EXPERIMENTAL INVESTIGATION & ANALYSIS OF HEAT PIPEAPPLICATION IN LATHE MACHINE

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ABSTACT

Tool wear of machine tools and large usage of cutting fluids is one of the major problems in machining process during manufacturing. Cutting fluids are used to cool down the tool and have been shown to cause environmental problems in machine shops. Tool life and temperature have an inverse relationship, namely that the higher the temperature at the tool-chip interface is, the lower the tool life will be, and vice-versa. This paper investigates the performance of a cutting tool embedded 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 properties of work piece and dimensional accuracy, as well as the tool life in machining. A new embedded heat pipe technology has been developed to effectivelyremove the heat generated at the tool–chip interface in machining, thereby, reducing temperature and increase tool life. Experiments should be carried out in both with and withoutheat pipe in machining and the temperature will be measured.

Keywords:Cutting Temperature,Heat pipe, Minitab 17,Surface Roughness

I.INTRODUCTION

Machining is an important manufacturing operation in industry. The purpose of a machining process is to generate a surface having a specified shape and acceptable surface finish, and to prevent tool wear and thermal damage that leads to geometric inaccuracy of the finished part. The objective of this work is to investigate the performance of cutting tool with and without heat pipe assisted cooling technology in machining that can effectively carry away the heat generated at the tool-chip interface in machining which result in decrease in tool-chip interface temperature and reduce surface roughness.A heat pipe is a simple device with high thermal conductivity that can transfer large quantities of heat over fairly large distances essentially at a constant temperature without requiring any power input. Heat pipe mainly consist of three section namely evaporative, adiabatic and condenser. Because the use of the heat pipe cooling system may reduce or eliminate the need for cutting fluid, the pollution and contamination of the environment by cutting fluids, and the health problems of skin exposure and particulate inhalation in manufacturing can be effectively minimized. Experiments were carried out to characterize the temperature distributions when performing turning experiments on lathe machine using a cutting tool installed with an embedded heat pipe.Experiments were carried out on conventional lathe

machine using brazed carbide to characterize the temperature distributions when performing turning experiments on lathe machine using a cutting tool installed with an embedded heat pipe.

II.WORKING of HEAT PIPE IN MACHINING

The main regions of the standard heat pipe are shown in Fig.1. The heat pipe is made up of an evaporator section and a condenser section and adiabaticsection in between evaporator and condenser section. The heat pipe consists of the container wall with copper material and the wick structure with stainless steel material and the vapour space for flow of water vapour. Heat pipe will be embedded on tool holder to the contact of cutting tool with the help of brass brazing. The main function of heat pipe is when machining is started the temperature at the tool will be increased.When temperature of tool increase then heat is generated. This heat is absorbed by heat pipe in evaporation section where temperature of working fluid increases and it converted in vapour. Due to pressure difference between evaporative and condensation section vapour flows from evaporative section to condensation section. In condensation section the heat will be taken out, because of that the vapour becomes fluid. This process will continue until the machining is stopped.

