool in machining. Animplanted heat pipe technology has been developed to efficientlyreduce the heat produced at the tool–chip interface in machining, thereby, reducing temperature of tool life and increase tool life. Compared with dry turning and fluid cooling, the results indicate considerable benefit of heat-pipe-helped cooling on cutting temperature, tool wear, and tool life. This may be mainly credited to the fact that the heatpipe cooling can ease the cutting temperature at the tool tip and especially the difference of temperatures between thecuttingedgeandthebulkoftheinsert byimprovingheat dissipation.Trials should be carried out in both with and withoutheat pipe in machining and the temperature of tool will be measured.Initial experiments were carried out using an air cooled heat pipe and an attempt was made to measure the improvement in cutting operation that can be achieved when the air cooled heat pipe was replaced by a water cooled heat pipe.

Keywords: ***Cutting Temperature, Heat pipe, Surface Roughness, Dry Turning.***

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1. Introduction

Machining is an important manufacturing process in industry. The purpose of a machining process is to produce a surface having a quantified shape and surface finish of product, and to prevent tool wear that leads to geometric imprecision of the finished part. Hard turning process integrallyproduces high cutting temperature due to dry turning of the work piece and the generating of high friction at the tool–chip and the tool–work interface. The tool life is commonly improved by supplying large quantity of coolant. The objective of this effort is to contribute to the important understanding of the application heat pipe technology in metal cutting that can effectively carry away the heat generated at the cutting tool point in machining, and thus reduce wearing to tool and increase life of tool. Because the use of the heat pipe cooling system may reduce the need for lubricant in manufacturing, the pollution and impurity of the environment by coolants, and the health problems related to skin exposure and particulate breathing in manufacturing can be efficiently minimized.

In machining process, mechanical work is converted to heat by using plastic deformation involved in chip formation as well as friction between the tool and the work piece. The interface at which the chip comes in contact with tool is normally the hottest region during cutting i.e. manufacturing process. The aim of this work is to examine the performance of cutting tool with and without heat pipe aided cooling technology in machining that can efficiently carry away the heat produced at the tool-chip interface in machining which result in reducing tool chip interface temperature and increase surface finish. The tool temperature is affected due to work piece material, cutting speed, feed, Depth of cut, tool geometry, lubricant, and many other parameters. Due to the interface of the chip and tool, which takes place at high pressures and high temperatures of cutting tool because of this the tool will always wear. A heat pipe is anactive passive heat transfer device with a high thermal conductivity. It is used to transfer heat from one point to another point by means of evaporation and condensation of the working fluid, in which circulation of the fluid is done with the help of capillary forces acting on it. Heat pipes are used in wide range of applications such as cooling purposes, die-casting and injection moulding, heat recovery, aircraft de-icing, the cooling of batteries and the control of manufacturing temperatures

1.1 WORKING OF HEAT PIPE

The main components of heat pipe are shown in fig.1 the heat pipe consists of evaporator section and condenser section and adiabatic section in between. Heat pipe is made up of tube of copper material and wick structure. Path is provided in pipe for flow of working fluid. When temperature at evaporator section increases the temperature of working fluid also increases and it

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changes the phase in vapour. Due to pressure difference between condenser and evaporator section vapour flows from evaporator section to condenser section. At condenser section heat is taken out due to natural convection and vapour converts back into fluid. This process keeps on running until the heating at evaporator section stops.

