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MILLING PROCESS MODELLING AND NON-STEADY-STATE THERMAL ANALYSIS USING A VARIETY OF CONVENTIONAL FLUIDS

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AbstractMilling is the process of cutting material from a work item by feeding it through a rotating cutter with several teeth. Having many teeth in the processing should allow for a fast way of machining. As a result, the temperatures produced at the cutting edge are in a continual state of flux. Extreme temperature changes occur when the cutting edge enters and exits the cut. The use of cutting fluid extends the life of tools in finishing activities since less heat is generated during these processes than in roughing. This machining process has the potential to result in a curved, exact, or inaccurately sized surface.

Cutting fluids such as servo oil, palm oil, and sun flower oil are used as coolants during milling in the current experiment. Two-stroke and four-stroke engines, such as those seen in motorcycles, utilise servo oil as a lubricant. Sunflower oil is also used as cooking oil and in the manufacture of cosmetics and detergents, whereas palm oil is utilised in the food industry, the cosmetics industry, and as a biofuel. Oils used in the milling process improve heat transmission. In each scenario, the unsteady state FEA behaviour is calculated using the face milling procedure. These cutting fluids are used with cemented carbide and HSS cutting tools. The milling was performed in a dry environment, and three different coolants were used. In this work, parametric modelling software (CATIA) was used to create the models, and analytic software (ANSYS) was utilised to compare the heat transfer rates of three different oils.

Milling, cutting fluid, ANSYS, CATIA, and finite element analysis

I. INTRODUCTION

A milling machine removes material from aworkpiecebyrotatingacuttingtool(cutter)andmovingitintotheworkpiece.Millingmachines,eitherverticalorhorizontal,areusuallyusedtomachine flat and irregularly shaped surfaces and canbeusedtodrill, bore,andcutgears,threads,andslots. Milling is one of the types of cutting machinewhichis used forvarioustypesofoperationsonit.

Themillingmachineisoperatedwiththehelp of an electricmotorwhich is connected to aspindle of the cutting tool to produce high rotationalspeed to remove the extra material from work. on thistype of machine, we can work on small parts andlargeparts.Wecanoperatevarioustypesofoperations on this machine like angular, form, face,upanddownmilling,etc.Inthistypeofoperation,the work piece used to feed against the cutting toolwhichmakesthehighrotationalspeedatafixedcenter. In this type of machining operation, there aredifferent types of cutters used in milling operationsandincuttingtoolsofthemillingmachinethenumberofteethonitdependsonthecircumferenceofa cuttingtool.

1.1 MillingMachineOperation

Allthemillingmachinesareusedtocut/remove the extra material from a workpiece toobtainarequiredproduct.First,thesupplyofelectricity is needed to run the motor with the help ofthis, spindlemakes rotation with high speed due tothe connection between them. for further rotation ofthe cutting tool, the spindle is connected to cuttingtool holder. In some of the milling machines, we canmove the spindle in different directions according totheworkrequired.weneedtofeedtheworktowards thecuttingtool,inmostofthemillingmachineprocess work gets completed in one pass towards thecutting tool due to the cutting tool consist of morethan two cutters on it. In this type of machine, we canadjust the knee and there is a need of cooling oil dueto continuouscuttingandfastrate.

1.2 Cuttingfluidsusedinthisstudy

a) Servooil

SERVO brand, from Indian Oil, is the brand leaderamong lubricants and greases in India and has beenconferred the "Consumer Super brand" status by theSuperbrandsCouncil of India. Recognizedfor itsbrandleadershipby the WorldBrandCongress andas a Master Brand by CMO, Asia, SERVO has nowcarved a significant niche in over 20 countries acrosstheglobe.

b) Palmoil

It is an edible vegetable oil that comes from the fruitofoilpalmtrees,thescientificnameisElaeisguineens is. Two types of oil can be produced; crudepalm oil comes from squeezing the fleshy fruit, andpalmkerneloilwhichcomesfromcrushingthekernel, orthestone inthemiddle ofthefruit.

c) Sunflower oil

The cutting fluid consisted of a vegetable oil (refinedsunflower oil) as base oil and additives. It was an oil-in water Nemulsion type which contained a surfactantmixture (Tween 85 and Peg 400, Merck), and variousadditives in the formula tomeet the specificationssuchasresistancetobacterialgrowth,corrosion,antifoamingagentandantiwear.Theadditiveconcentrationsusedwerebelow10%w/w.Anemulsion is a dispersion of one immiscible liquid intoanother, through the use of a chemical reagent thatreducestheinterfacialtensionbetweenthetwoliquids toachieve stability.