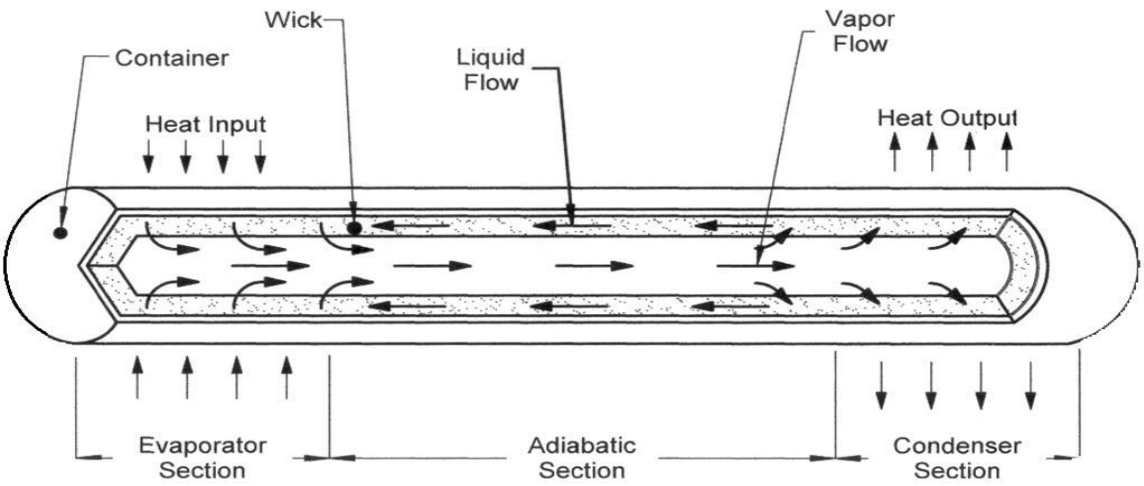

Fig.1 : Structure of Heat Pipe

III. EXPERIMENTS IN A CUTTING TOOL

An experimental study was undertaken on a conventional lathe using a commercially available brazed carbide tool. The work piece material was taken for the experiment are Mild Steel, Aluminium, Brass. The work piece was in the form of a 80cm long cylindrical rod with a diameter of 32 mm. The standard tool with specification Carbide insert DNMG442RP and tool holder with specification Sandwickchoromant – PDJNL 2525 M15 WIDAX was used for cutting experiments. The Walnut Innovation Infrared Temperature gun which is non-contact laser was used to measure the temperature at tool chip interference after completing five cuts with respect to input parameter for the machining distance of 60cmlength. Experiments were conducted for twocases such as with and without heat pipe.The geometry andmaterial properties of the tool and the heat pipe are given below

Heat pipe length	:	100 mm
Heat pipe inner diameter	:	6.3mm
Heat pipe outer diameter	:	15 mm
Condenser length of heat pipe	:	50 mm
Tool holder size	:	25x25 mm
Carbide insert thickness	:	7 mm
Carbide insert length	:	25 mm
Carbide insert width	:	14 mm

The turning operation is controlled by varying the inputparameters like material, depth of cut and cutting speed are as follows,

Material	Mild Steel	Aluminum	Brass
Depth of Cut(mm)	0.5	1.0	1.5
Spindle Speed(rpm)	348	539	835

The experimental setup for with and without heat pipe was given in the following figure.

Fig.2Experimental setup for with heat pipe

Fig.3Experimental setup for without heat pipe

3.1 Taguchi Orthogonal Array

This experiment consists of 3 factors with 3 levelsso, total numbers of experiments are 27. By using Taguchi OrthogonalArray the number of experiments reduced to 9 instead of 27 with almost same accuracy. There are three machining parameters i.e. Material, Depth of cut, Spindle speed. Different experiments are done by varying one parameter and keeping other two fixed so maximum value of each parameter was obtained. Taguchi orthogonal array is designed with three levels of turning parameters with the help of software Minitab 17 .Experiments are performed according to the selected design of experiment as shown in Table.

Material	Depth of Cut(mm)	Speed(rpm)
Mild Steel	0.5	348
Mild Steel	1	539
Mild Steel	1.5	835
Aluminum	0.5	539
Aluminum	1	835
Aluminum	1.5	348
Brass	0.5	835
Brass	1	348
Brass	1.5	539

IV. RESULT

Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The temperature at tool-chip interface and surface roughness was considered as the quality characteristic with the concept of "the smaller-the-better".

The formula of S/N ratio for the smaller-the-better is

$$\frac{S}{N_{(Smaller)}} = -10 \log\left(\frac{\sum y_i^2}{n}\right)$$

The S/N ratio values are calculated by taking into consideration the above equation. The tool chip interface temperature and surface roughness values are measure from the experiments and their corresponding S/N ratio values are listed in the table given bellow:

Experimental Results And Corrosponding S/N Ratio:

With Heat Pipe:

