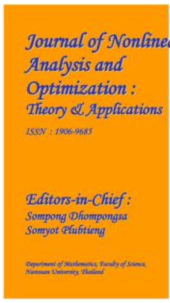

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ANALYSIS OF THERMAL REACTIONS IN MILLING PROCESSES WITH CONVENTIONAL FLUIDS AND MODELLING OF NON-STEADY-STATE PROCESSES

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ABSTRACT The process of milling involves passing material through a spinning cutter with several teeth in order to cut it off a work item. A large number of teeth in the procedure should enable quick machining. The temperatures generated at the cutting edge are thus constantly changing. When the cutting edge enters and leaves the cut, there are drastic temperature variations. Since less heat is produced during finishing operations than during roughing, the use of cutting fluid prolongs the life of tools. This machining method may produce a surface that is precisely proportioned, curved, or scaled incorrectly.

In the present experiment, cutting fluids such servo oil, palm oil, and sun flower oil are employed as coolants during milling. Motorcycle engines and other two- and four-stroke engines use servo oil as a lubricant. While palm oil is utilised in the food, cosmetics, and biofuel industries, sunflower oil is also used as cooking oil and in the production of detergents and cosmetics. The milling process enhances heat transfer with the use of oils. The face milling process is used in each scenario to compute the FEA behaviour in an unstable condition. Cutting tools made of HSS and cemented carbide are utilised with these fluids. Three distinct coolants were employed, and the milling was done in a dry atmosphere. In this study, the models were created using parametric modelling software (CATIA), and the heat transfer rates of three different oils were compared using analytic software (ANSYS).

Finite element analysis, ANSYS, CATIA, milling, and cutting fluid

I. INTRODUCTION

A milling machine removes material from a work piece by rotating a cutting tool (cutter) and moving it into the work piece. Milling machines, either vertical or horizontal, are usually used to machine flat and irregularly shaped surfaces and can be used to drill, bore, and cut gears, threads, and slots. Milling is one of the types of cutting machine which is used for various types of operations on it.

The milling machine is operated with the help of an electric motor which is connected to a spindle of the cutting tool to produce high rotational speed to remove the extra material from work. on this type of machine, we can work on small parts and large parts. We can operate various types of operations on this machine like angular, form, face, up and down milling, etc. In this type of operation, the work piece used to feed against the cutting tool which makes the high rotational speed at a fixed center. In this type of machining operation, there are different types of cutters used in milling operations and in cutting tools of the milling machine the number of teeth on it depends on the circumference of a cutting tool.

1.1 Milling Machine Operation

All the milling machines are used to cut/remove the extra material from a workpiece to obtain a required product. First, the supply of electricity is needed to run the motor with the help of this, spindle makes rotation with high speed due to the connection between them. for further rotation of the cutting tool, the spindle is connected to cutting tool holder. In some of the milling machines, we can move the spindle in different directions according to the work required. we need to feed the work towards the cutting tool, in most of the milling machine process work gets completed in one pass towards the cutting tool due to the cutting tool consist of more than two cutters on it. In this type of machine, we can adjust the knee and there is a need of cooling oil due to continuous cutting and fast rate.

1.2 Cutting fluids used in this study

a) Servo oil

SERVO brand, from Indian Oil, is the brand leader among lubricants and greases in India and has been conferred the "Consumer Super brand" status by the Super brands Council of India. Recognized for its brand leadership by the World Brand Congress andas a Master Brand by CMO, Asia, SERVO has now carved a significant niche in over 20 countries across the globe.

b) Palm oil

It is an edible vegetable oil that comes from the fruit of oil palm trees, the scientific name is Elaeis guineensis. Two types of oil can be produced; crude palm oil comes from squeezing the fleshy fruit, and palm kernel oil which comes from crushing the kernel, or the stone in the middle of the fruit.

c) Sun flower oil

The cutting fluid consisted of a vegetable oil (refined sunflower oil) as base oil and additives. It was an oil- in water Nemulsion type which contained a surfactant mixture (Tween 85 and Peg 400, Merck), and variousadditives in the formula to meet the specifications such as resistance to bacterial growth, corrosion, antifoaming agent and anti wear. The additive concentrations used were below 10%w/w. An emulsion is a dispersion of one immiscible liquid into another, through the use of a chemical reagent that reduces the interfacial tension between the two liquids to achieve stability.