1.3 Workpiece details

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

Table1: Compositionsofworkpiece

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. LITERATURESURVEY

MandeepChahaletal.withthemoreprecisedemands of modern engineering products, the controlof surface texture has become more important. ThisinvestigationoutlinestheTaguchioptimizationmethodology,which is applied to optimizecuttingparameters in end milling operation. The study wasconducted in machining operation for hardened diesteel H-13. The processing of the job was done bysolid carbide four flute end-mill tools under finishingconditions.Theinputmachiningparameterslikespindlespeed,depthofcut,andfeedratewereevaluatedtostudytheireffectonSR(surfaceroughness)usingL-9standardorthogonalarray.Signal-to-Noise(S/N)ratio,AnalysisofVariance(ANOVA)andvarious plotswere generatedusingMINITAB software. Finally the effect of machininginput parameters on SR is studied and reported in thispaper.

LohithakshaMMaiyeretal.studiedtheoptimization of machining parameters for end millingof Inconel 718 super alloy using Taguchi based greyrelational analysis. Cutting speed, feed rate and depthof cut ate optimized with, consideration of surfaceroughness and material removal rate (MRR). Useduncoated tungsten carbide tool of 10mm diameter and4 flutes. L9 orthogonal array of Taguchi method areapplied.Analysisofvariance(ANOVA)andgrey

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relationalanalysisisalsoappliedtogetthemostsignificant factor. He found that cutting velocity ismostaffectingfactorandfollowedbyfeedrateaffectingthe multipleperformancecharacteristics.

M.Alauddinetal.studiedtheoptimizationofsurface finish in end milling Inconel 718 by using atungstencarbideinsertindrycondition.Thenoseradius of insert is 0.80 mm. for the analysis of resulthe has taken two process variables: cutting speed andfeedrate.HeUsedresponsesurfacemethodforexperimentaldesign.Hefoundthatiffeedrateisincreased,thenthesurfaceroughnessisalsoincreasedandviceversaandifcuttingspeedisincreased.

III METHODOLOGYUSED

3.1FiniteElementAnalysis(FEA)

Finite Element Analysis (FEA) was first developed in1943 by R. Courant, who utilized the Ritz method ofnumericalanalysis andminimization of variationalcalculus to obtain approximate solutions to vibrationsystems. Shortly thereafter, a paper published in 1956byM.J.Turner,R.W.Clough,H.C.Martin,andL. J. Top established a broader definition of numericalanalysis.Thepapercenteredonthe"stiffnessanddeflectionofcomplexstructures".

Bytheearly70's,FEAwaslimitedtoexpensivemainframe computersgenerallyownedbytheaeronautics,automotive,defense,andnuclearindustries.Sincetherapiddecline inthecostofcomputers and the phenomenal increase in computingpower,FEAhasbeendevelopedtoanincredibleprecision.Presentdaysupercomputersarenowabletoproduceaccurateresultsforallkindsofparameters. FEA consists of a computer model of amaterial or design that is stressed and analyzed forspecific results. It is used in new product design, andexisting product refinement. A company is able toverifyaproposeddesignwillbeabletoperformtothe client's specifications prior to manufacturing orconstruction.Modifyinganexistingproductorstructure is utilized to qualify the product or structureforanewservicecondition.Incaseofstructuralfailure,FEAmaybeusedtohelpdeterminethedesignmodificationstomeetthenewcondition.

