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Effect of Cutting Fluids on H.S.S and Carbide Cutting Tools by Thermal Analysis

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ABSTRACT

Any liquid or gas applied directly to machining operation to improve cutting performance
Two main problems addressed by cutting fluids: Heat generation at shear zone and friction zone, Friction at the tool-chip and tool-work interfaces. Other functions and benefits: Wash away chips (e.g., grinding and milling), Reduce temperature of work part for easier handling, Improve dimensional stability of work part.

Cutting fluids are used in machining for a variety of reasons such as improving tool life, reducing work-piece thermal deformation, improving surface finish. Mota and Machado (1995) concluded that reducing cutting tool cost and increased production can be achieved through the use of appropriate cutting fluids.

In this thesis Air , water and palm kernel oil were used as coolants in machining operations. Tungsten carbide and HSS cutting tools are employed as cutter with different temperatures. Thermal analysis is done on the parametric model to determine the effect of different cutting fluids on the cutters.

Parametric Modeling is done in Pro/Engineer and analysis is done in Ansys.

INTRODUCTION

Milling is the process of cutting away material by feeding a work piece past a rotating multiple tooth cutter. The cutting action of the many teeth around the milling cutter provides a fast method of machining. The machined surface may be flat, angular, or curved. The surface may also be milled to any combination of shapes. The machine for holding the work piece, rotating the cutter, and feeding it is known as the Milling machine.

A milling machine is a machine tool used to machine solid materials. Milling machines are often classed in two basic forms, horizontal and vertical, which refers to the orientation of the main spindle. Both types range in size from small, bench-mounted devices to room-sized machines. Unlike a drill press, which holds the work piece stationary as the drill moves axially to penetrate the material, milling machines also move the workpiece radially against the rotating milling cutter, which cuts on its sides as well as its tip.Workpiece and cutter movement are precisely controlled to less than 0.001 in (0.025 mm), usually by means of precision ground slides and leadscrews or analogous technology. Milling machines may be manually operated, mechanically automated, or digitally automated via computer numerical control.

Milling machines can perform a vast number of operations, from simple (e.g., slot and keyway cutting, planing, drilling) to complex (e.g., contouring, die sinking). Cutting fluid is often pumped to the cutting site to cool and lubricate the cut and to wash away the resulting swarf.

USING A MILLING CUTTER

Chip formation

Although there are many different types of milling cutter, understanding chip formation is fundamental to

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the use of any of them. As the milling cutter rotates, the material to be cut is fed into it, and each tooth of the cutter cuts away a small chip of material. Achieving the correct size of chip is of critical importance. The size of this chip depends on several variables.

Surface cutting speed (V_c):

This is the speed at which each tooth cuts through the material as the tool spins. This is measured either in metres per minute in metric countries, or surface feet per minute (SFM) in America. Typical values for cutting speed are 10m/min to 60m/min for some steels, and 100m/min and 600m/min for aluminum. This should not be confused with the feed rate. This value is also known as "tangential velocity."

Spindle speed (S):

This is the rotation speed of the tool, and is measured in revolutions per minute (rpm). Typical values are from hundreds of rpm, up to tens of thousands of rpm.

Diameter of the tool (D):

Feed per tooth (F_z):

This is the distance the material is fed into the cutter as each tooth rotates. This value is the size of the deepest cut the tooth will make.

Feed rate (F):

This is the speed at which the material is fed into the cutter. Typical values are from 20mm/min to 5000mm/min.

Depth of cut:

This is how deep the tool is under the surface of the material being cut (not shown on the diagram). This will be the height of the chip produced. Typically, the depth of cut will be less than or equal to the diameter of the cutting tool.

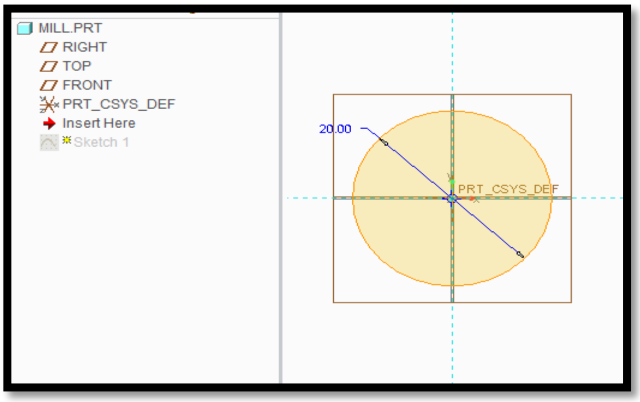
The machinist needs three values: **S**, **F** and **Depth** when deciding how to cut a new material with a new tool. However, he will probably be given values of V_c and F_z from the tool manufacturer. **S** and **F** can be calculated from them:

Spindle Speed	Feed rate
$S = \frac{1000V_c}{\pi D}$	$F = zSF_z$
Looking at the formula for the spindle speed, S, it can be seen that larger tools require lower spindle speeds, while small tools may be able to go at high speeds.	The formula for the feed rate, F shows that increasing S or z gives a higher feed rate. Therefore, machinists may choose a tool with the highest number of teeth that can still cope with the swarf load.