1.3 Work piece details

The material used for the test is an aluminum alloy (Al 6061). The work piece material compositions are as follows.

Table 1: Compositions of work piece

Component	Weight %
Al	87.1 - 91.4 %
Cr	0.18 - 0.28 %
Cu	1.2 - 2.0 %
Fe	<= 0.50 %
Mg	2.1 - 2.9 %
Mn	<= 0.30 %
Other,each	<= 0.05 %
Other,total	<= 0.15 %
Si	<= 0.40 %
Ti	<= 0.20 %
Zn	5.1 - 6.1 %

II. LITERATURE SURVEY

Mandeep Chahal et al. with the more precise demands of modern engineering products, the control of surface texture has become more important. This investigation outlines the Taguchi optimization methodology, which is applied to optimize cutting parameters in end milling operation. The study was conducted in machining operation for hardened die steel H-13. The processing of the job was done by solid carbide four flute end-mill tools under finishing conditions. The input machining parameters like spindle speed, depth of cut, and feed rate were evaluated to study their effect on SR (surface roughness) using L-9 standard orthogonal array. Signal-to-Noise (S/N) ratio, Analysis of Variance (ANOVA) and various plots were generated using MINITAB software. Finally the effect of machining input parameters on SR is studied and reported in thispaper.

Lohithaksha M Maiyer et al. studied the optimization of machining parameters for end milling of Inconel 718 super alloy using Taguchi based grey relational analysis. Cutting speed, feed rate and depthof cut ate optimized with, consideration of surface roughness and material removal rate (MRR). Used uncoated tungsten carbide tool of 10mm diameter and4 flutes. L9 orthogonal array of Taguchi method are applied. Analysis of variance (ANOVA) and grey
relational analysis is also applied to get the mostsignificant factor. He found that cutting velocity is most affecting factor and followed by feed rate affecting the multiple performance characteristics.

M. Alauddin et al. studied the optimization of surface finish in end milling Inconel 718 by using a tungsten carbide insert in dry condition. The nose radius of insert is 0.80 mm. for the analysis of result he has taken two process variables: cutting speed and feed rate. He Used response surface method for experimental design. He found that if feed rate isincreased, then the surface roughness is also increased and vice versa and if cutting speed is increased.

III METHODOLOGY USED

3.1 Finite Element Analysis (FEA)

Finite Element Analysis (FEA) was first developed in 1943 by R. Courant, who utilized the Ritz method of numerical analysis and minimization of variational calculus to obtain approximate solutions to vibration systems. Shortly thereafter, a paper published in 1956 by M. J. Turner, R. W. Clough, H. C. Martin, and L.

J. Top established a broader definition of numerical analysis. The paper centered on the "stiffness and deflection of complex structures".

By the early 70's, FEA was limited to expensive mainframe computers generally owned by the aeronautics, automotive, defense, and nuclear industries. Since the rapid decline in the cost of computers and the phenomenal increase in computing power, FEA has been developed to an incredible precision. Present day supercomputers are now able to produce accurate results for all kinds of parameters. FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