IV STRUCTURAL ANALYSIS OFMILLINGMACHINE

4.1 MATERIAL – HSSAT-3000RPM

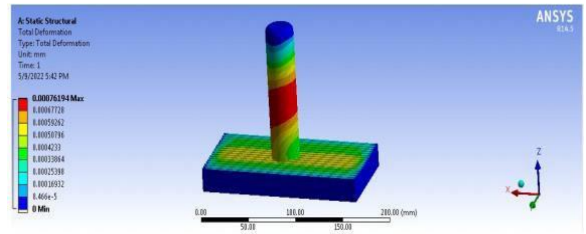

Fig1: Totaldeformationat3000 RPMforHSSmaterial

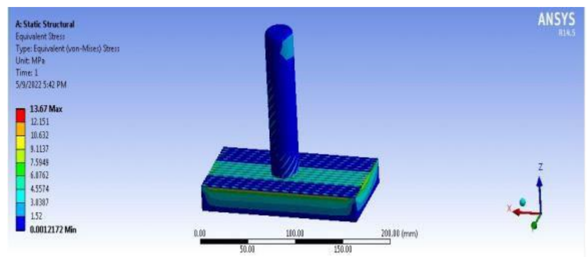

Fig2: Stressat3000RPMforHSSmaterial

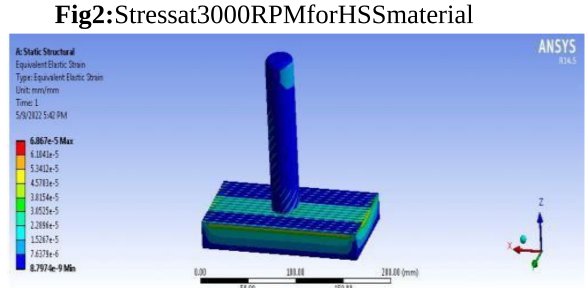

Fig3: Strainat3000 RPMforHSSmaterial

ATRPM-4000

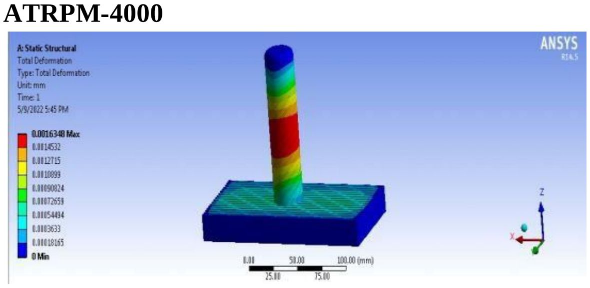

Fig4: Totaldeformationat4000 RPMforHSSmaterial

Fig5: Stressat3000RPMforHSSmaterial

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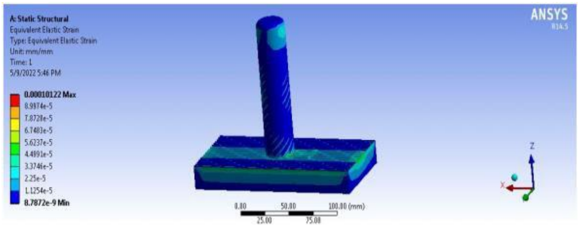