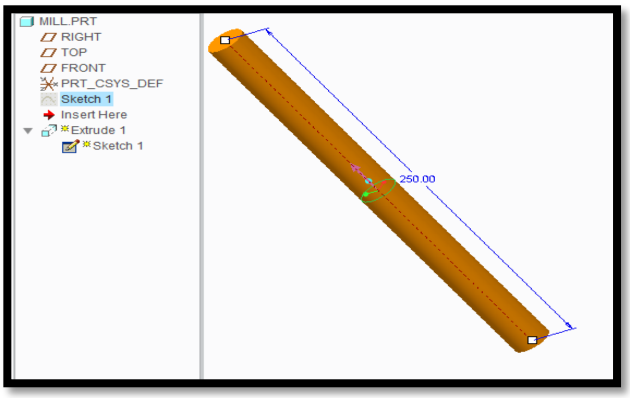
3D MODELING AND ASSEMBLY OF CUTTING TOOL AND WORKPIECE

MODEL OF CUTTING TOOL

Skecth



Extrude



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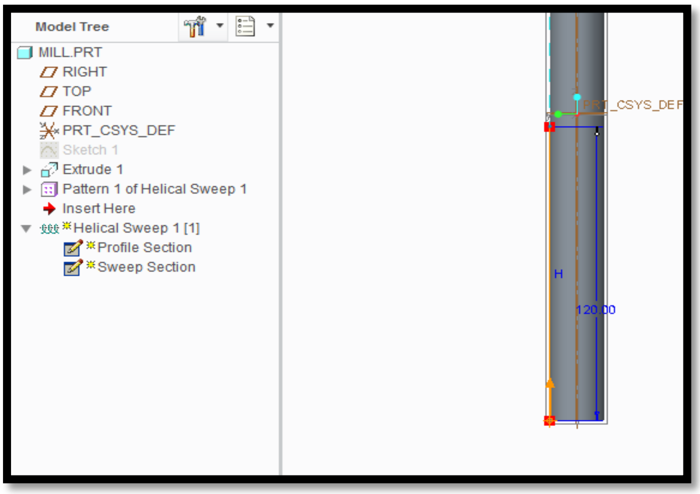
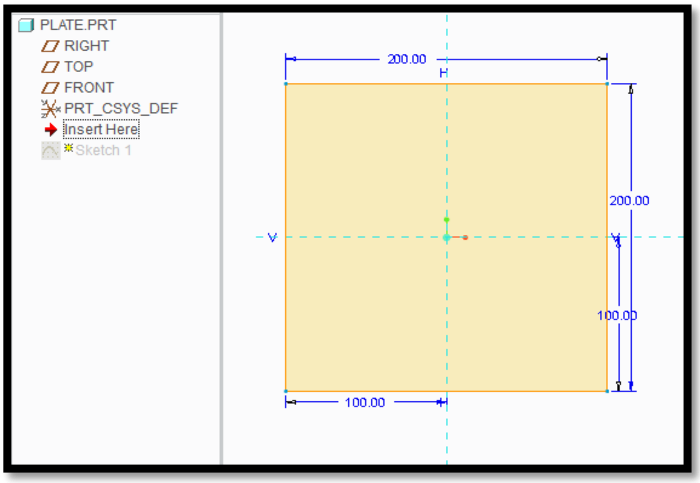
Helical Sweep profile