IV STRUCTURAL ANALYSIS OFMILLING MACHINE

4.1 MATERIAL –HSSAT -3000 RPM

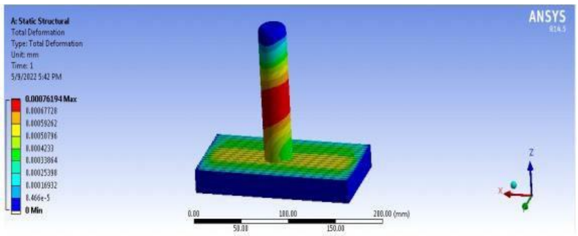

Fig 1: Total deformation at 3000 RPM for HSSmaterial

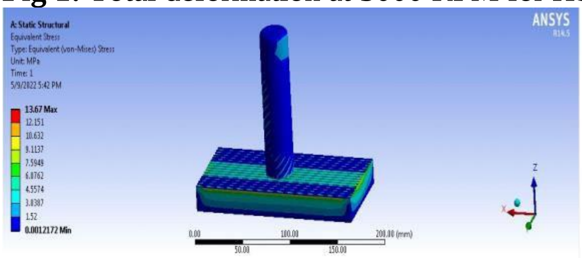

Fig 2: Stress at 3000 RPM for HSS material

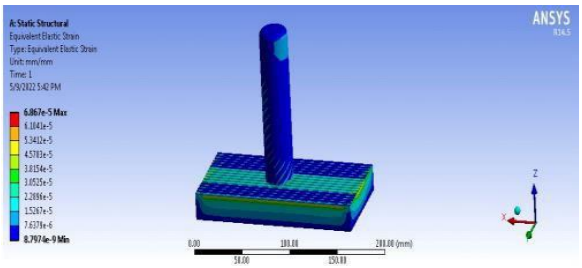

Fig 3: Strain at 3000 RPM for HSS material

AT RPM-4000

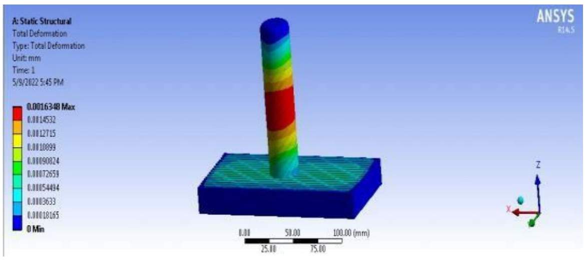

Fig 4: Total deformation at 4000 RPM for HSSmaterial

Fig 5: Stress at 3000 RPM for HSS material

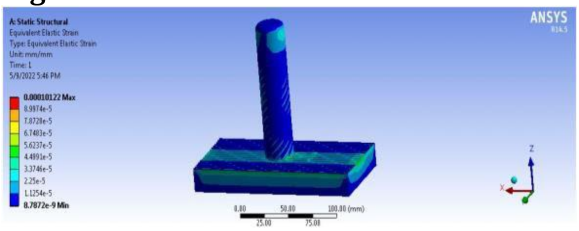

Fig 6: Strain at 3000 RPM for HSS material

4.2 MATERIAL – CEMENTED CARBIDEAT RPM-3000 RPM

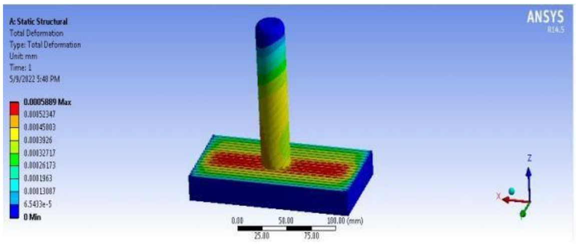

Fig 7: Total deformation at 3000 RPM for cementedcarbide material

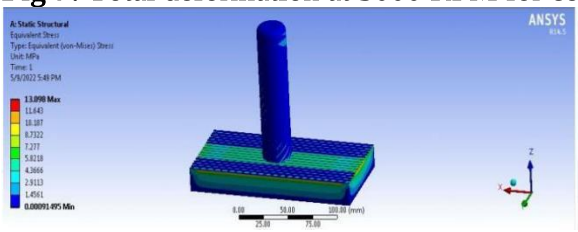

Fig 8: Stress at 3000 RPM for cemented carbidematerial

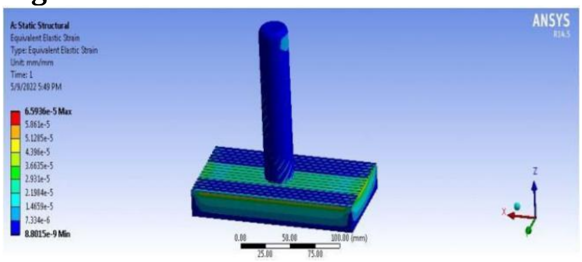

Fig 9: Strain at 3000 RPM for cemented carbidematerial

V TRANSIENT THERMAL ANALYSISOF MILLING MACHINE

