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Comparision of experimental results of different tool alloys materials with FEA analysis

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Abstract:-*In this research work the Investigation of Tool Wear and Tool Life with Optimization of parameters on different tool alloys on S1(SS316),S2(SS304),S3(SS410),S4(SS440C),S5(HSS),S6Titanium alloy gradeS6 (Ti-6Al-4V) Tool material ,Workpiece material ,Max. Time elapsed(in min.)Flank wear(in mm),Wear rate m/min For mild steel workpiece material at low cutting speed the shear force of theSS440C(S4) material is high a scompared to the HSS (S6)tool. For aluminium workpiece material, at lower cutting speed SS316(S1) has a greater Shear force than the Titanium alloy (Ti-6Al-4V) (S5), but at higher cutting speeds Titanium alloy(Ti-6Al-4V)(S5)was found to have higher Shear force thanSS316(S1).For mild steel workpiece material, at all cutting speeds tool life of HSS (S6) andSS440C(S4)was found to be relatively close. For aluminium workpiece material, at all speeds Titanium alloy (Ti-6Al-4V) (S5) was found to be having longer tool life than SS316(S1) and (Ti-6Al-4V) S5 tool cost is very high compare to other tools (S6) (S4)(S3) (S2)(S1). Finally the cutting tool Titanium alloy (Ti-6Al-4V) (S5) and HSS (S6) is good compare to other alloy materials with FEA analysis is carried with less 10% error.

Keywords:- S1(SS316),S2(SS304),S3(SS410),S4(SS440C),S5(HSS),S6Titanium alloy gradeS6 (Ti-6Al-4V) Tool material, FEA analysis, Optimization of parameters.

1.Introduction:- **1.1.Cutting tool** :-It is defined as eliminate or withdraw material from the component by using lathe machine.Removal of material on the workpiece is done by using single point cutting tool.

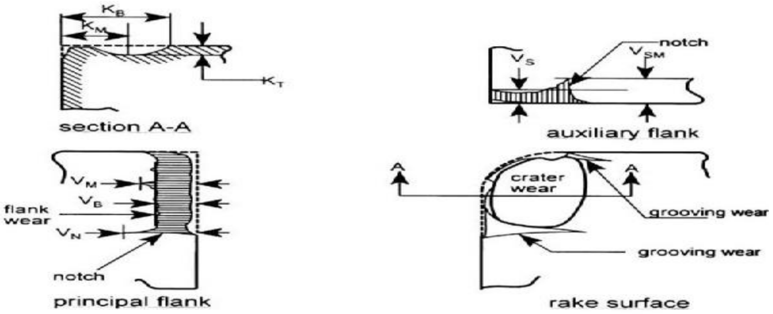
Designation and Features of tools:-The Designation and Features of tools are ASA system (AmericanStandards Association), ORS or ISO Old System (Orthogonal Rake System), NRS or ISONewSystem (Normal Rake System), MRS (MaximumRakeSystem)

The resources for cutting tool are Ceramics; Cubic Boron Nitride(c-BN);High Speed Steel(HSS);Tungsten carbide and Diamond.

Breakdownofcutting tools:-Due to extreme forces and impacts.Due to exhaustive stress and thermal properties.Due to erosion of the cutting edges of the tool.The following are the methods of cutting tool wear,The following are the methods of cutting toolwear are: Mechanical wear,Thermochemicalwear,Chemicalwear and ,Galvanicwear

Prevention of Toolwear:Suggestion from Machine Shop staff ;The following coating should be done to improve the tool life and reduces tool wear namely CVD and PVD technology (Chemical VapourDepositionand Physical Vapour Deposition).

Figure1.1:Shows Different flank and crater wear of turning tool[6-10]



1.2.The finite element method (FEM)/FEA:- is a popular method for numerically solving differential equations arising in engineering and mathematical modeling. Typical problem areas of interest include the traditional fields of structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential.

The FEM is a general numerical method for solving partial differential equations in two or three space variables (i.e., some boundary value problems). To solve a problem, the FEM subdivides a large system into smaller, simpler parts that are called finite elements. This is achieved by a particular space discretization in the space dimensions, which is implemented by the construction of a mesh of the object: the numerical domain for the solution, which has a finite number of points. The finite element method formulation of a boundary value problem finally results in a system of algebraic equations. The method approximates the unknown function over the domain.[1] The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. The FEM then approximates a solution by minimizing an associated error function via the calculus of variations.

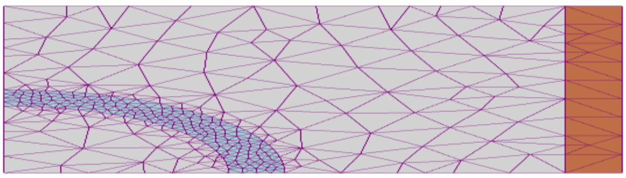


Fig.1.2.Meshing[6-10]

FEM mesh created by an analyst prior to finding a solution to a magnetic problem using FEM software. Colors indicate that the analyst has set material properties for each zone,

1.3.Finite element analysis (FEA) is a numerical analysis method used for solving a multitude of engineering problems related to structural analysis and fluid flow.

The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use FEA software to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster while saving on expenses.

It is necessary to use mathematics to comprehensively understand and quantify any physical phenomena such as structural or fluid behavior, thermal transport, wave propagation, the growth of biological cells, etc. Most of these processes are described using Partial Differential Equations (PDEs). However, for a computer to solve these PDEs, numerical techniques have been developed over the last few decades and one of the prominent ones, today, is the Finite Element Analysis.

Differential equations not only describe natural phenomena but also physical phenomena encountered in engineering mechanics. These partial differential equations (PDEs) are complicated equations that need to be solved in order to compute relevant quantities of a structure (like stresses (ϵ), strains (ϵ), etc.) in order to estimate the structural behavior under a given load. It is important to know that FEA only gives an approximate solution to the problem and is a numerical approach to get the real result of these partial differential equations. Simplified, FEA is a numerical method used for the prediction of how a part or assembly behaves under given conditions. It is used as the basis for modern simulation software and helps engineers to find weak spots, areas of tension, etc. in their designs. The results of a simulation-based on the FEA method are usually depicted via a color scale that shows, for example, the pressure distribution over the object.

Depending on one's perspective, FEA can be said to have its origin in the work of Euler, as early as the 16th century. However, the earliest mathematical papers on Finite Element Analysis can be found in the works of Schellbach [1851] and Courant [1943].

FEA was independently developed by engineers in different industries to address structural mechanics problems related to aerospace and civil engineering. The development for real-life applications started around the mid-1950s as papers by Turner, Clough, Martin & Topp [1956], Argyris [1957], and Babuska & Aziz [1972] show. The books by Zienkiewicz [1971] and Strang & Fix [1973] also laid the foundations for future developments in FEA software.[11].

2.LITERATURESURVEY

[1].Yung-Chang Yen et.al.[2004]They investigated that the effects of edge preparation of the cutting tool (round/hone edge and T-land/chamfer edge) upon chip formation, cutting forces, and process variables (temperature, stress, and strain) in orthogonal cutting as determined with finite element method (FEM) simulations. The results obtained from this study provide a fundamental understanding of the process mechanics for cutting with realistic cutting tool edges and may assist in the optimization of tool edge design.The Lagrangian thermo-viscoplastic cutting simulation of 0.2% carbon steel was conducted until the steady chip flow and cutting forces were obtained. The predicted cutting forces and chip geometries for the hone tools with different edge radii were compared with the experimental results given in the literature. Tool temperatures and tool stresses on the tool rake face were predicted while the material flow at the vicinity of the edge radius was characterized by the location of the stagnation point. A similar process model and the relevant analyses were extended to the application of chamfer tools with different chamfer widths and chamfer angles.