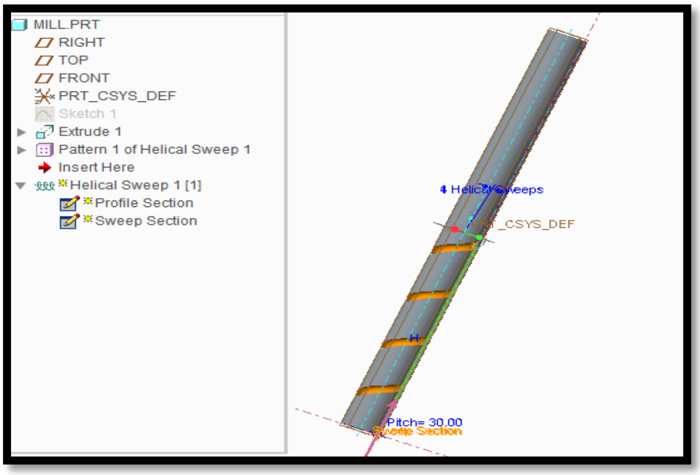


WORKPIECE

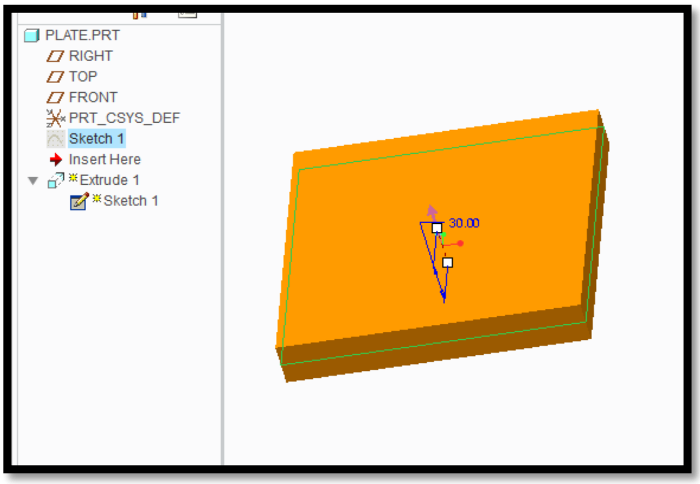
Skecth



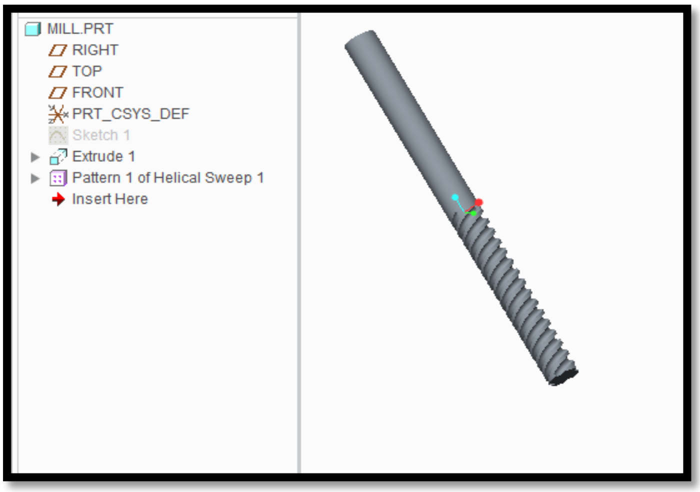
Helical Sweep section



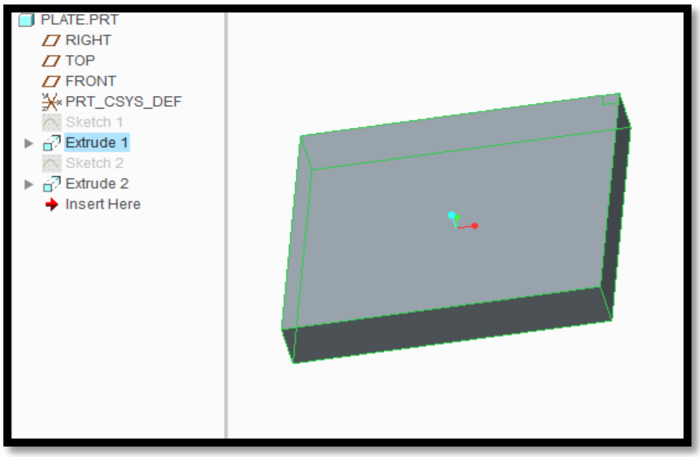
Extrude



Pattern



Solid part



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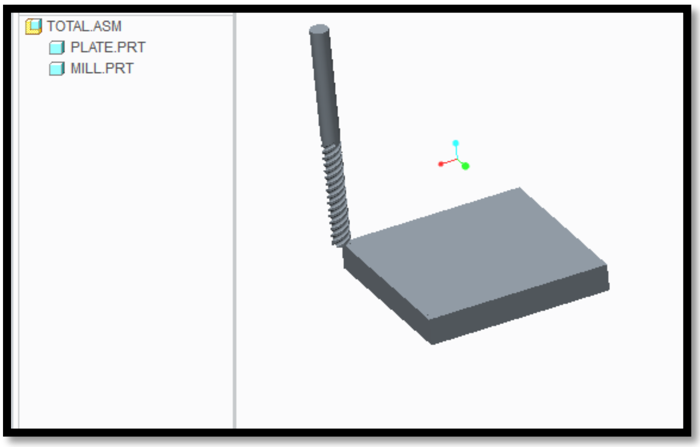
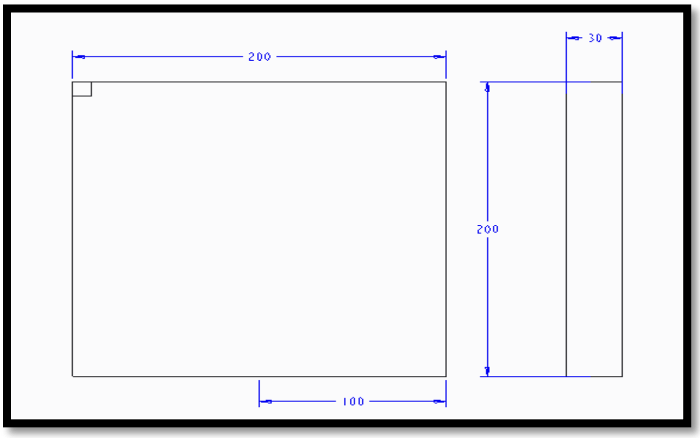
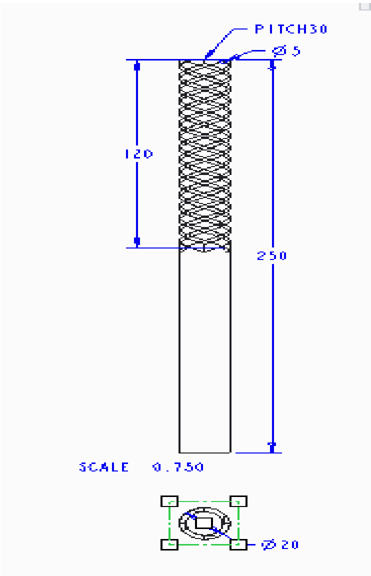
Assembly