5.1 TOOL MATERIAL- HSS

A) FLUID –AIR

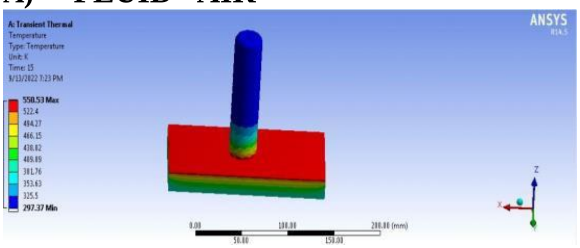

Fig 10: Temperature for air fluid for HSS material

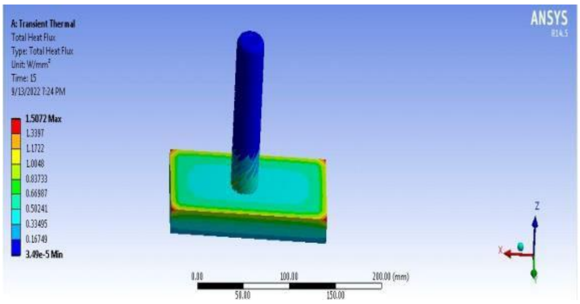

Fig 11: Heat flux for air fluid for HSS material

B) FLUID –PALM OIL

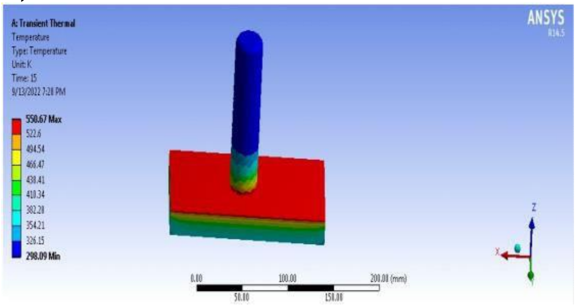

Fig 12: Temperature for fluid Palm oil material

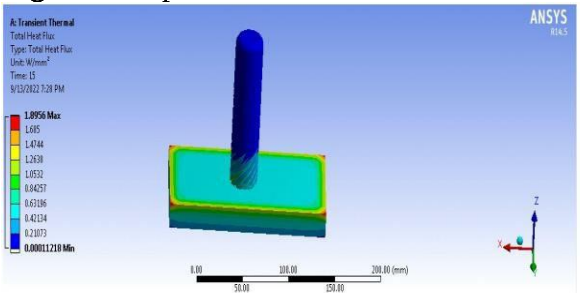

Fig 13: Heat flux for Palm oil material

C) FLUID- SERVO OIL

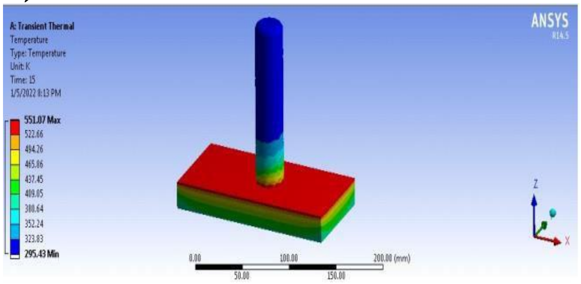

Fig 14: Temperature for Servo oil material

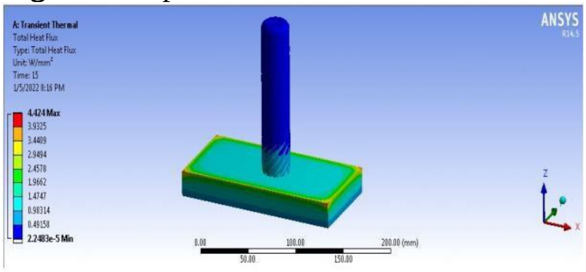

Fig 15: Heat flux for Servo oil material

D) FLUID-SUNFLOWER OIL

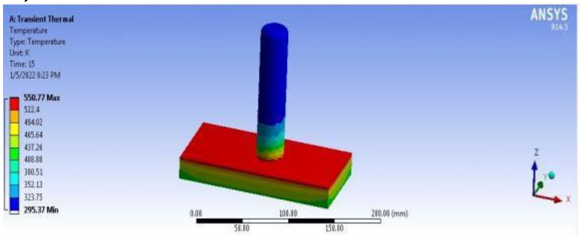

Fig 16: Temperature for sun flower oil material

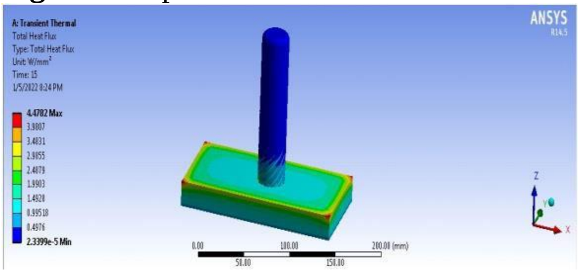

Fig 17: Heat flux for Sun flower oil material

5.2 TOOL MATERIAL- CEMENTED CARBIDE

A) FLUID- AIR

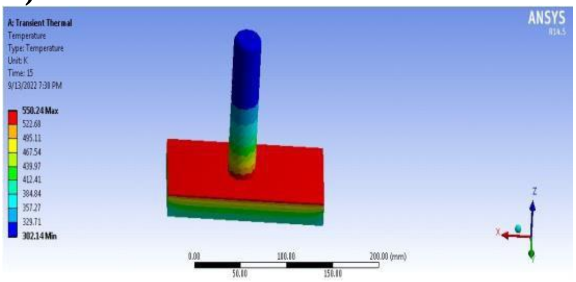

Fig 18: Temperature for cemented carbide material

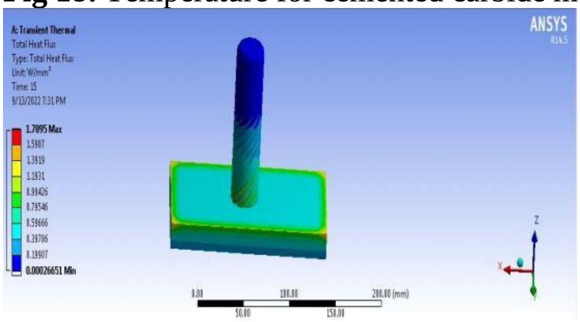