Fig6: Strainat3000 RPMforHSSmaterial

4.2 MATERIAL–CEMENTEDCARBIDEATRPM-3000RPM

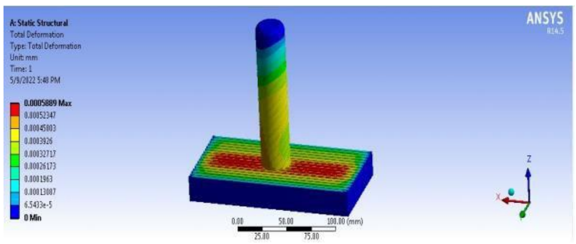

Fig7: Totaldeformationat3000RPMforcementedcarbidematerial

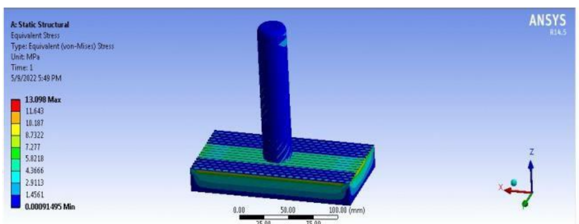

Fig8: Stressat3000RPMforcementedcarbidematerial

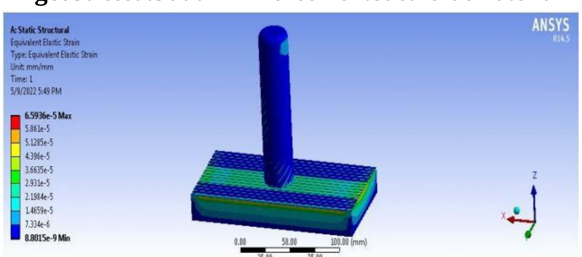

Fig9: Strainat3000RPMforcemented carbidematerial

V TRANSIENTTHERMALANALYSISOFMILLINGMACHINE

5.1 TOOLMATERIAL-HSS

A) FLUID–AIR

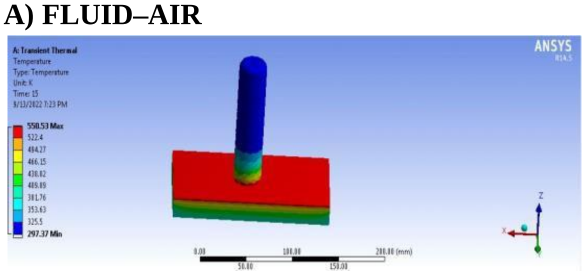

Fig10: Temperature forairfluid forHSSmaterial

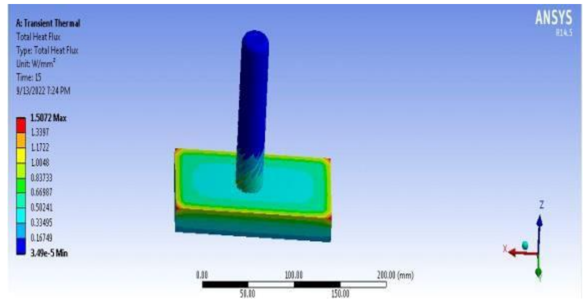

Fig11: HeatfluxforairfluidforHSSmaterial

B) FLUID–PALM OIL

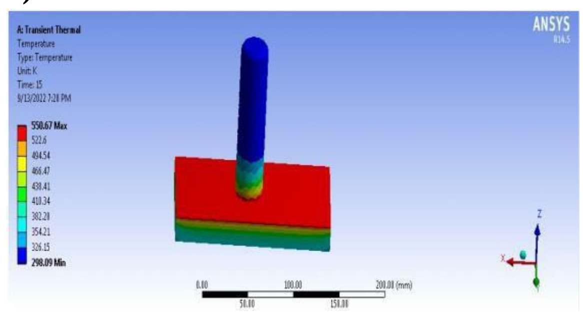

Fig12: Temperatureforfluid Palmoil material

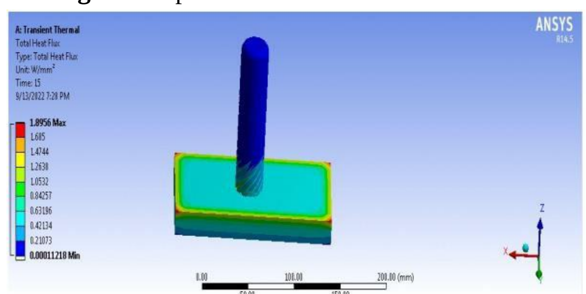

Fig13: HeatfluxforPalmoilmaterial

C) FLUID-SERVOOIL

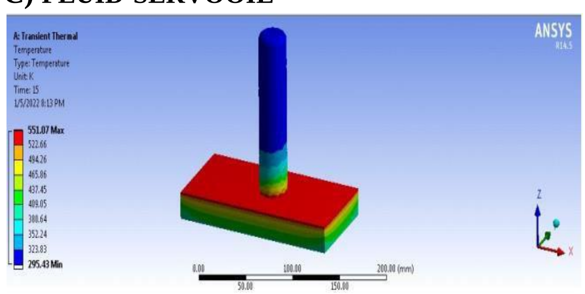

Fig14: TemperatureforServooilmaterial

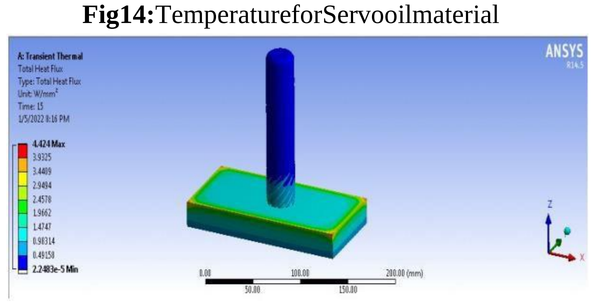