Drafting



Cutting Tool



THERMAL ANALYSIS

MATERIAL PROPERTIES

Cutting Tool – HSS

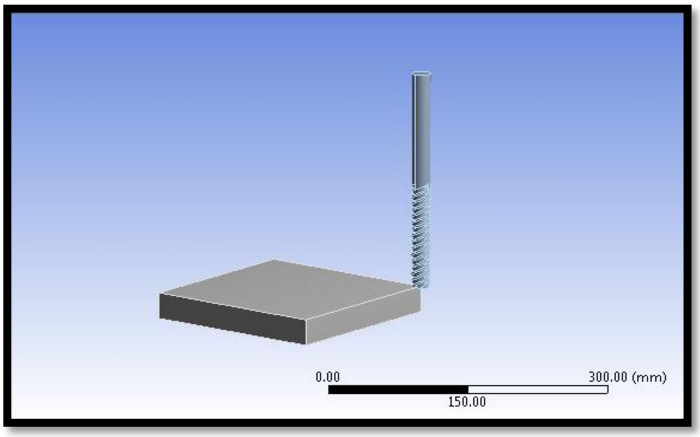
Thermal conductivity =0.019 W/mm K
Specific Heat – 460J/Kg K
Density = 0.0000081 Kg/mm^3

Work Piece – Aluminum alloy 6063

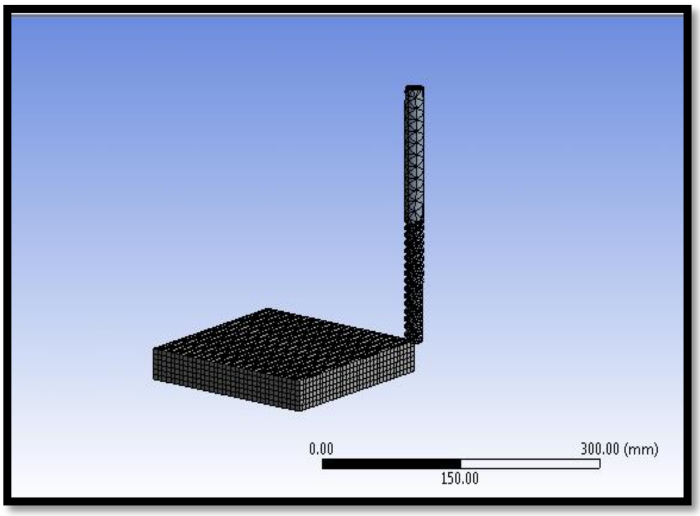
Thermal conductivity =0.2 W/mm K
Specific Heat – 900J/Kg K
Density = 0.0000027 Kg/mm^3