Fig 19: Heat flux for cemented carbide material

B) FLUID- PALM OIL

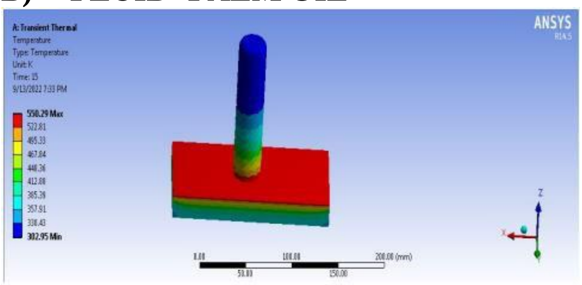

Fig 20: Temperature for palm oil material

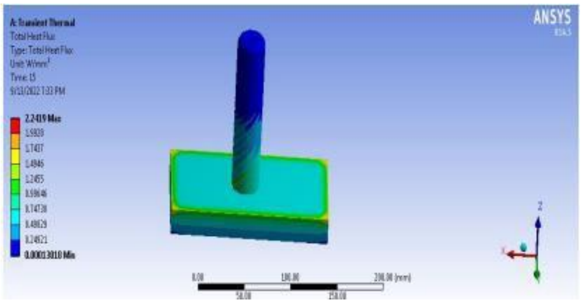

Fig 21: Heat flux for palm oil material

C) FLUID- SERVO OIL

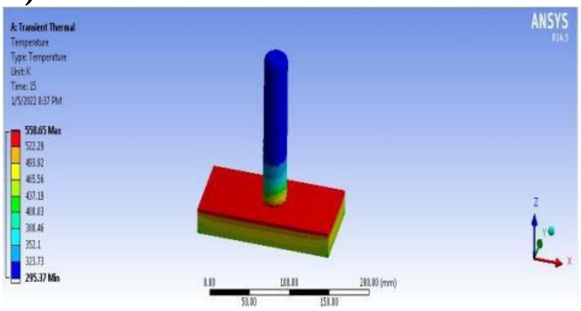

Fig 22: Temperature for servo oil material

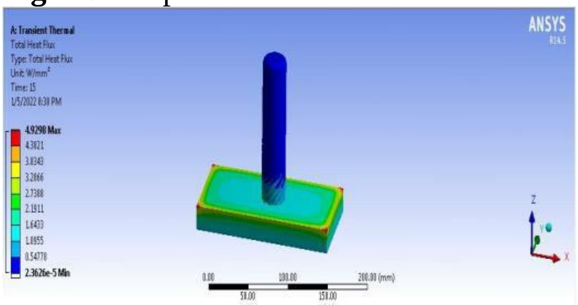

Fig 23: Heat flux for servo oil material

D) FLUID- SUN FLOWER OIL

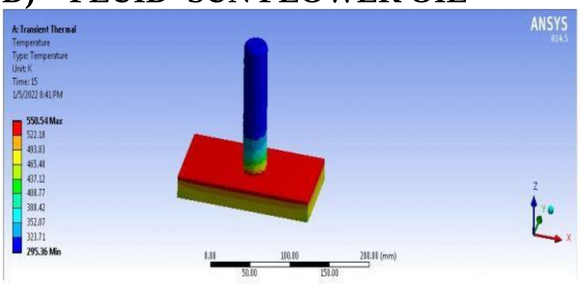

Fig 24: Temperature for sun flower oil material

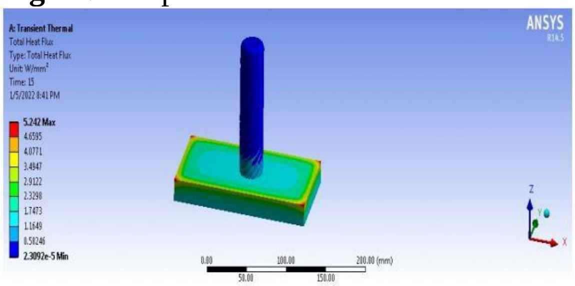

Fig 25: Heat flux for sun flower oil material

Table 2: Static Analysis Results

TOOLMATERIAL	Tool Rotational Speed(Rpm)	Total Deformation (mm)	Stress (Mpa)	Strain
HSS	3000	0.00076194	13.67	6.86e-5
	4000	0.0016348	17.066	7.12e-5
CEMENTED CARBIDE	3000	0.0005899	13.098	6.59e-5
	4000	0.0010641	14.326	7.21e-5

Table 3: Thermal analysis results

TOOL MATERIAL	FLUID	TEMPERATURE(k)		HEAT FLUX (W/mm^2)
		MIN	MAX	
HSS	AIR	297.37	550.53	1.5072
	PALM OIL	298.09	550.67	1.8956
	SERVO OIL	295.43	551.07	4.424
	SUNFLOWER OIL	295.37	550.77	4.4782
CEMENTED CARBIDE TOOL	AIR	302.14	550.24	1.7895
	PALM OIL	302.95	550.29	2.2419
	SERVO OIL	297.37	550.65	4.9298
	SUNFLOWER OIL	295.36	550.54	5.242

VI. CONCLUSIONS

Sunflower oil and servo oil are employed as coolants in machining processes in this thesis. Cutting tools made of HSS and cemented carbide are used at varying temperatures. Temporary The parametric model is thermally analysed to ascertain the impact of various cutting fluids on the cutters. CATIA is used for parametric modelling, whereas Ansys is used for analysis. Given that sunflower oil has a higher thermal flux than servo oil, the analytical findings show that using sunflower oil leads in higher heat transfer rates. When comparing the tool material values, carbide tools have higher heat transfer rates than HSS tools.

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