International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 04
February 2018

Finite Element Method for Analysing the Temperature Acting On Cutting Tool

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ABSTRACT

In this thesis, experiments are conducted on SS blocks at different speeds and at different coolant ratios. The coolant is a mixture of different percentages of liquids. The percentages of coolant ratios are 30:70, 40:60 and 20:80 and different cutting speeds are 2000 rpm, 2500 rpm and 3000 rpm are taken while machining SS blocks.

Experimental investigation is conducted by increasing the cutting oil percentage, thereby reducing water percentage by measuring the temperatures produced while machining SS blocks.

Thermal Analysis is performed on the tool and workpiece assembly by applying the temperatures measured experimentally by varying coolant ratios and cutting speeds for cutting tool materials HSS and Carbide. The work piece material is Stainless Steel.

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.

Milling cutters are cutting tools typically used in milling machines or machining centres (and occasionally in other machine tools). They remove material by their movement within the machine (e.g., a ball nose mill) or directly from the cutter's shape (e.g., a form tool such as a hobbing cutter).

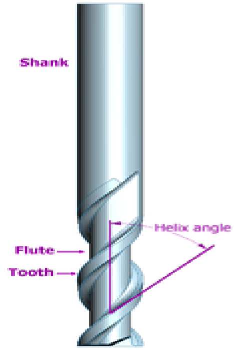

Fig.An End Mill cutter with two flutes

Milling cutters come in several shapes and many sizes. There is also a choice of coatings, as well as rake angle and number of cutting surfaces.

LITERATURE SURVEY

In the paper by L. B. Abhang[1], In metal cutting, the heat generated on the cutting tool is important for the performance of the tool and quality of the work piece. Maximum heat is generated on the tool – chip interface during machining. The machining can be improved by the knowledge of cutting temperature on the tool. In this study, the temperature generated on the cutting tool and experimental methods for the measurement of temperatures are reviewed. Special attention has been paid to tool- work thermocouple method and an experimental setup fabricated to measure the temperature on the cutting tool and work piece junction during metal cutting is described. With this method, the average temperature at the tool-chip interface is measured. The output of the thermocouple is in the mill volt range and measured by a digital milli- voltmeter. The voltmeter is basically current sensitive device; hence the meter reading will be dependent on the emf generated by tool-work-thermocouple. The thermoelectric power of the circuit is usually small and estimated by calibrating the circuit against a reference thermocouple (Alumel-Cromel K type). The setup for calibration and the procedure is described in this work.

In the paper by M. Dogra[2], The effect of cutting tool geometry has long been an issue in understanding mechanics of turning. Tool geometry has significant influence on chip formation, heat generation, tool wear, surface finish and surface integrity during turning. This article presents a survey on variation in tool geometry i.e. tool nose radius, rake angle, groove on the rake face, variable edge geometry, wiper geometry and curvilinear edge tools and their effect on tool wear, surface roughness and surface integrity of the machined surface. Further modeling and simulation approaches on tool geometry including one approach developed in a recent study, on variable micro-geometry tools, is discussed in brief.

In the paper by by Karin Kandananond[3], The purpose of this paper is to determine the optimal cutting conditions for surface roughness in a turning process. This process is performed in the final assembly department at a manufacturing company that supplies fluid dynamic bearing (FDB) spindle motors for hard disk drives (HDDs). The workpieces used were the sleeves of FDB motors made of ferritic stainless steel, grade AISI 12L14. The optimized settings of key machining factors, depth of cut, spindle speed, and feed rate on the surface roughness of the sleeve were determined using the response surface methodology (RSM). The results indicate that the surface roughness is minimized when the depth of cut is set to the lowest level, while the spindle speed and feed rate are set to the highest levels. Even though the results from this paper are process specific, the methodology deployed can be readily applied to different turning processes.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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In the paper by NeerajSharma[4], The present study applied extended Taguchi method through a case study in straight turning of mild steel bar using HSS tool for the optimization of process param. The study aimed at evaluating the best process environment which could simultaneously satisfy requirements of both quality as well as productivity with special emphasis on reduction of cutting tool flank wear, because reduction in flank wear ensures increase in tool life. The predicted optimal setting ensured minimization of surface roughness. From the present research of ANOVA it is found the Depth of cut is most significant, spindle speed is significant and feed rate is least significant factor effecting surface roughness.