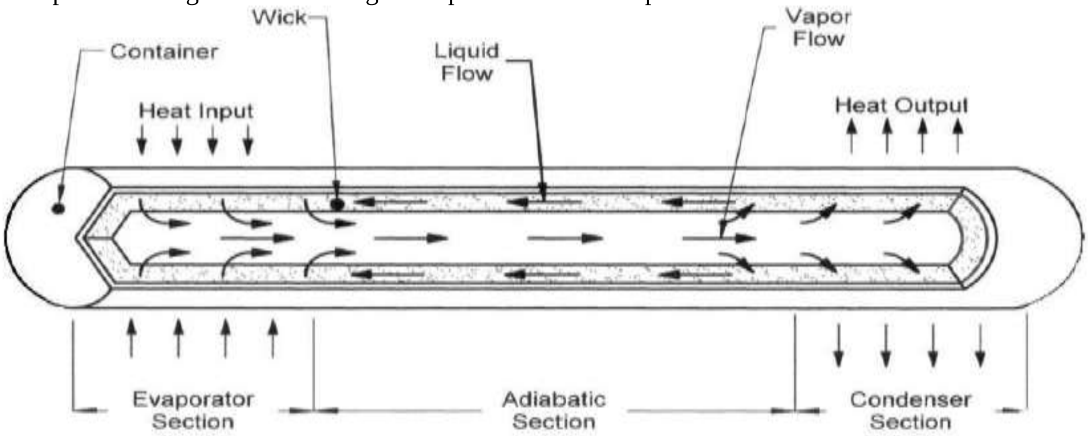

Fig-1: Structure of Heat Pipe

At the heat source the cold liquid is evaporated, the hot vapour flow is afterwards transported to the heat sink where the vapour condensates again and is transported back to the heat source. To have a convective flow of the fluid it is a necessity to generate a pressure difference between the hot and the cold side of the pipe.

1.2Analysis of tool holder

Static structural analysis of cutting tool is carried out to check the effect of drilling a hole of 5mm diameter on the cutting tool. Force of 30 N is applied and Equivalent Von-Misses stress and total deformation is calculated and results are shown in figures below.

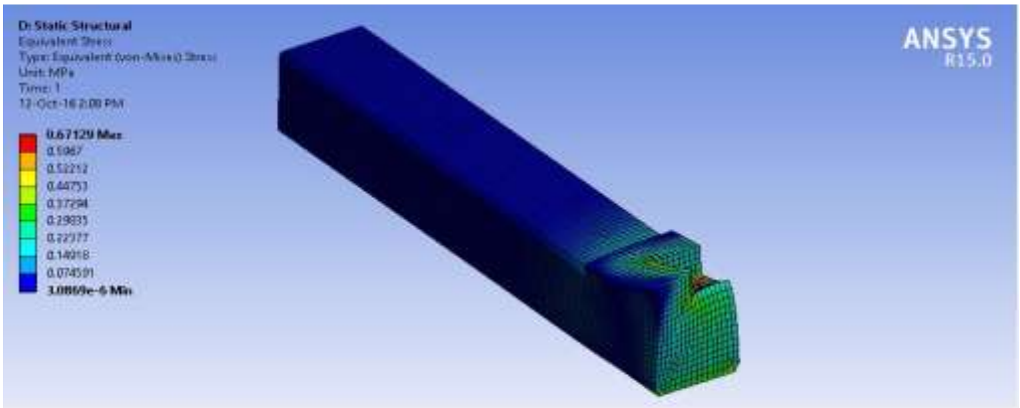

Fig-2: Equivalent stress on cutting tool without hole

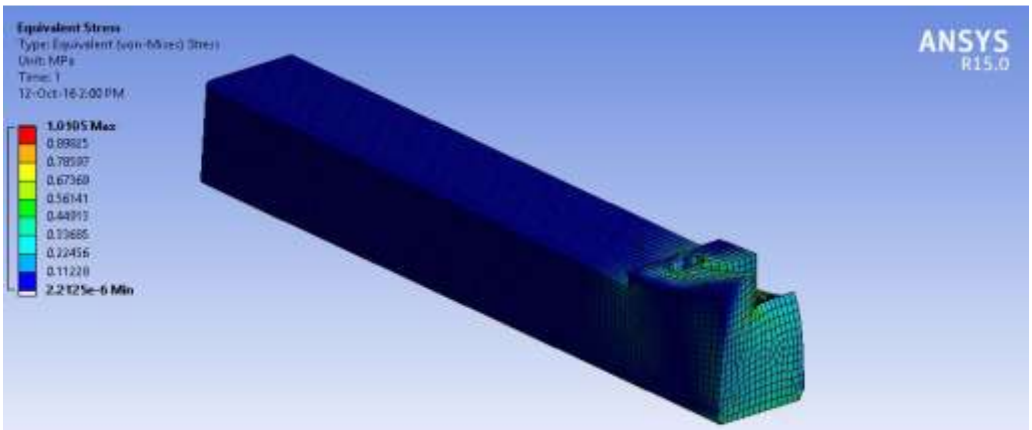

Fig-3: Equivalent stress on cutting tool with hole

From results it is observed that drilling a hole in cutting tool produces more stress in it but still it is in safe limits and factor of safety of tool does not reduce in large amount