[2] Tugrul Özelet.al.[2006] In this work, In the analysis of orthogonal cutting process using finite element (FE) simulations, predictions are greatly influenced by two major factors; a) flow stress characteristics of work material at cutting regimes and b) friction characteristics mainly at the tool-chip interface. The uncertainty of work material flow stress upon FE simulations may be low when there is a constitutive model for work material that is obtained empirically from high-strain rate and temperature deformation tests. However, the difficulty arises when one needs to implement accurate friction models for cutting simulations using a particular FE formulation. In this study, an updated Lagrangian finite element formulation is used to simulate continuous chip formation process in orthogonal cutting of low carbon free-cutting steel. Experimentally measured stress distributions on the tool rake face are utilized in developing several different friction models. The effects of tool-chip interfacial friction models on the FE simulations are investigated. The comparison results depict that the friction modeling at the tool-chip interface has significant influence on the FE simulations of machining. Specifically, variable friction models that are developed from the experimentally measured normal and frictional stresses at the tool rake face resulted in most favorable predictions. Predictions presented in this work also justify that the FE simulation technique used for orthogonal cutting process can be an accurate and viable analysis as long as flow stress behavior of the work material is valid at the machining.

[3] Muñoz-Sánchez et.al.[2011] They investigated that Machining is a dynamic process involving coupled phenomena: high strain and strain rate and high temperature. Prediction of machining induced residual stresses is an interesting objective at the manufacturing processes modelling field. Tool wear results in a change of tool geometry affecting thermo-mechanical phenomena and thus has a significant effect on residual stresses. The experimental study of the tool wear influence in residual stresses is difficult due to the need of controlling wear evolution during cutting. Also the involved phenomena make the analysis extremely difficult. On the other hand, Finite Element Analysis (FEA) is a powerful tool used to simulate cutting processes, allowing the analysis of different parameters influent on machining induced residual stresses. The aim of this work is to develop and to validate a numerical model to analyse the tool wear effect in machining induced residual stresses. Main advantages of the model presented in this work are, reduced mesh distortion, the possibility to simulate long length machined surface and time-efficiency. The model was validated with experimental tests carried out with controlled worn geometry generated by electro-discharge machining (EDM). The model was applied to predict machining induced residual stresses in AISI 316L and reasonable agreement with experimental results were found.

[4]. Deepak Lathwal1et.al [2013]They have analyzed on In this investigation, on HSS tool the outcomes are created from different orders of Force and mathematical conditions forced for to apparatus and following end are made. The apparatus powers decline and device life increments. On additional expansion it is accounted for that in spite of the fact that apparatus powers continues diminishing, instrument life diminishes. It is said that on expanding the rake point, cutting power diminishes thus less warmth is created. It is the explanation of resulting improvement in apparatus life .In any case, exceptionally huge positive rake calculated device have less mechanical quality which diminishes device life we have used the express unique Arbitrary Lagrangian Eulerian strategy with versatile cross section capacity to develop a FEM reproduction model for symmetrical cutting of Aluminum utilizing round edge HSS cutting device without utilizing a re-lattice conspire and without utilizing a chip division basis.

[5] Poonam Det.al.[2017] They investigated that In this work, the effect of temperature and cutting forces on the tip of Single Point Cutting Tool. Temperature at tool-tip is measured, generated in high speed machining operations. Temperature at cutting point of the tool is crucial parameter in the control of the machining process. Specifically, three different analyses are compared to an experimental measurement of temperature in a machining process at slow, medium and high speed. Tool-work Thermocouple technique is used for measuring temperature on tip of tool at various cutting parameters (depth of cut, speed and feed rate) and it found that with increase of speed and depth of cut temperature at tip of cutting tool increases. Cutting forces are analytically determined and stresses are found out at tip of cutting tool. Single Point Cutting Tool is modeled in CATIA software and model is then imported in ANSYS software for analysis. By applying temperature readings, temperature distribution on cutting tool is found out. Also from stress analysis of cutting tool it is observed that the effect of cutting force is more as compared to thrust force.

3.Selection of materials and methodology:-In this the SS316, SS304, SS410, SS440C, HSS and Ti-6Al-4V six different alloy materials are selected to conduct the Optimisation parameters with FEA methodology as follows Geometrical models of cutting tools and work piece geometry is built in 2 dimensional space as software's with axisymmetry option supports stress calculation under cutting force loads. Two types of plane elements are considered for cutting tool and work piece. Since work piece is circular, axisymmetry option of software was used for representation. So only radius of the work piece required to be modeled. But for cutting tool, plane element with thickness option is considered as the cutting tool geometry is not circular. Other elements were defined for contact definitions to estimate the contact stress and penetrations.

4.FEAAnalysis:-

Comparative Results of Experimental and numerical analysis.
Methodology :

Geometrical Modeling of cutting tool and geometry of the work piece

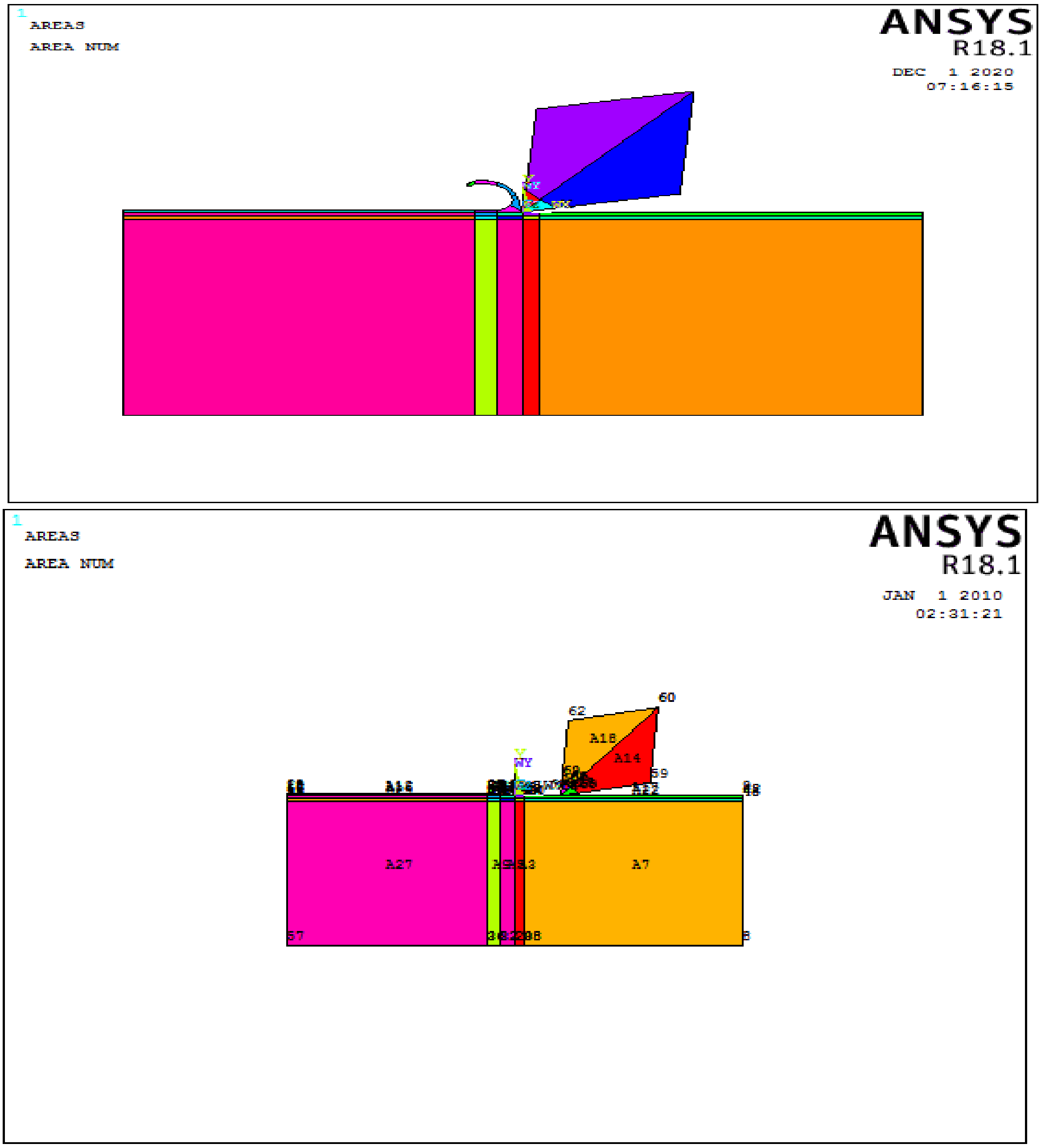


Fig:4.1. Geometrical modeling of cutting tool and the work piece geometry

Geometrical models of cutting tools and work piece geometry is built in 2 dimensional space as software's with axi-symmetry option supports stress calculation under cutting force loads.