In the paper by Rogov Vladimir Aleksandrovich[5], This paper presents an experimental investigation focused on identifying the effects of cutting conditions and tool construction on the surface roughness and natural frequency in turning of AISI1045 steel. Machining experiments were carried out at the lathe using carbide cutting insert coated with TiC and two forms of cutting tools made of AISI 5140 steel. Three levels for spindle speed, depth of cut, feed rate and tool overhang were chosen as cutting variables. The Taguchi method L_9 orthogonal array was applied to design of experiment. By the help of signal-to-noise ratio and analysis of variance, it was concluded that spindle speed has the significant effect on the surface roughness, while tool overhang is the dominant factor affecting natural frequency for both cutting tools. In addition, the optimum cutting conditions for surface roughness and natural frequency were found at different levels. Finally, confirmation experiments were conducted to verify the effectiveness and efficiency of the Taguchi method in optimizing the cutting parameters for surface roughness and natural frequency.

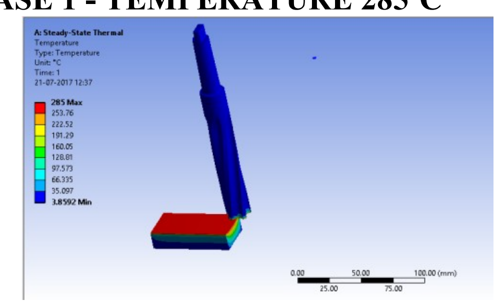
In the paper by J. M. Gadhiya[6], Turning is widely used machining process in today's industrial requirement. In the present research, the effect of CNClathe machine processing parameters such as speed, feed and depth of cut effect on measured response such as surface roughness. The experiment was designed according to full factorial with three different level of each input parameter.For result interpretation, analysis of variance (ANOVA) was conducted and optimum parameter is selected on the basis of the signal to noise ratio,which confirms the experimental result. The result indicated that cutting speed and Feed play important role in surface roughness.

In the paper by Vikas B. Magdum[7], This study used for optimization and evaluation of machining parameters for turning on EN8 steel on Lathe machine. This study investigates the use of tool materials and process parameters for machining forces for selected parameter range and estimation of optimum performance characteristics. Develop a methodology for optimization of cutting forces and machining parameters.

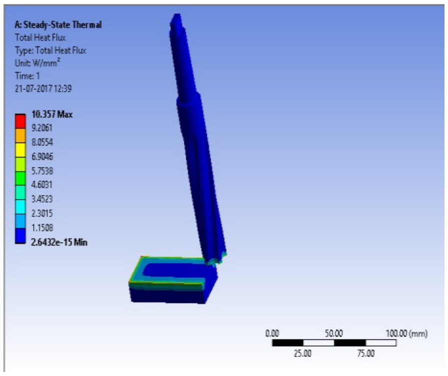
THERMAL ANALYSIS OF MILLING CUTTER AND WORK PIECE ASSEMBLY

CUTTING TOOL –HSS

CASE 1 - TEMPERATURE 285^0C

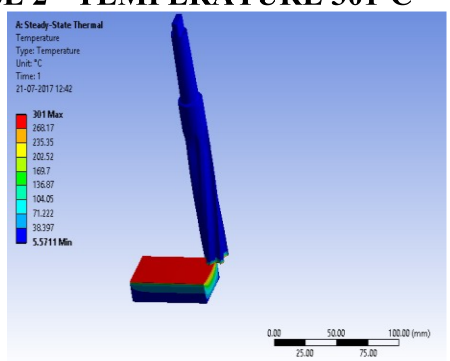


Temperature



Heat flux

CASE 2 - TEMPERATURE 301^{0}C



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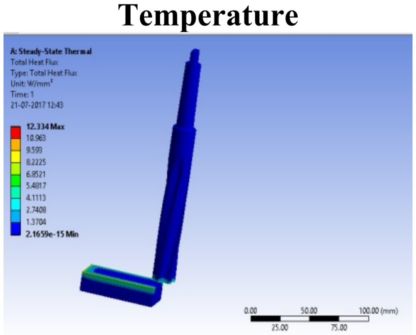
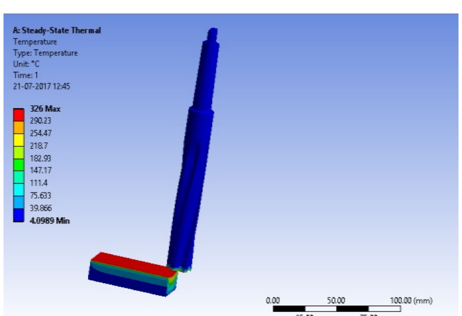