CUTTING TOOL MATERIAL - HSS
COOLANT - AIR
TEMPARATURE - 410K

Imported model



Meshed model



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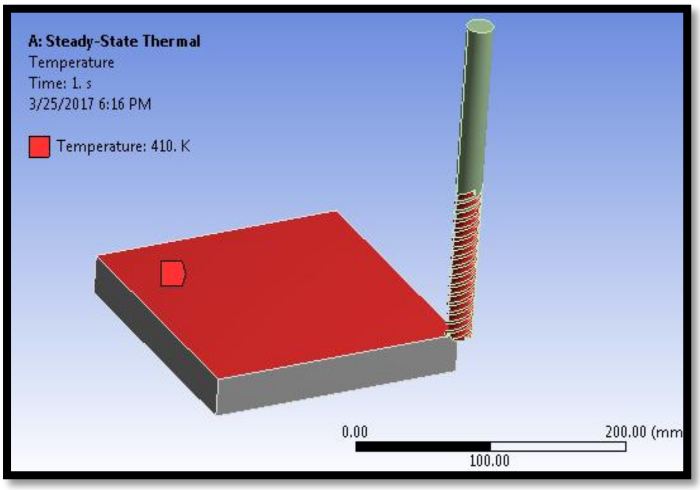
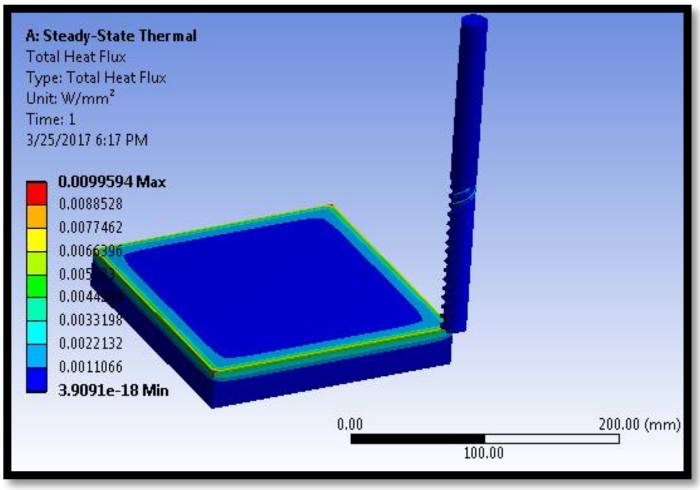
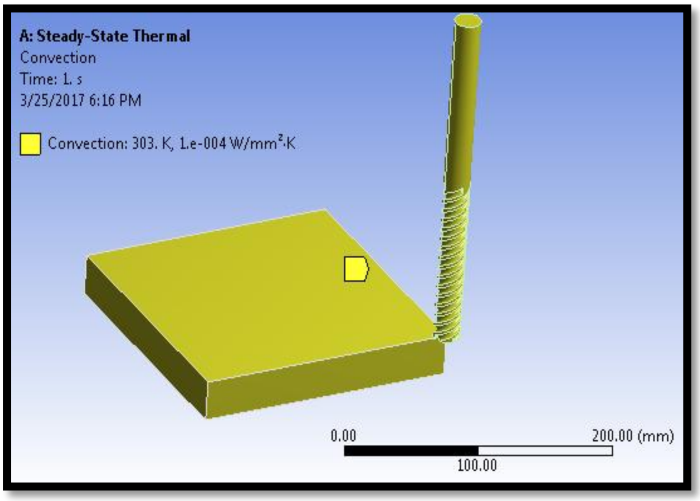
Temperature