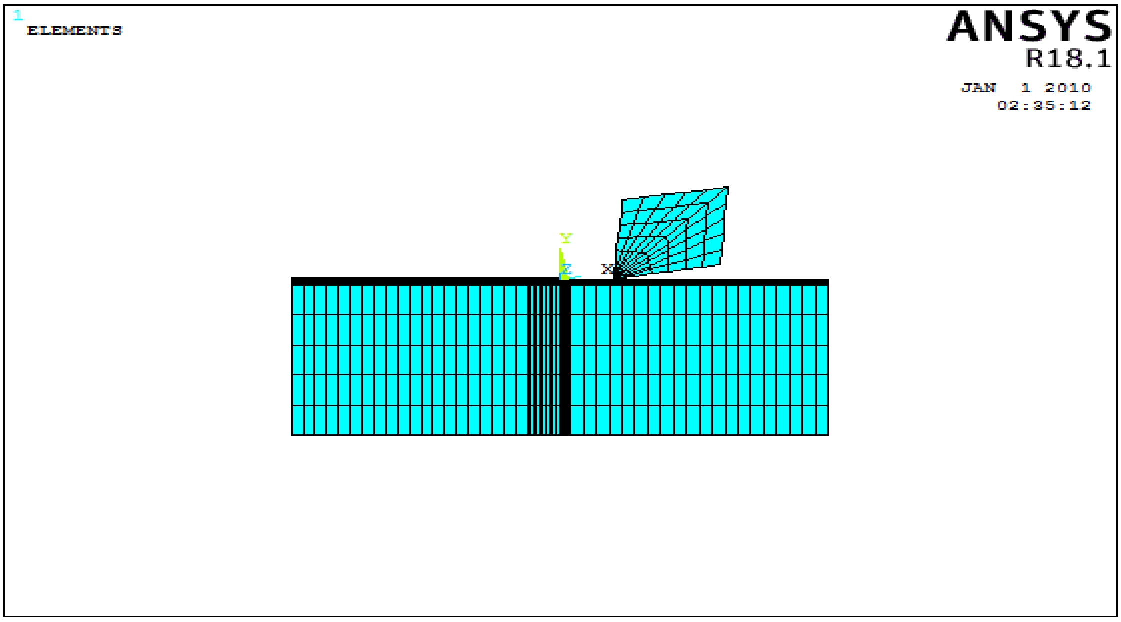
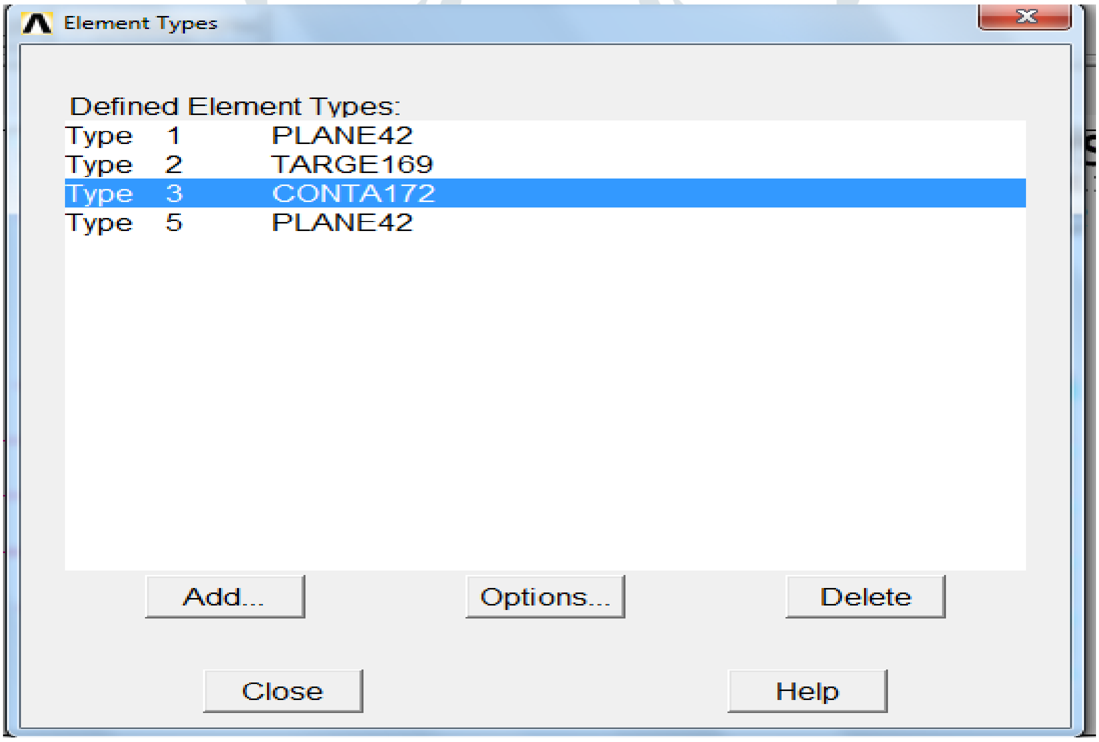


Fig.4.2.Mesh generation

Number of elements ;1077

Number of nodes : 1324



<u>Element types defined:-</u>Two types of plane elements are considered for cutting tool and work piece. Since work piece is circular, axisymmetry option of software was used for representation. So only radius of the work piece required to be modeled. But for cutting tool, plane element with thickness option is considered as the cutting tool geometry is not circular. Other elements were defined for contact definitions to estimate the contact stress and penetrations.

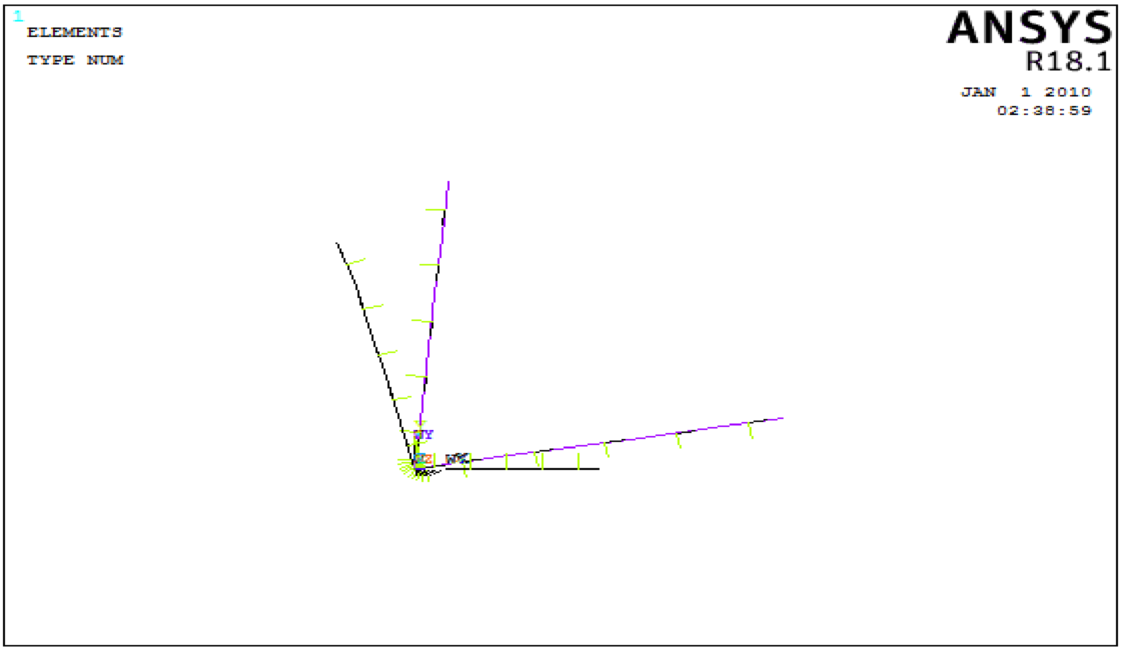


Fig.4.3:-Contact elements creation

These elements are defined with targe169 and contac172 to represent contact condition between cutting tool and the work piece geometry. As the cutting tool moves, the contact definition changes the position of the nodal contact between contacting members. Contact friction of 0.2 is considered between both cutting tool and the work piece material assuming the lubrication in the process.