Heat flux

CASE 3 - TEMPERATURE 326^{0}C



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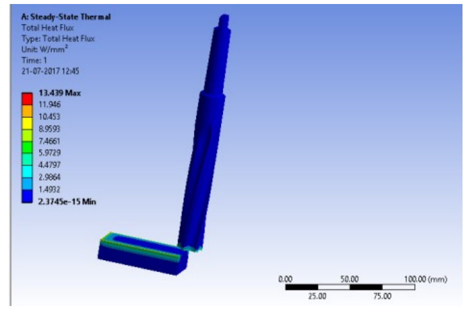
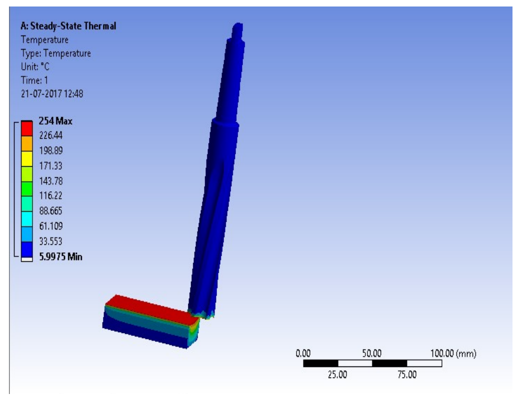
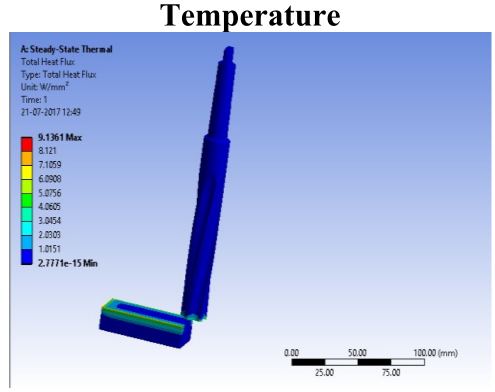


Heat flux

CASE 4 - TEMPERATURE 254^{0}C

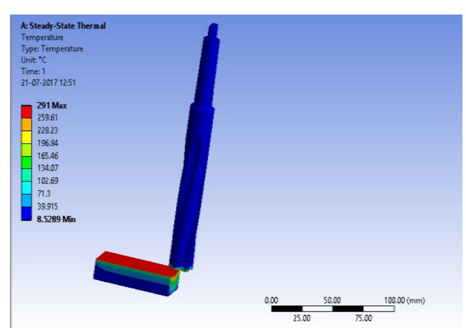


Temperature



Heat flux

CASE 5 - TEMPERATURE 291^{0}C



Temperature

e-ISSN: 2348-6848
p-ISSN: 2348-795X
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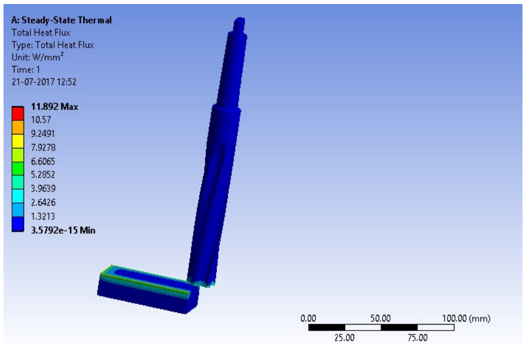
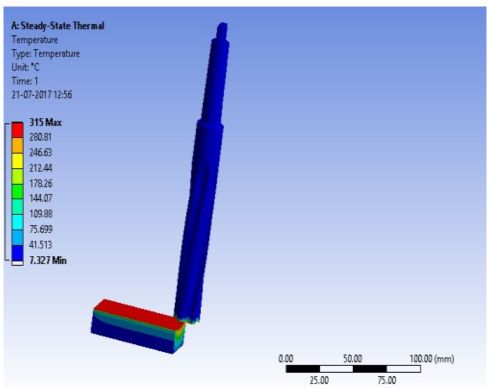