Heat flux

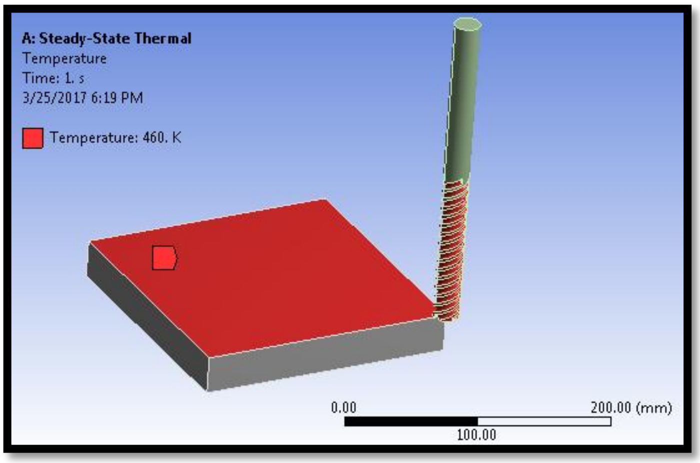


Convection

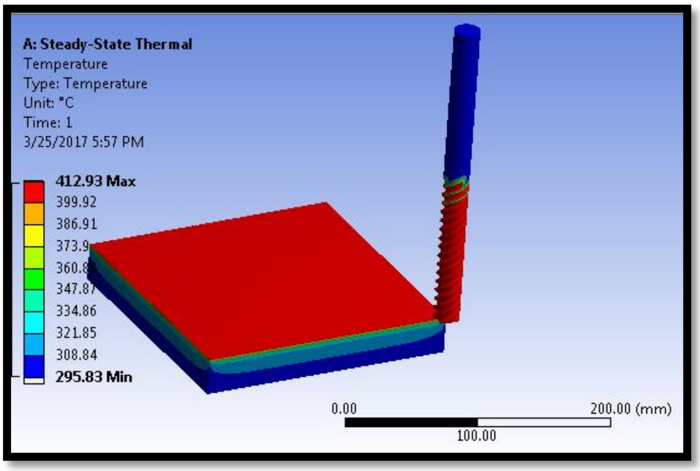


TEMPARATURE - 460K

Temperature



Temperature



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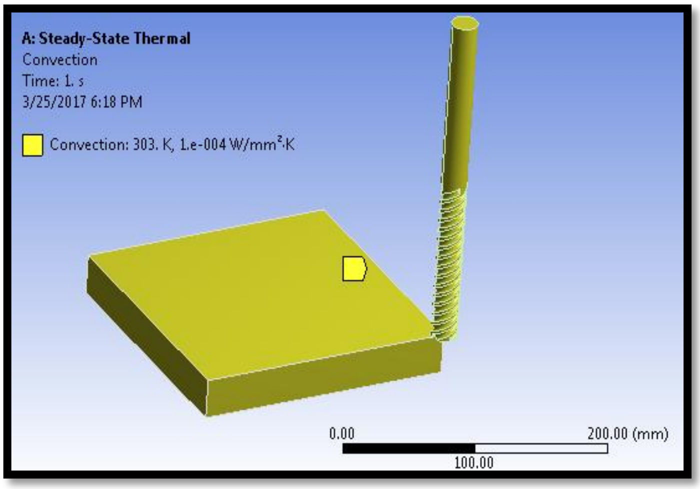

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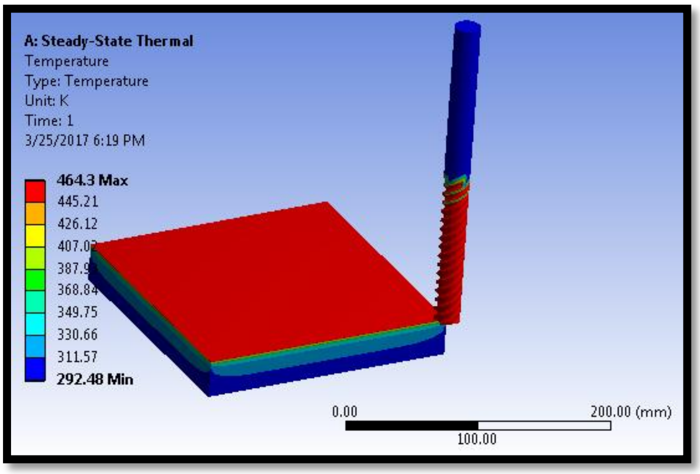
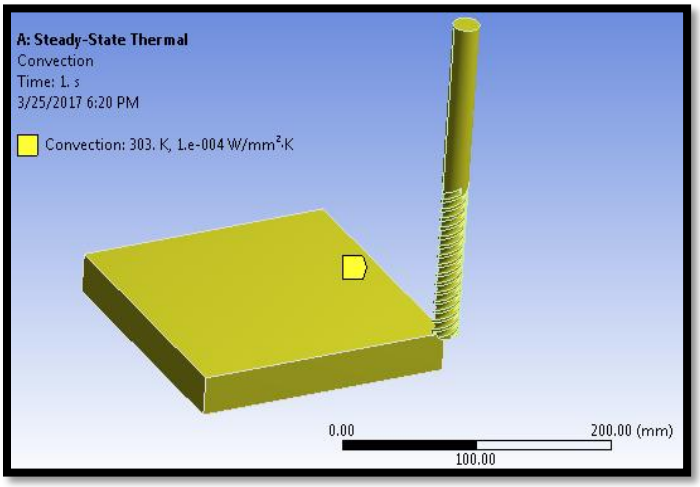
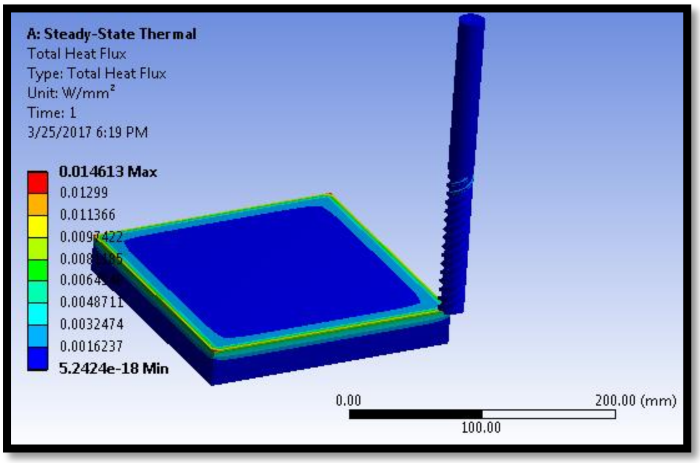
Temperature