Fig15: HeatfluxforServo oil material

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D) FLUID-SUNFLOWEROIL

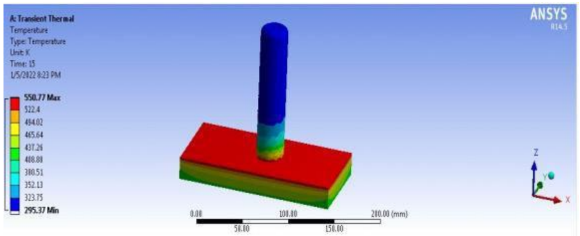

Fig16: Temperature forsunfloweroil material

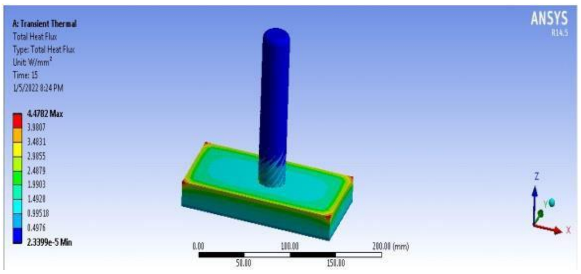

Fig17: HeatfluxforSun floweroilmaterial

5.2 TOOLMATERIAL-CEMENTEDCARBIDE

A) FLUID-AIR

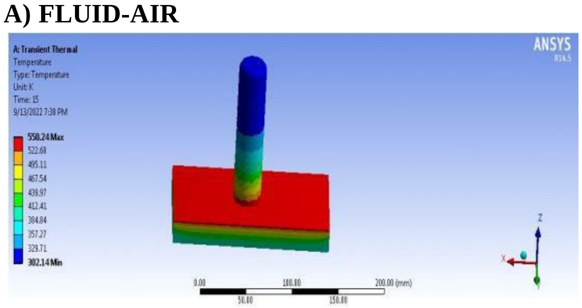

Fig18: Temperatureforcementedcarbidematerial

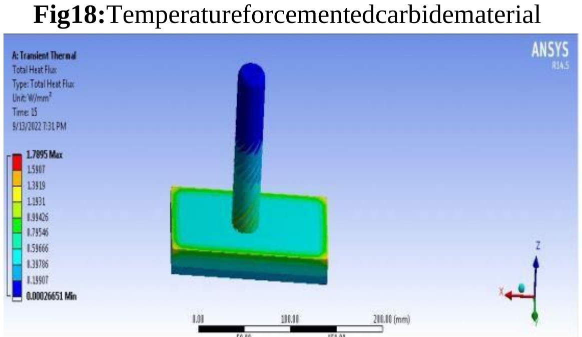

Fig 19: Heat fluxfor cementedcarbidematerial

B) FLUID-PALMOIL

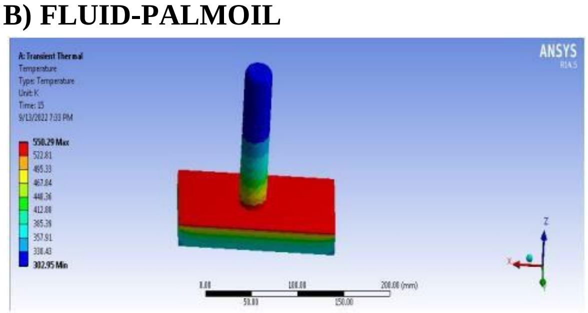

Fig20: Temperatureforpalmoilmaterial

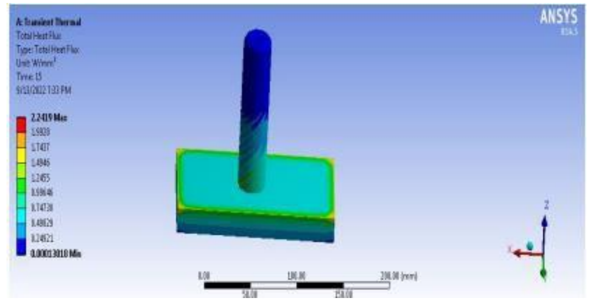

Fig21: Heatfluxforpalmoilmaterial

C) FLUID-SERVOOIL

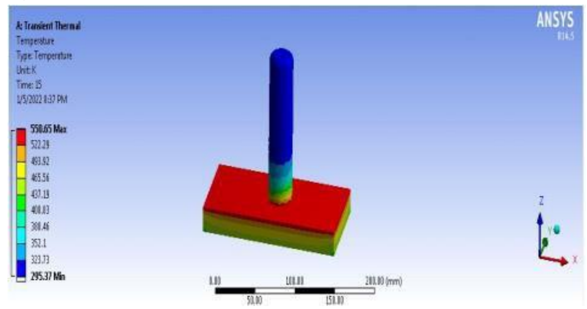

Fig22: Temperature forservooilmaterial

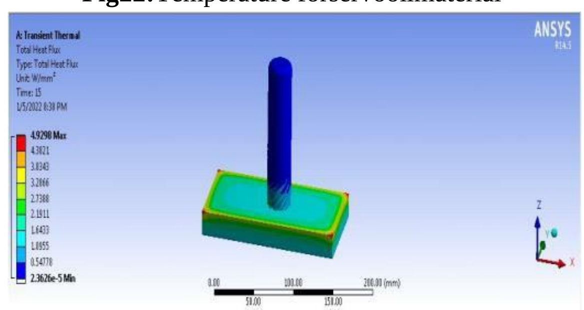

Fig23: Heatfluxforservo oil material

D) FLUID-SUNFLOWEROIL

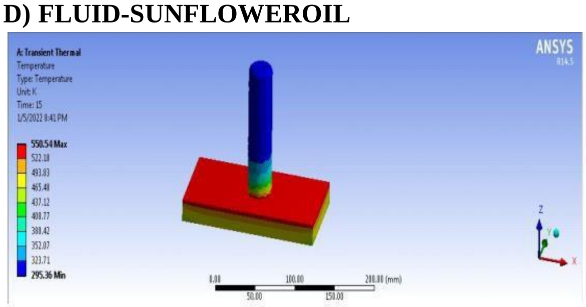

Fig24: Temperature forsunfloweroil material