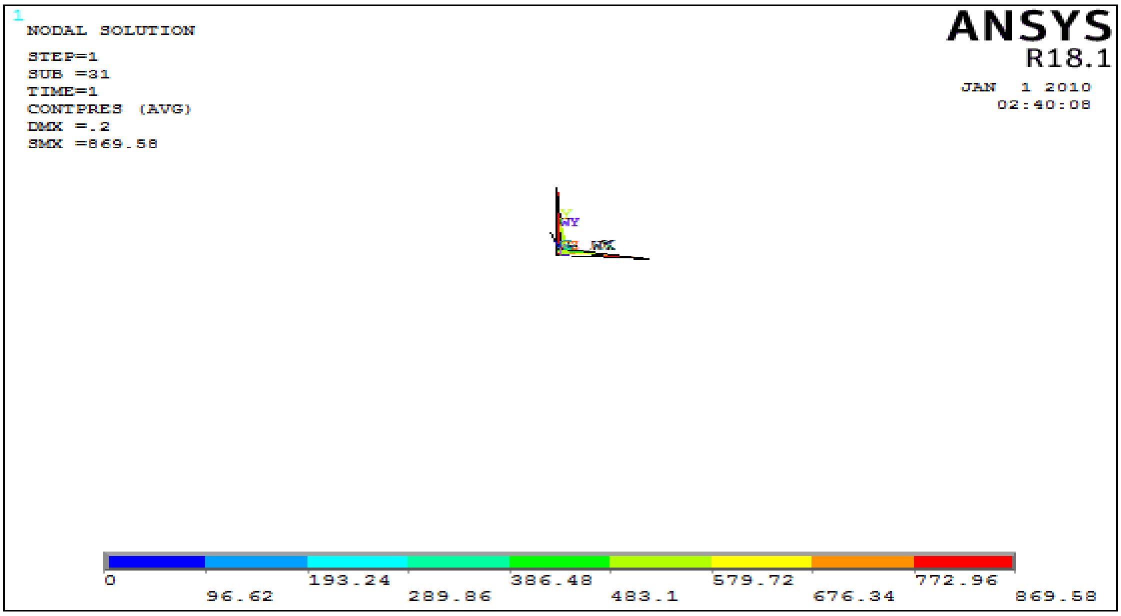


Fig.4.4.Contact pressure generation

After analysis the results shows contact pressure development in the process which is linked to contact wear in the problem.

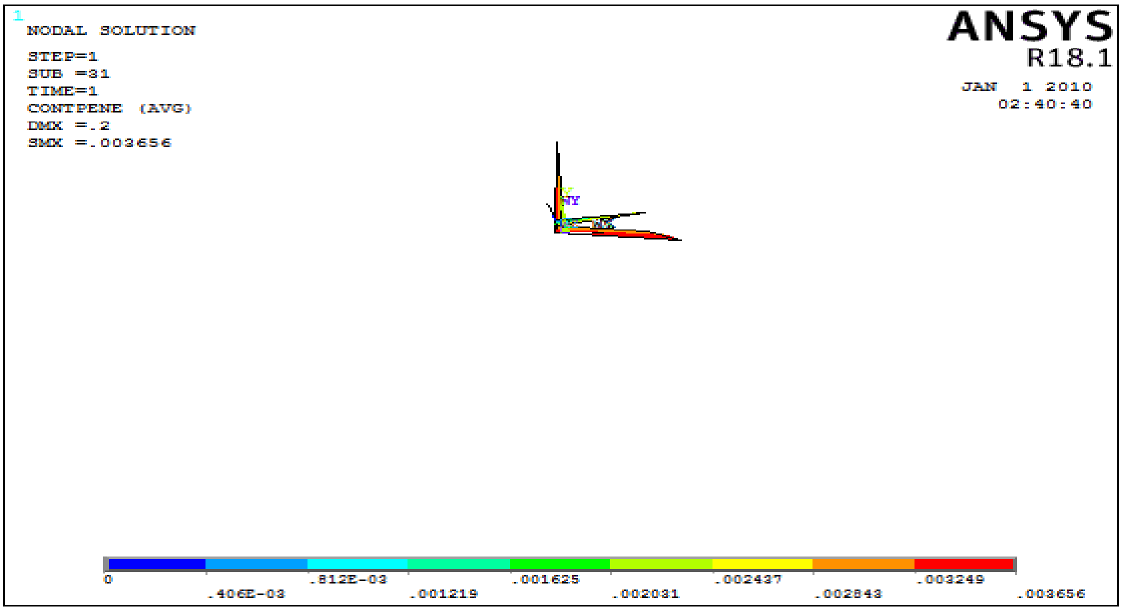
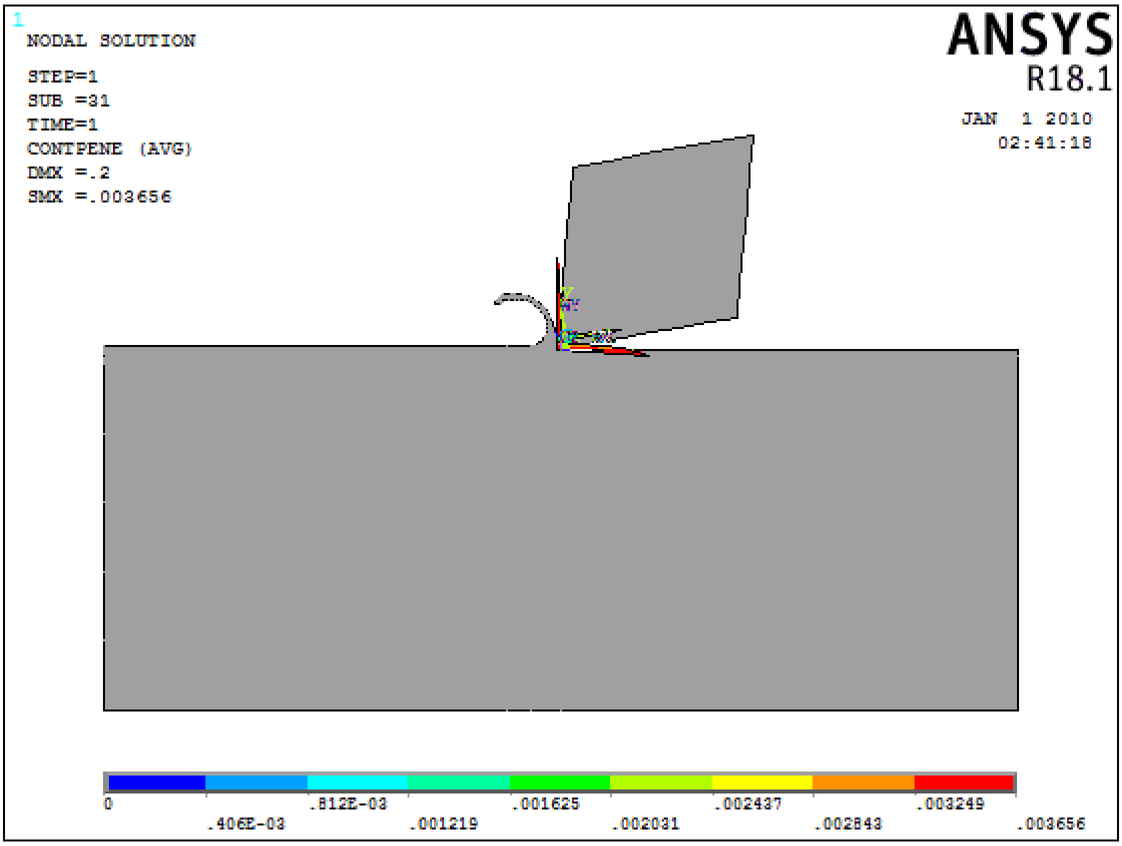


Fig.4.4.Contact penetration

Possible Contact penetration value can be estimated in the simulation process. This penetration values helps in finding the contact wear in the problem.