Het flux

CASE 6 - TEMPERATURE 315^{0}C



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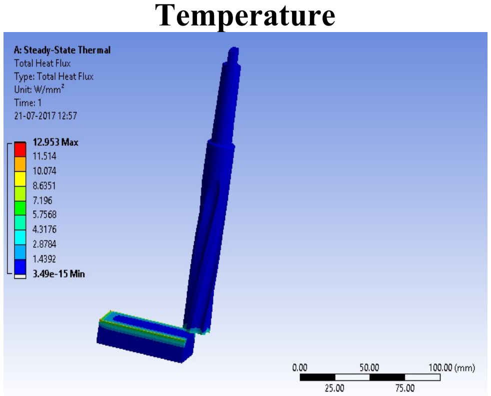
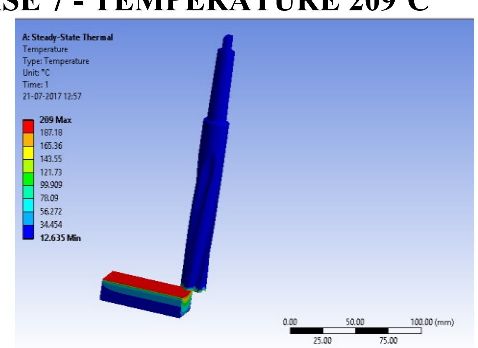
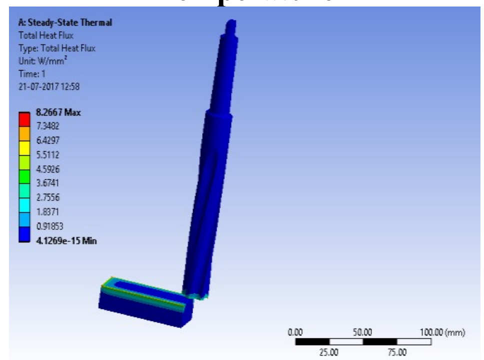


Heat flux

CASE 7 - TEMPERATURE 209^{0}C

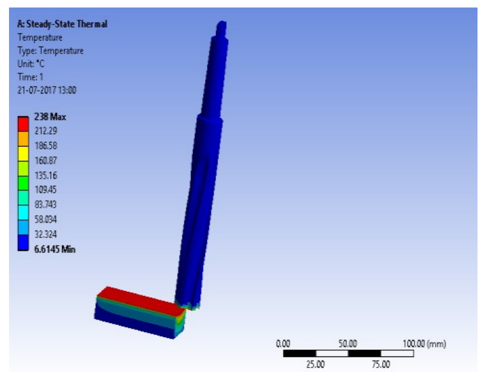


Temperature

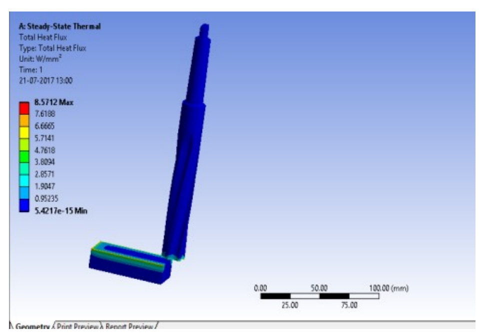


Heat flux

CASE 8 - TEMPERATURE 238^{0}C

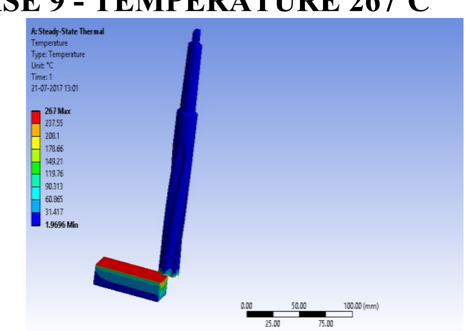


Temperature



Heat flux

CASE 9 - TEMPERATURE 267^{0}C



e-ISSN: 2348-6848
p-ISSN: 2348-795X
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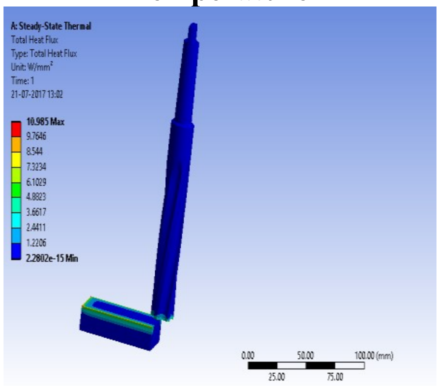
Temperature