Material	Depth of Cut	Speed	Temperature(°c)	Surface Roughness(µm)	SNRA1
Mild Steel	0.5	348	42	10.3	-29.7083
Mild Steel	1	539	45	11.2	-30.315
Mild Steel	1.5	835	55	9	-31.9117
Aluminum	0.5	539	36	6.2	-28.2427
Aluminum	1	835	40	7.1	-29.1656
Aluminum	1.5	348	43	9.1	-29.8493
Brass	0.5	835	38	8.9	-28.8173
Brass	1	348	37	4.2	-28.4093
Brass	1.5	539	40	6.1	-29.1307

Without Heat Pipe:

Material	Depth of Cut	Speed	Temperature(°c)	Surface Roughness(µm)	SNRA1
Mild Steel	0.5	348	60	12.3	-32.7315
Mild Steel	1	539	63	14.2	-33.1917
Mild Steel	1.5	835	67	10.2	-33.6107
Aluminum	0.5	539	44	11	-30.122
Aluminum	1	835	47	10.5	-30.6432
Aluminum	1.5	348	55	12.7	-32.0226
Brass	0.5	835	46	11.2	-30.495
Brass	1	348	49	10.4	-30.985
Brass	1.5	539	57	9.3	-32.2213

- **Analysis and Discussion**

Regardless of the category of the performance characteristics, a smaller S/N value corresponds to a better performance. Therefore, the optimal level of the machining parameters is the level with the smaller value.

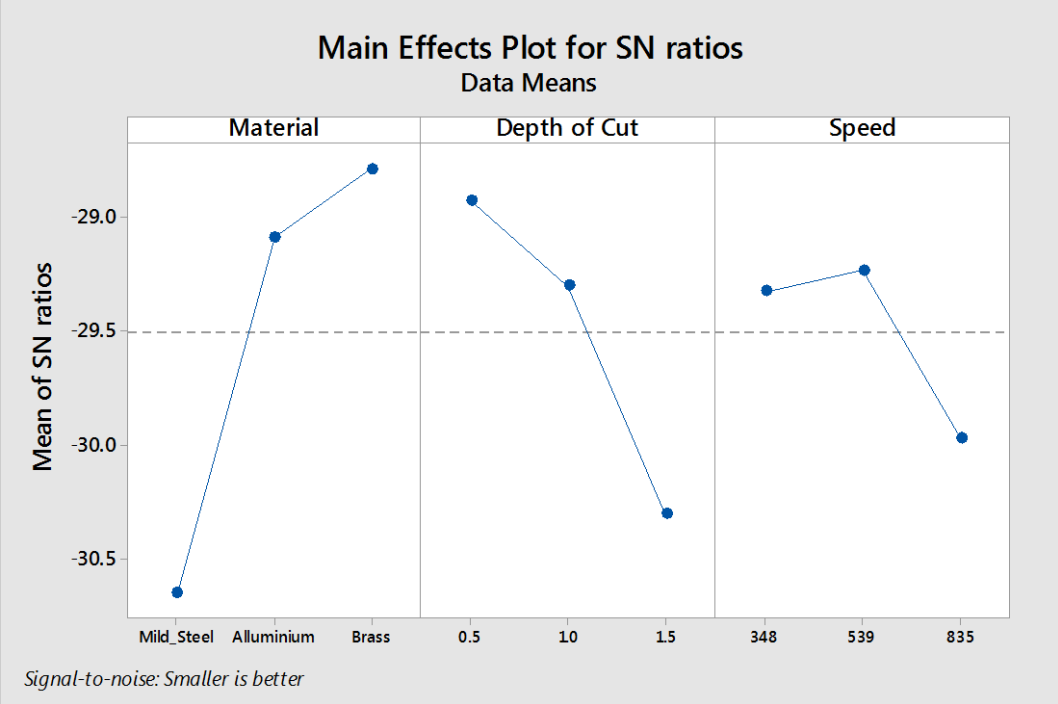

Fig.4 Effect of turning parameters on tool-chip interface temperature and surface roughness with heat pipe for S/N ratio.