Wear rate :-Wear rate is estimated using the following formulae. Penetration value is taken from the software.

Wear rate : πdNŸλTL

Here d: diameter of work piece:N: rpm:Ÿ = Penetration distance:λ= Non linear material parameter(Ratio of hardness of work piece material /cutting tool):L=sliding distance(1 meter is assumed):T= Elapsed time

Example : D=0.04m(40mm):N=71 rpm:Ÿ = 003656:λ =130/415 (Hardness of SS340L/Hardness of cutting tool)=0.313:T=17.5 seconds:L=1

Wear rate =3.14*.04*71*0.000003656*0.313*17.5*1=1.786e-4 m^3/min

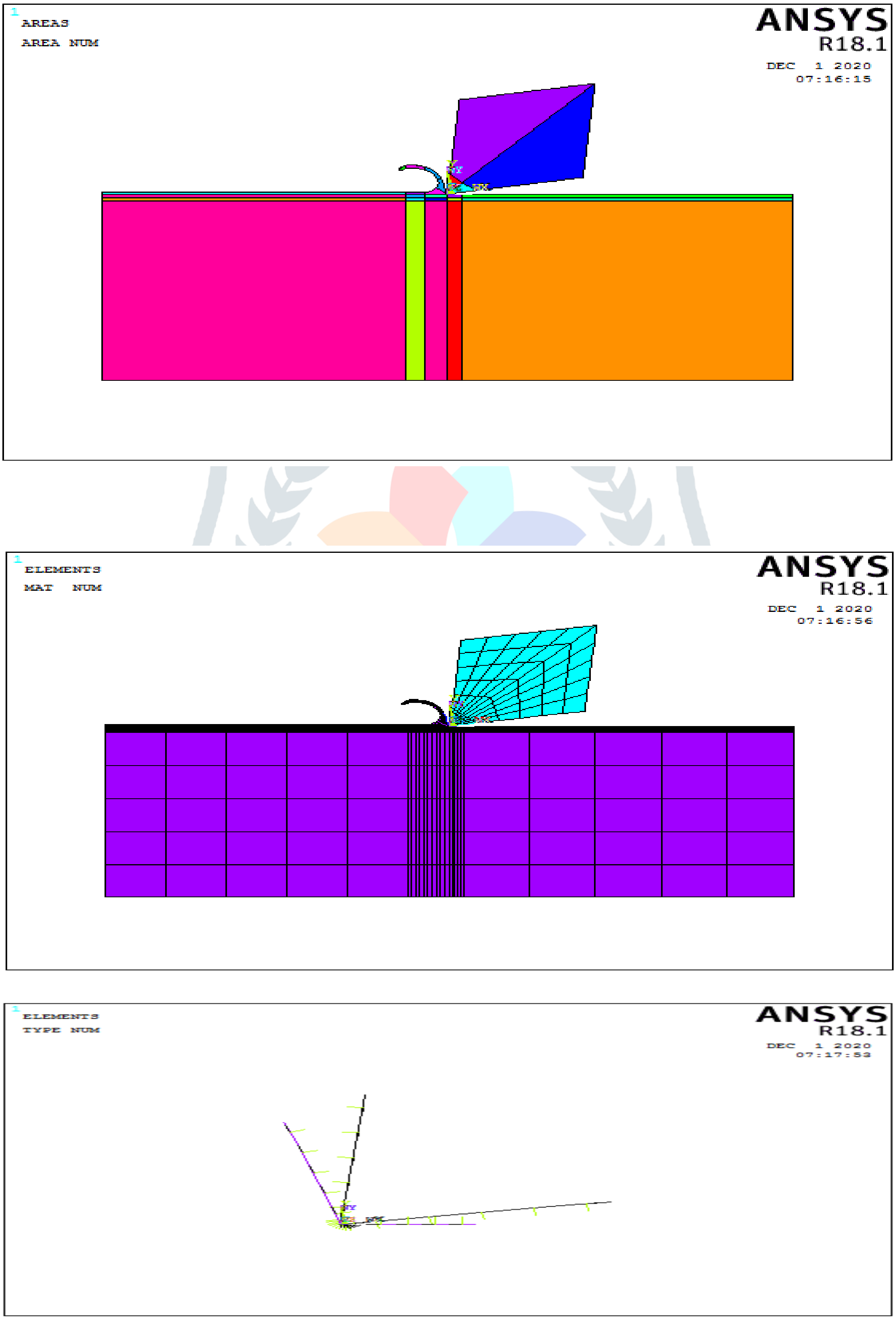


Fig.4.5:FEA for tool with Area and Elements

4.2.FEA on Tool Wear Calculation for S1(SS316)

Observations: Speed=71 rpm:Feed=0.4mm/rev:Depth of cut=1.0mm:Workpiece material=Aluminium

Table4.1:Tool wear for S1 (SS316) material

ne elapsed (in min.)	ank wear (in mm)
3	0.5
6	0.65
9	0.75
12	1.06
15	1.75
17.5	1.9
Wear rate	1.08×10^{-4}m/min

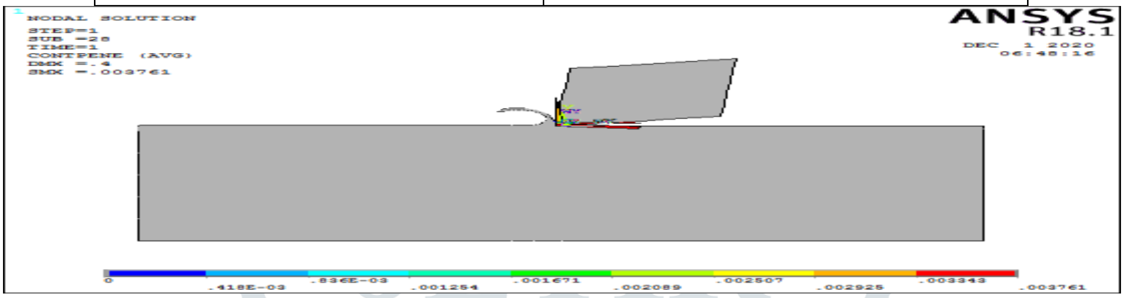


Figure.4.6:Wearrate:1.468e-4m/min

4.3.FEA On Tool Wear Calculation for S2 (SS304)

Observations:

Speed =71 rpm

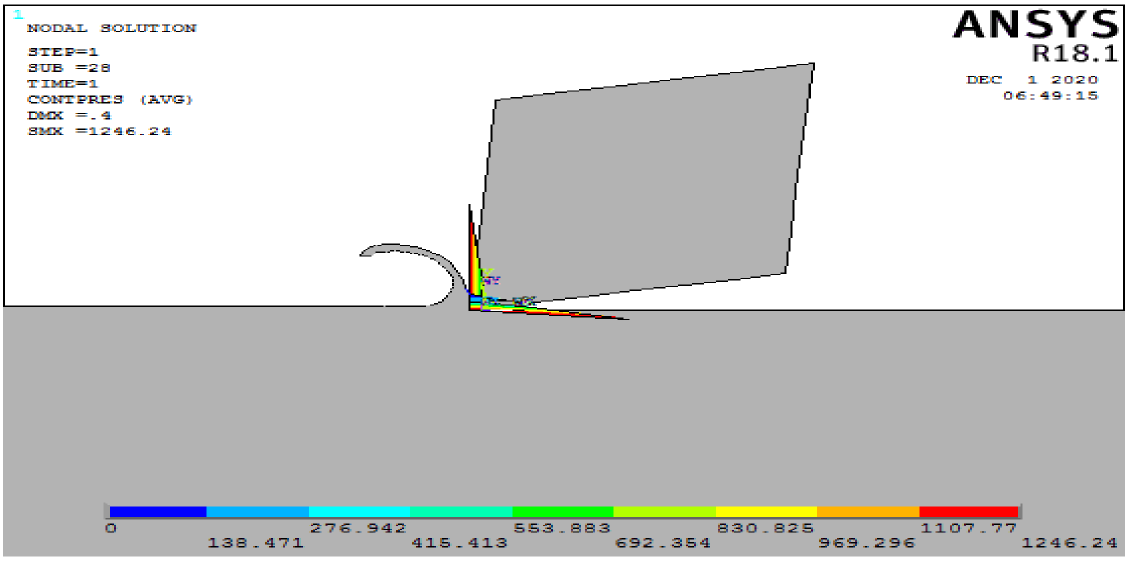
Feed =0.4mm/rev

Depthofcut =1.0 mm

Workpiecematerial=Aluminium

Table.4.2:Tool wear for S2(SS304) material

me elapsed (in min.)	lank wear(in mm)
3	0.6
6	0.75
9	0.81
12	1.15
15	1.90
17.5	2.01
Wear rate	1.15×10^{-4}m/min



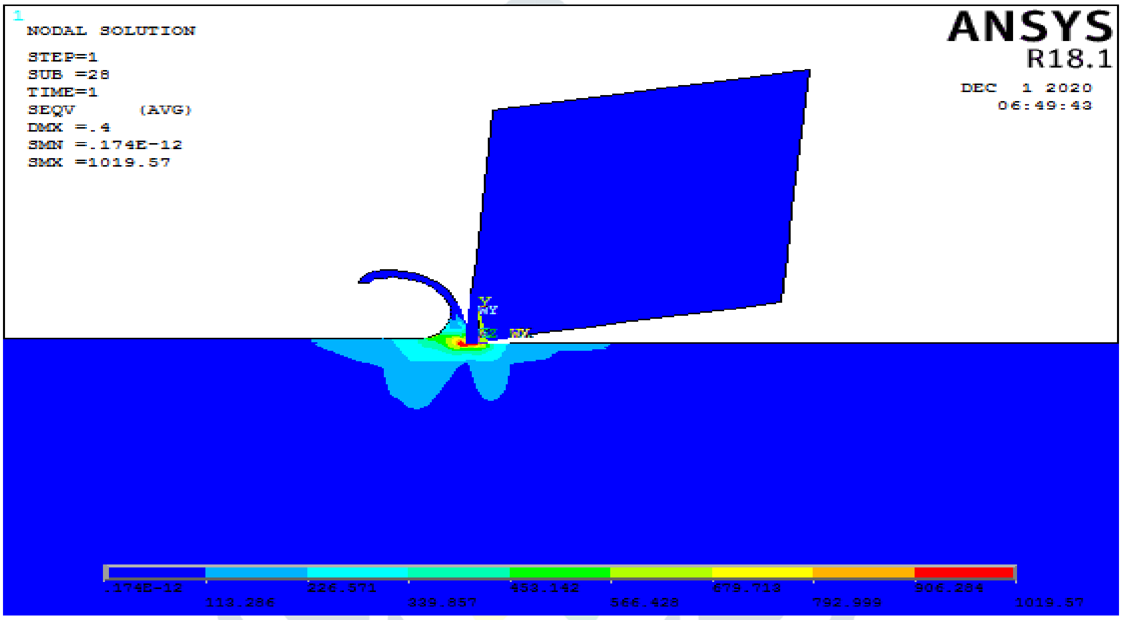


Figure.4.7:Tool wear of S2 (SS304) material

4.4.FEA on Tool Wear Calculation for Titanium Alloy S5 (TI-6AL-4V)

Observations:

Speed =71 rpm

Feed =0.4mm/rev

Depth of cut =1.0 mm Workpiece

material =Aluminium

Table.4.3:Tool Wear for S5 (Ti-6Al-4V) material

me elapsed (in min.)	lank wear (in mm)
3	0.3
6	0.55
9	0.66
12	0.7
15	0.79
18	1.0
21	1.4
24	1.6
27.33	1.9
Wearrate	1.35×10^{-4}m/min