Heat flux

RESULTS TABLE

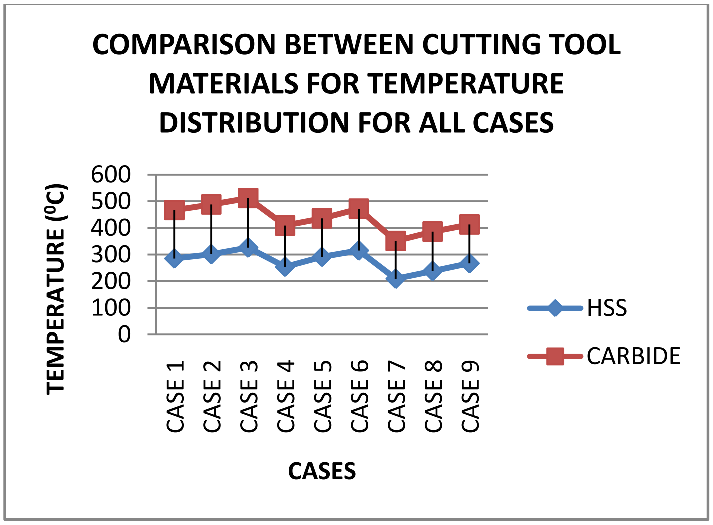
CUTTING TOOL – HSS

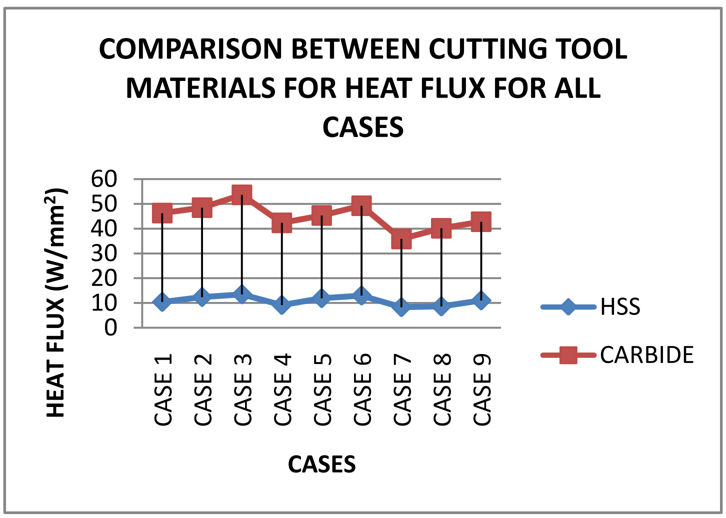
	Nodal Temperature(^oC)	Heat flux(W/mm^2)
CASE 1	285	10.357
CASE 2	301	12.334
CASE 3	326	13.439
CASE 4	254	9.1361
CASE 5	291	11.8927
CASE 6	315	12.953
CASE 7	209	8.266
CASE 8	238	8.5712
CASE 9	267	10.985

CUTTING TOOL – CARBIDE

	Nodal Temperature(^0C)	Heat flux(W/mm^2)
CASE 1	467	46.24
CASE 2	488	48.42
CASE 3	512	53.593
CASE 4	409	42.32
CASE 5	436	45.27
CASE 6	472	49.20
CASE 7	351	35.79
CASE 8	386	40.13
CASE 9	413	42.757

S-2 glass FGI-1800 cross ply 20 lamina	0	4.8208	1.02E-08	1.06E-03	2.01E-04	63.895





By observing the above results, the heat transfer rate is more for carbide tool than HSS since heat flux is more.

CONCLUSION

In this thesis, experiments are conducted on SS blocks at different speeds and at different coolant ratios. The coolant is a mixture of different percentages of water + Palm Kernel oil The percentages of coolant ratios are 30:70, 40:60 and 20:80 and different cutting speeds are 2000 rpm, 2500 rpm and 3000 rpm are taken while machining SS blocks.

Experimental investigation is conducted by increasing the cutting oil Palm Kernel oil percentage, thereby reducing water percentage by measuring the temperatures produced while machining SS blocks.
By observing the experimental results, by increasing the cutting oil percentage the temperature produced is decreasing and the temperatures are increasing by increasing the speeds. When compared the results for HSS and Carbide tools, by using Carbide tools more heat is generated which reduces the tool life.
So it can be concluded that use of more cutting oil than water in the coolant is better, cutting speeds should be less and using HSS cutting tool is better.
Thermal Analysis is performed on the tool and workpiece assembly by applying the temperatures measured experimentally by varying coolant ratios and cutting speeds for cutting tool materials HSS and Carbide. The work piece material is Stainless Steel.
Parametric Modeling is done in Pro/Engineer and analysis is done in Ansys.
By observing the results, the heat transfer rate is more for carbide tool than HSS since heat flux is more.

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