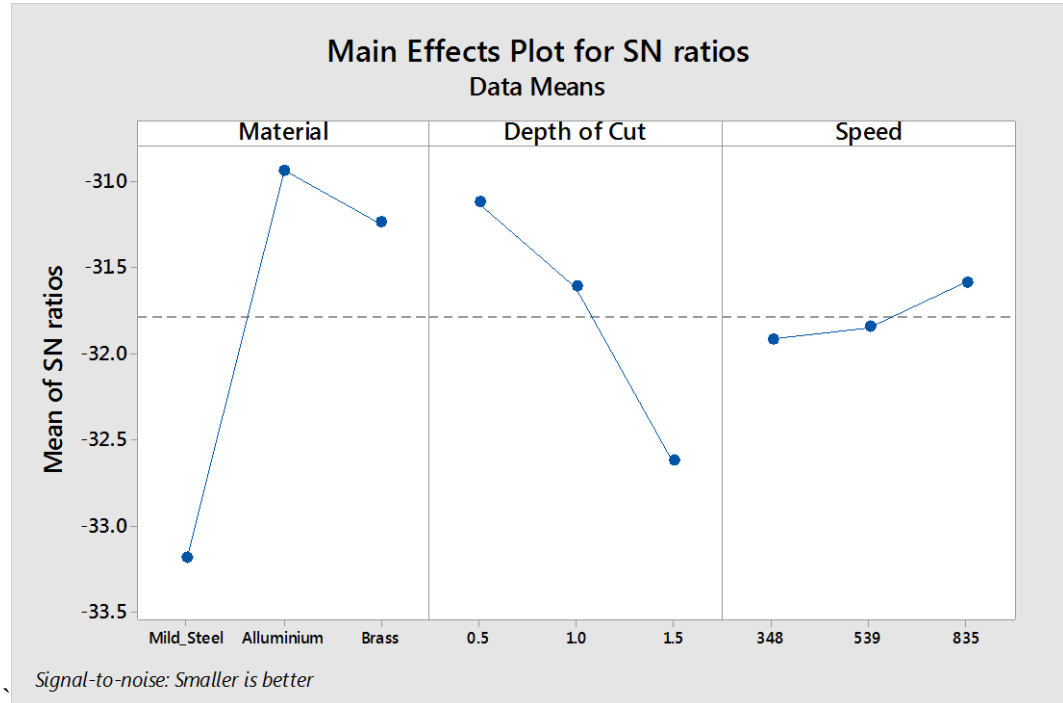

Fig.5. Effect of turning parameters on tool-chip interface temperature and surface roughness without heat pipe for S/N ratio.

Table: Optimum machining condition based On Graph of SR (With Heat Pipe)

Factors	Level Value	Level
Material	Mild Steel	1
Depth of Cut	1.5	3
Spindle speed	348	1

Table: Optimum machining condition based On Graph of SR (Without Heat Pipe)

Factors	Level Value	Level
Material	Mild Steel	1
Depth of Cut	1.5	3
Spindle speed	835	3

Material :-The effect of parameter material on the tool chip interface temperature and surface roughness values is shown above figure S/N ratio. Its effect is minimum in case of Mild steel. So the optimum material is level 1 Mild steel.

Depth of Cut :-The effect of parameters depth of cut on the tool chip interface temperature and surface roughness values is shown above figure for S/N ratio. Its effect is increasing with increase in depth of cut. So the optimum depth of cut is level 3 i.e. 1.5 mm/rev.

Spindle Speed :-The effect of parameter spindle speed on thetool chip interface temperature and surface roughness is shown above figure for S/N ratio. Its effect is decreasing with increase in spindle speed upto 835 RPM. So the optimum spindle speed is level 3 i.e. 835 RPM.

V. CONCLUSION

The heat transfer behaviour from an experimental model in the present study demonstrated that the heat generated in machining can be effectively removed by the use of a heat pipe installed on a cutting tool. After comparing the result of both the type, with heat pipe as well as without heat pipe by using "Taguchi Method L9 Array (Minitab-17)" & SN Graphs we are predicting that 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 interference temperature and surface roughness of work piece by our applied device water type heat pipe.

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