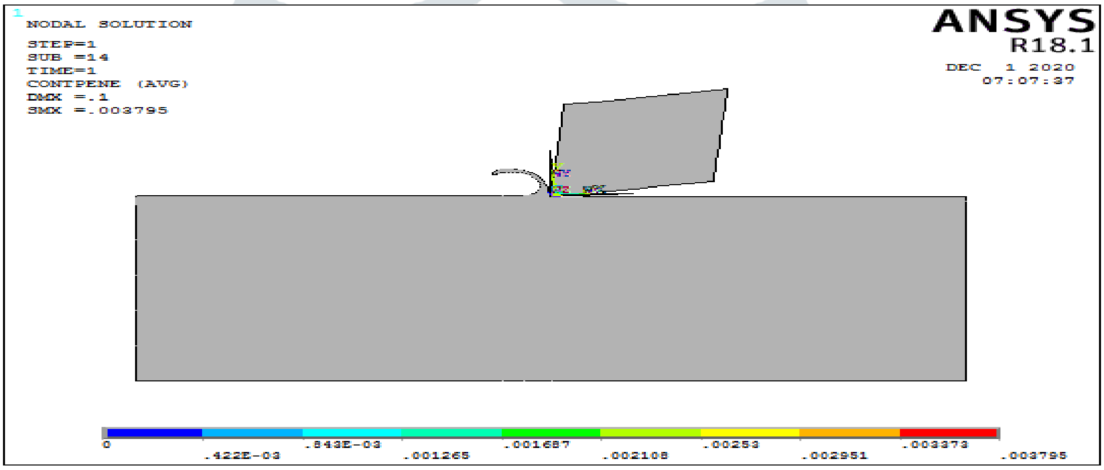


Figure.4.8:Penetration of the cutting tool

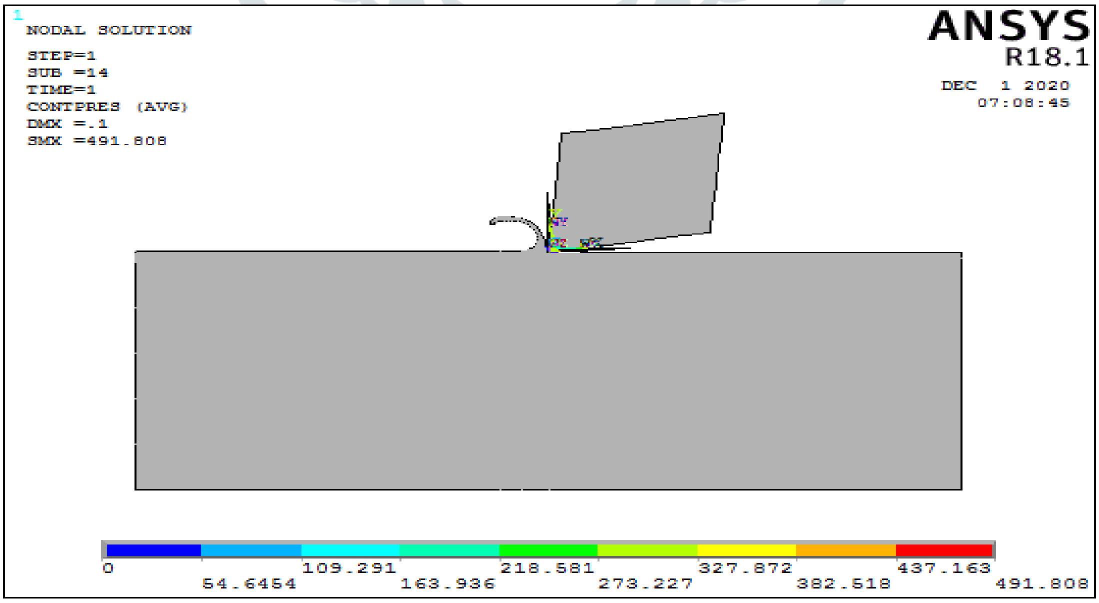


Figure.4.9:Contact Pressure Generation

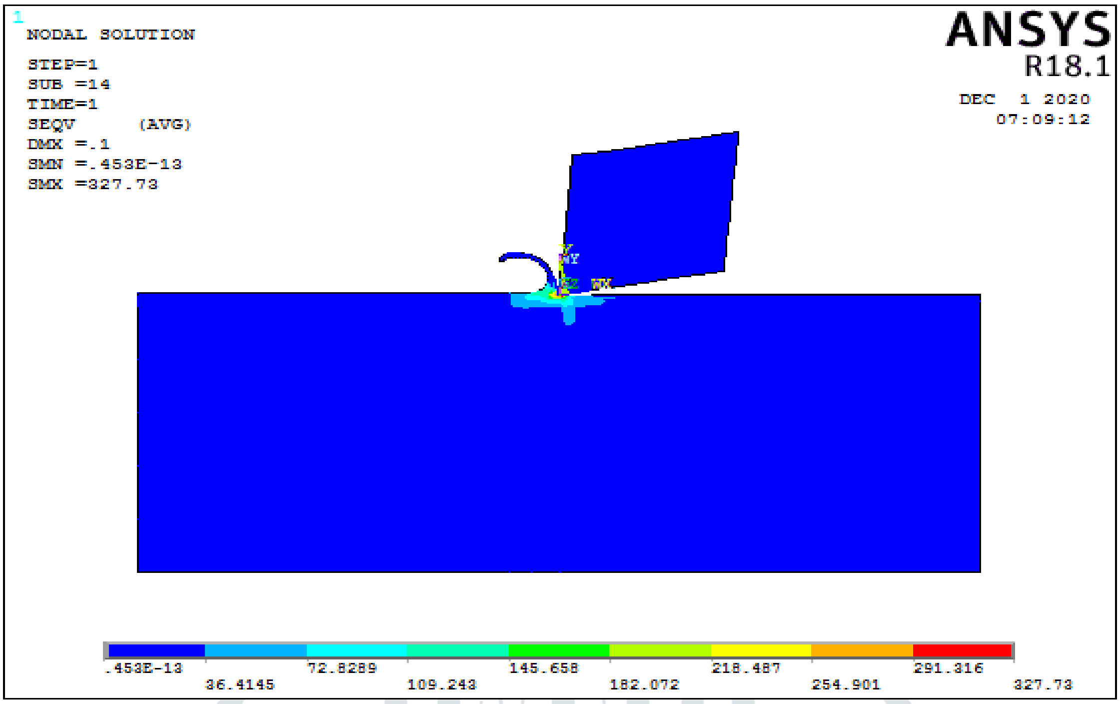


Figure.4.10:Wear rate:1.48e-4m/min

4.5.Tool Wear Calculation for S6 (HSS):-

Observations:

Speed =71 rpm

Feed =0.4mm/rev

Depth of cut =1.0 mm Work

piece material =Mild Steel

Table.4.4:Tool wear for S6(HSS) material

me elapsed(in min.)	lank wear(in mm)
3	0.6
6	0.8
9	0.88
12	1.3
15	1.9
Wear rate	1.26×10^{-4}m/min