2. EXPERIMENTAL PROCEDURE

Cutting experiments is conducted on a lathe to study the influence of heat pipe assisted cooling of cutting tool on cutting performance. Cutting tool contained of tungsten carbide introduces with sculptured rake face. Heat pipe used in this research work was made of copper and working fluid. Before filling working fluid, presence of non-condensable gases if any, was detached by elimination using a vacuum pump before selecting the structural parameters of heat pipe, authors managed preliminary experiments for optimizing the type of wick structure, location and the location of heat pipe. Accordingly, grooved type wick having an axial groove along the length of heat pipe has been designated for the study in order to circulate the working fluid inside the heat pipe with less flow resistance than other types of wicks such as mesh and sintered powder types. The tool holder was provided with a 6.5mm hole on the top face using EDM process for mounting the heat pipe in vertical position. The location of the hole was selected in such a way that there was sufficient surface contact between the heat pipe and the tool insert. Thermal cement with high-pitched thermal conductivity was consumed to fix the heat pipes to the tool holder to ensure good thermal contact between the insert and the heat pipe. Assembly of tool holder with heat pipe is schematically shown in Fig.4

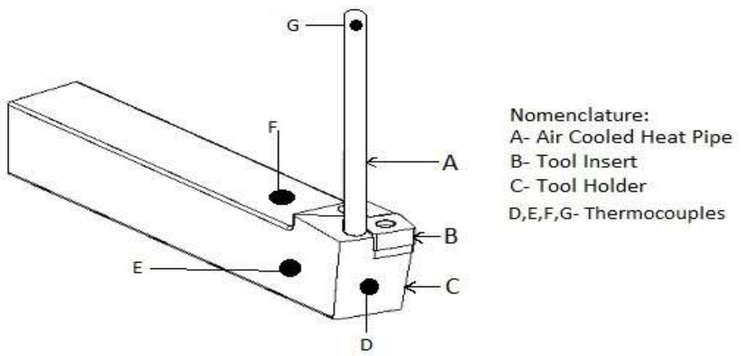

Fig-4: Arrangement of Heat Pipe

3. RESULTS AND DISCUSSION

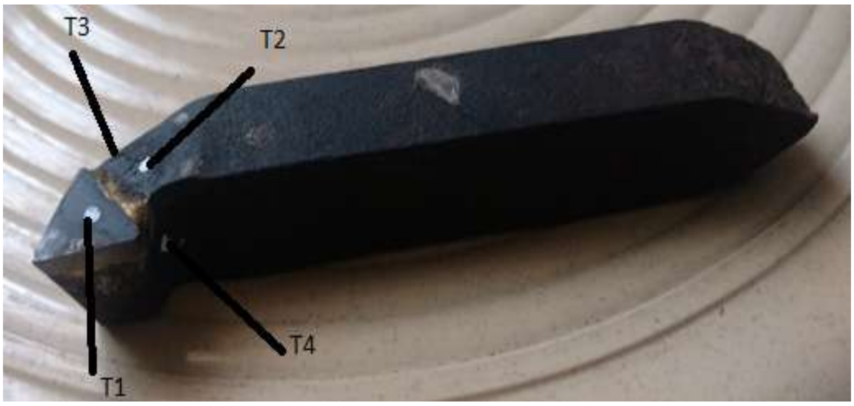

Fig-5: Temperature locations

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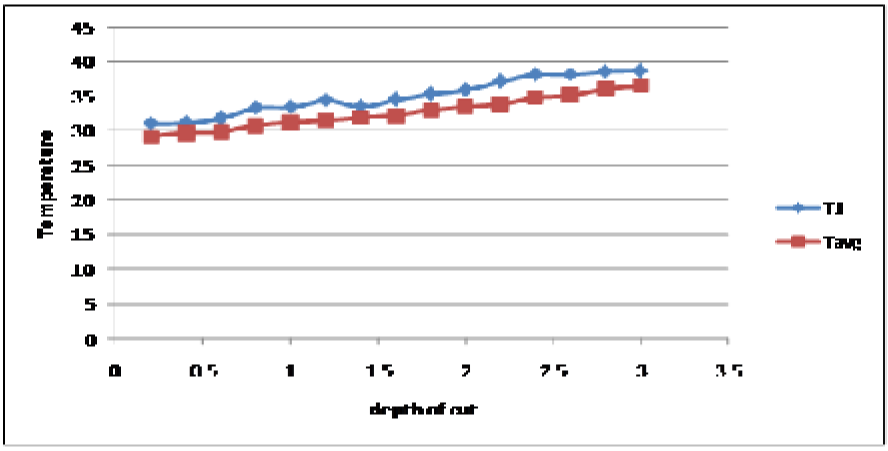
Trial.1 Temperature readings without heat pipe:-