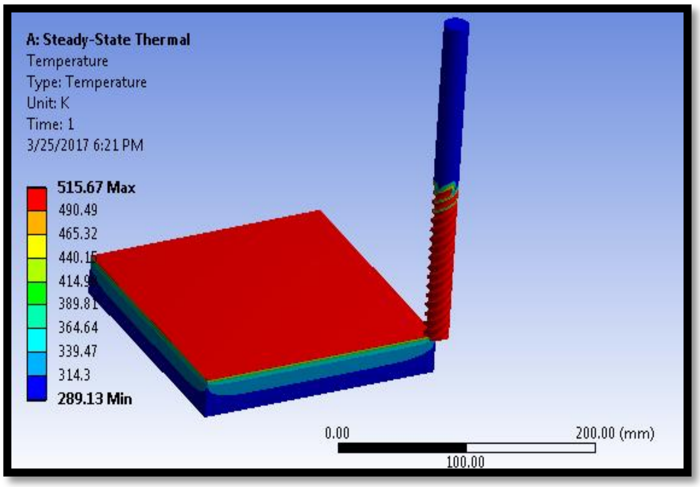
Convection



Heat flux

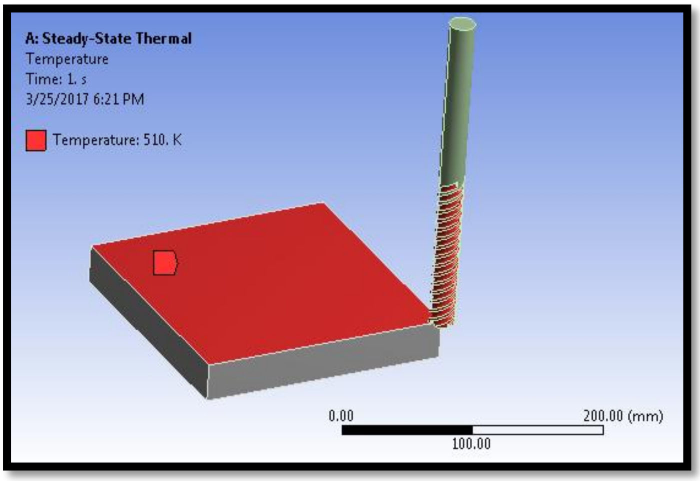


Temperature

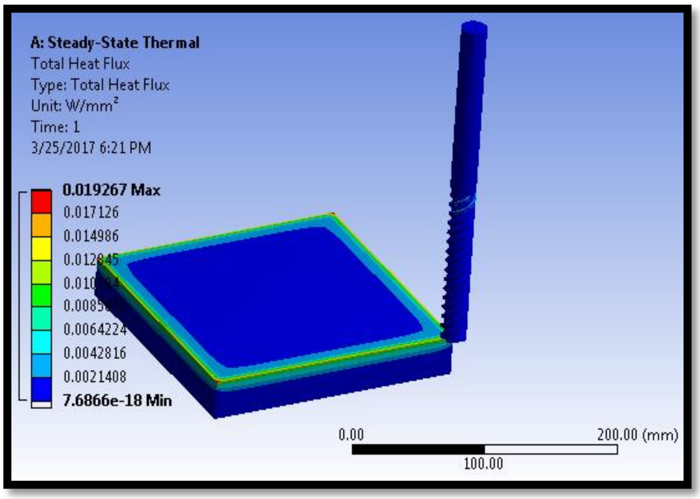


TEMPARATURE - 510K

Temperature



Heat flux



RESULT TABLES

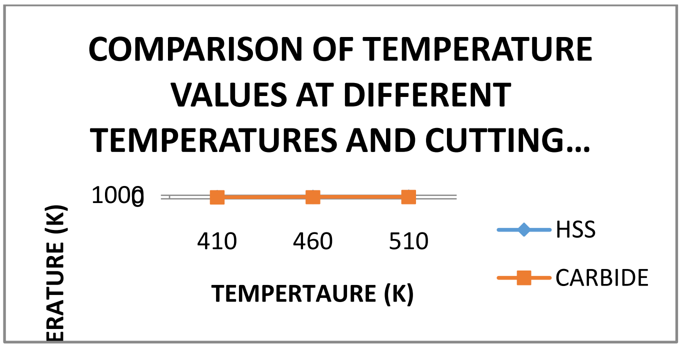
HSS

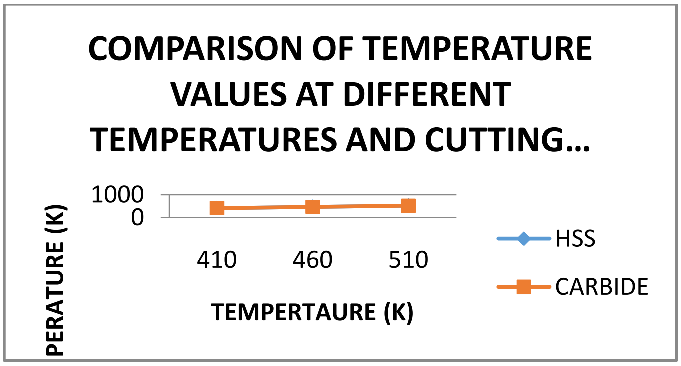
	Temperature (K)	Temperature(K)	Heat flux (W/mm^2)
KERNEL	410	414.08	0.016068
	460	465.98	0.023576
	510	517.88	0.031084
AIR	410	412.93	0.009594
	460	464.3	0.014613
	510	515.86	0.019267
WATER	410	414.06	0.015971
	460	465.96	0.023434
	510	517.86	0.030898