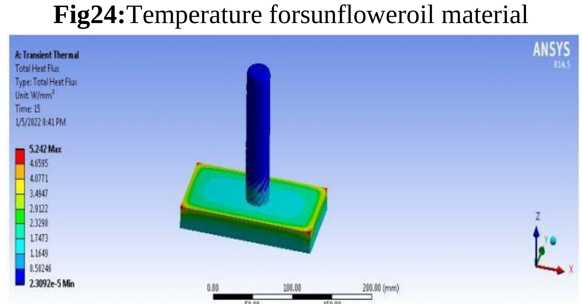

Fig25: Heatfluxforsunfloweroilmaterial

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Table2: Static AnalysisResults

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

Table3: Thermalanalysisresults

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

In this thesis servo oil and sun flower oil are used ascoolants in machining operations. Cemented carbideand HSS cutting tools are employed as cutter withdifferent temperatures. Transient Thermal analysis isdone on the parametric model to determine the effectof different cutting fluids on the cutters. ParametricModeling is done in CATIA and analysis is done inAnsys.Byobservingtheanalysisresults,theheattransferratesaremorewhenthefluidSunfloweroilis usedsincethermalflux ismorethan servooil.Whencomparedthevaluesfortoolmaterials,the heat transfer rates are more for carbide tool than HSStool.

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