Sr.No.	T1	T2	T3	T4	T_{avg}(2,3&4)
1	31.1	30.2	27.2	30.1	29.166
2	31.2	30.1	27.7	31.2	29.666
3	31.9	30.8	27.3	31.4	29.83
4	33.4	31.5	29.1	31.6	30.733
5	33.5	31.9	29.8	31.8	31.166
6	34.5	32.3	30.2	31.9	31.466
7	33.6	32.3	31.3	32	31.866
8	34.6	32.8	31.5	32.3	32.2
9	35.4	34.3	31.6	33.1	33
10	36	34.4	32.3	33.7	33.466
11	37.2	35.1	32.6	33.9	33.866
12	38.2	36.7	33.7	34	34.8
13	38.2	37.1	33.8	34.5	35.133
14	38.6	37.8	34.8	35.7	36.1
15	38.7	37.9	34.8	35.9	36.5
16	39	37.9	35	36	36.9

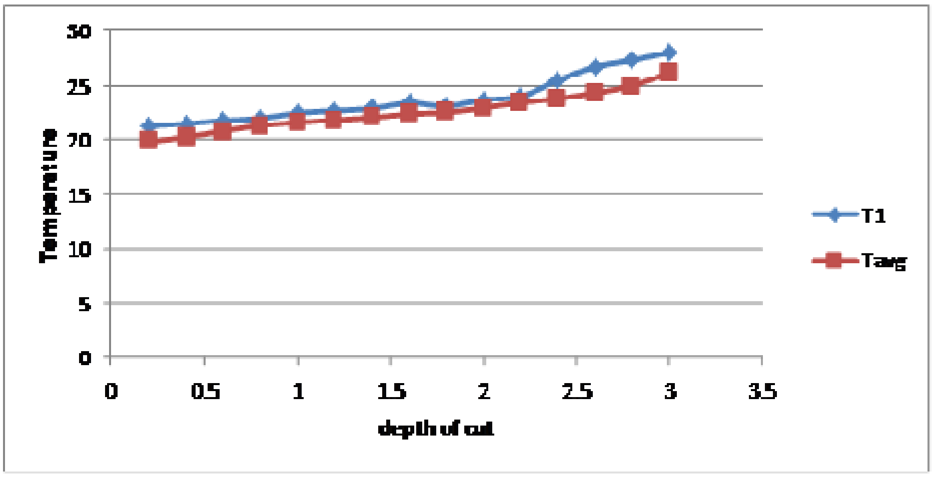
Trial.2 Temperature readings with heat pipe:-

Sr.No.	T1	T2	T3	T4	T_{avg}(2,3&4)
1	21.3	20.6	19.2	19.8	19.86667
2	21.5	20.9	19.8	20.1	20.26667
3	21.8	21.4	20.4	20.7	20.83333
4	22	21.7	21.3	21	21.33333
5	22.5	22	21.5	21.3	21.6
6	22.7	22.2	21.8	21.5	21.83333
7	22.9	22.4	22	21.8	22.06667
8	23.4	22.8	22.3	22.1	22.4
9	23.1	23.1	22.1	22.4	22.53333
10	23.7	23.5	22.5	22.9	22.96667
11	24	24	22.9	23.4	23.43333
12	25.5	24.7	23	23.7	23.8
13	26.7	25.3	23.8	23.9	24.33333
14	27.3	26.1	24.5	24.4	25
15	28	27.4	25.5	25.6	26.16667
16	29.4	28.1	26.3	26.3	26.9

Temperature increase vs. Depth of Cut (Turning) without heat pipe



Temperature increase vs. Depth of Cut (Turning) with heat pipe



3. CONCLUSION

The heat transfer performance from an experimental model in the current study confirmed that the heat generated in machining can be efficiently detached by the use of a heat pipe installed on a cutting tool. After equating the result of both the type, with heat pipe as well as without heat pipe by using "Taguchi Method". We are predicting that by using the heat pipe; effect of temperature and surface roughness is comparatively minimum at high value of speed and depth of cut on the working materials Mild Steel, Aluminium, Brass. So application of heat pipe in lathe machine operation is highly effective as compare to the using the normal coolant for cooling operation. Thus we control the tool chip interfering temperature and surface roughness of work piece by our practical device water type heat pipe.

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