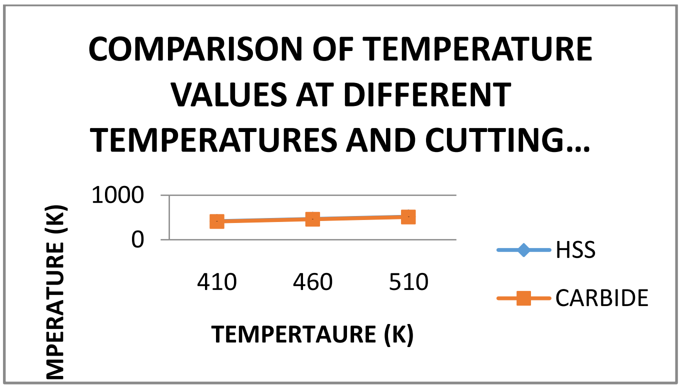
CARBIDE

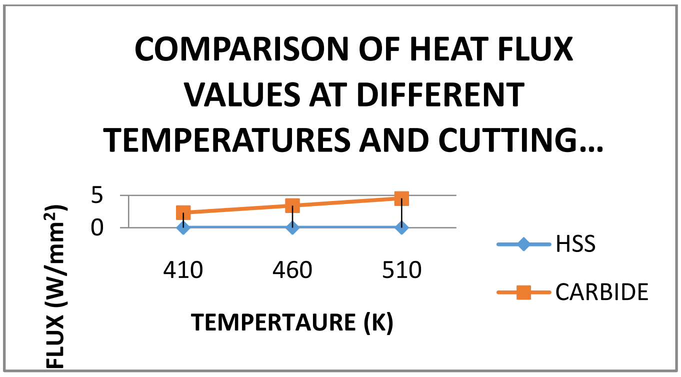
	Temperature (K)	Temperature(K)	Heat flux (W/mm^2)
KERNEL	410	412.3	2.3389
	460	463.38	3.4318
	510	514.46	4.5248
AIR	410	410	0.14218
	460	460	0.20862
	510	510	0.27505
WATER	410	410.55	0.86954
	460	460.81	1.2759
	510	511.07	1.6822

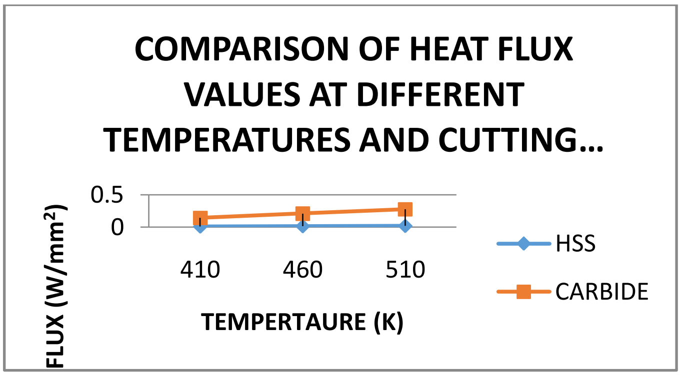
GRAPHS

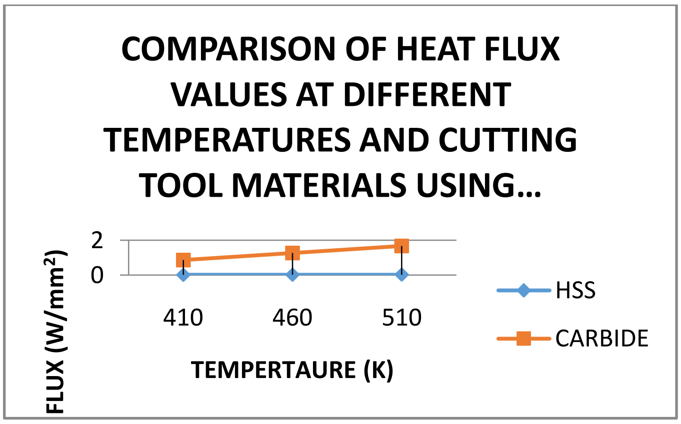












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CONCLUSION

In this thesis air, water and palm kernel oil are used as coolants in machining operations. Tungsten carbide and HSS cutting tools are employed as cutter with different temperatures. Thermal analysis is done on the parametric model to determine the effect of different cutting fluids on the cutters.

Parametric Modeling is done in Creo 2.0 and analysis is done in Ansys.

By observing the analysis results, the heat transfer rates are more when the fluid Palm Kernel is used since thermal flux is more than Air and water.

When compared the values for tool materials, the heat transfer rates are more for carbide tool than HSS tool.

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