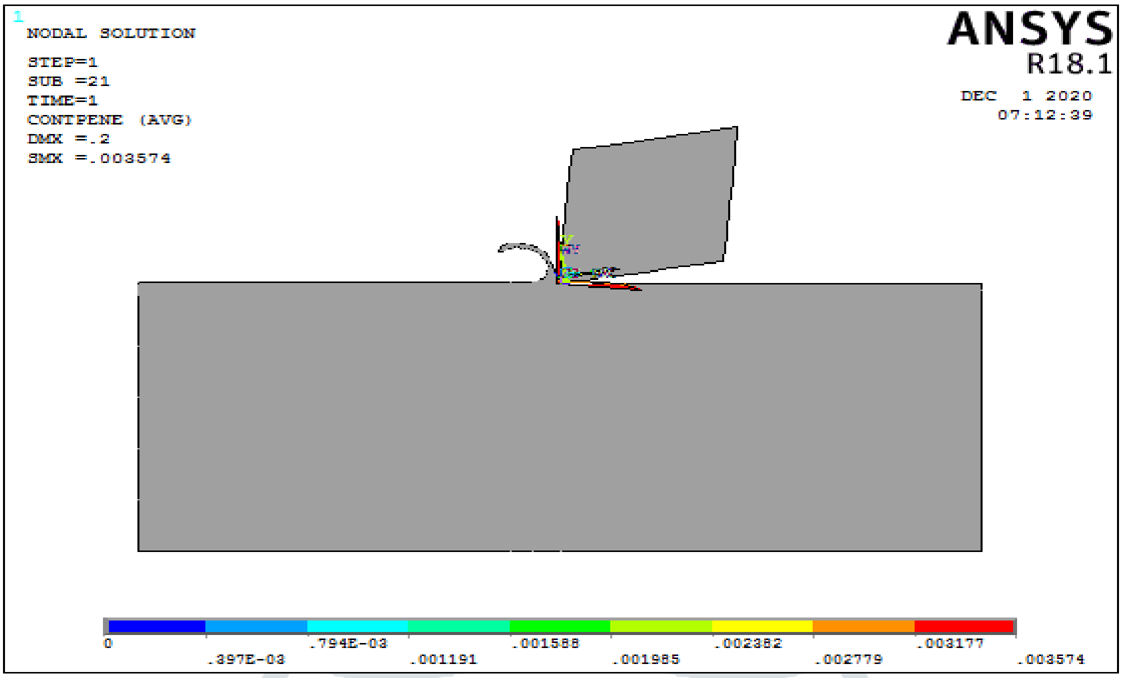


Figure.4.11:Contact penetration in the problem

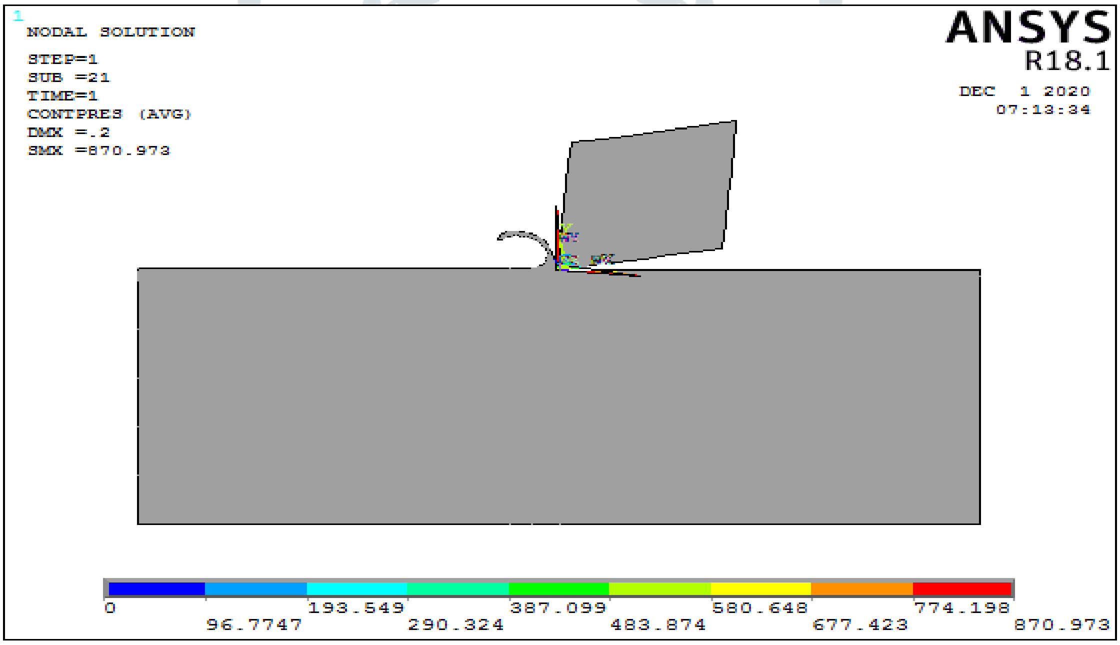


Table.4.12:Contact Pressure

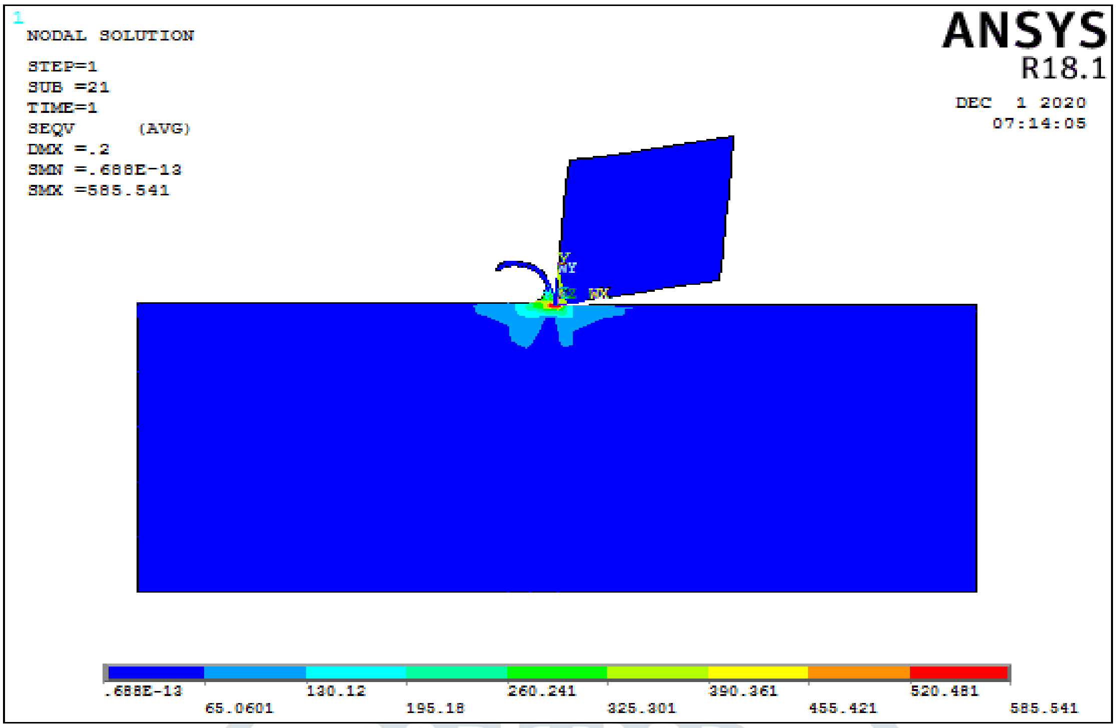


Figure.4.13:Wear rate:1.395e-4m/min

4.6.Tool Wear Calculation for S3 (SS410)

Observations:

Speed =71 rpm

Feed =0.4mm/rev

Depth of cut =1.0 mm

Workpiece material =Aluminium

Table.4.13.Tool wear for S3 (SS410) material

me elapsed(in min.)	lank wear(in mm)
3	0.46
6	0.85
9	1.10
12	1.6
15	1.98
17.5	2.4
Wearrate	1.45×10^{-4}m/min

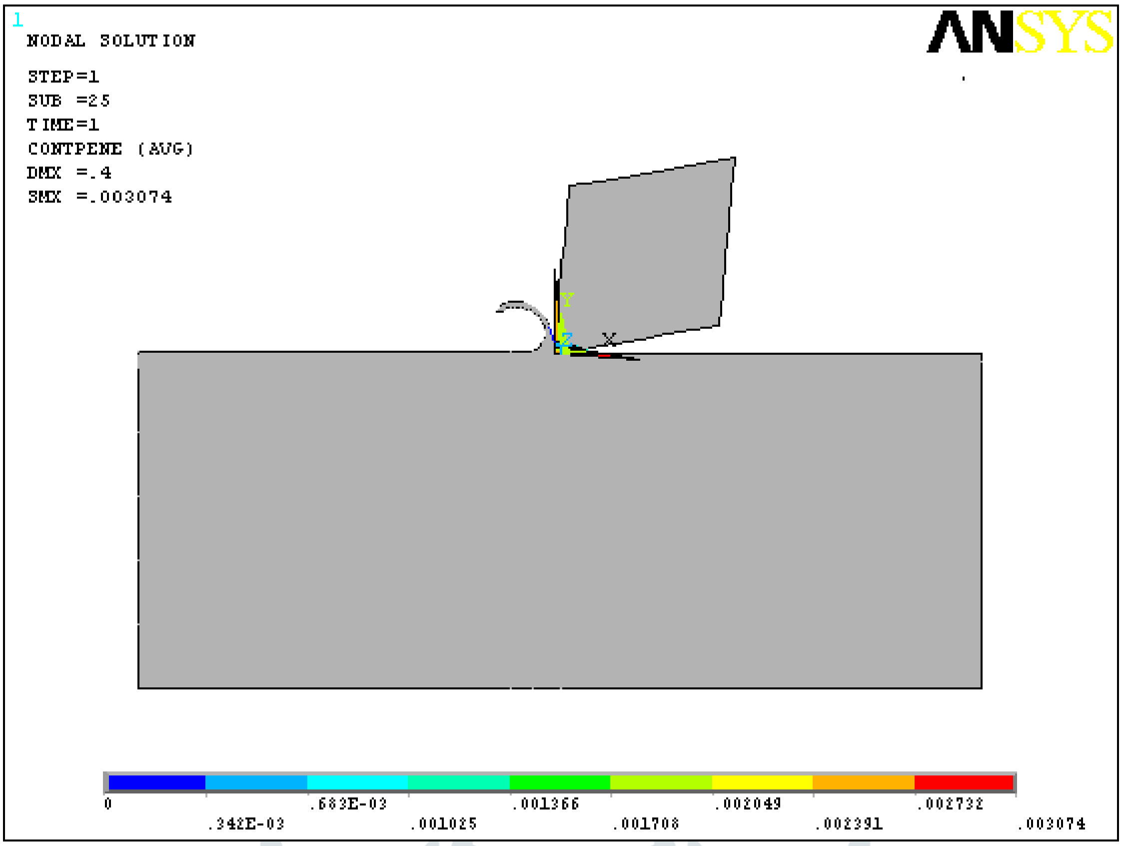


Figure.4.13:WearRate : 1.69e-4

4.7.Tool Wear Calculation for S4 (SS440C)

Observations:

Speed = 71 rpm

Feed = 0.4mm/rev

Depth of cut =1.0 mm

Workpiece material =Mild Steel

Table.4.14:Tool wear for S4 (SS440C) material

ne elapsed (In min.)	ank wear(in mm)
3	0.43
6	0.82
9	1.0
12	1.5
14	1.9
Wear rate	1.35×10^{-4}m/min

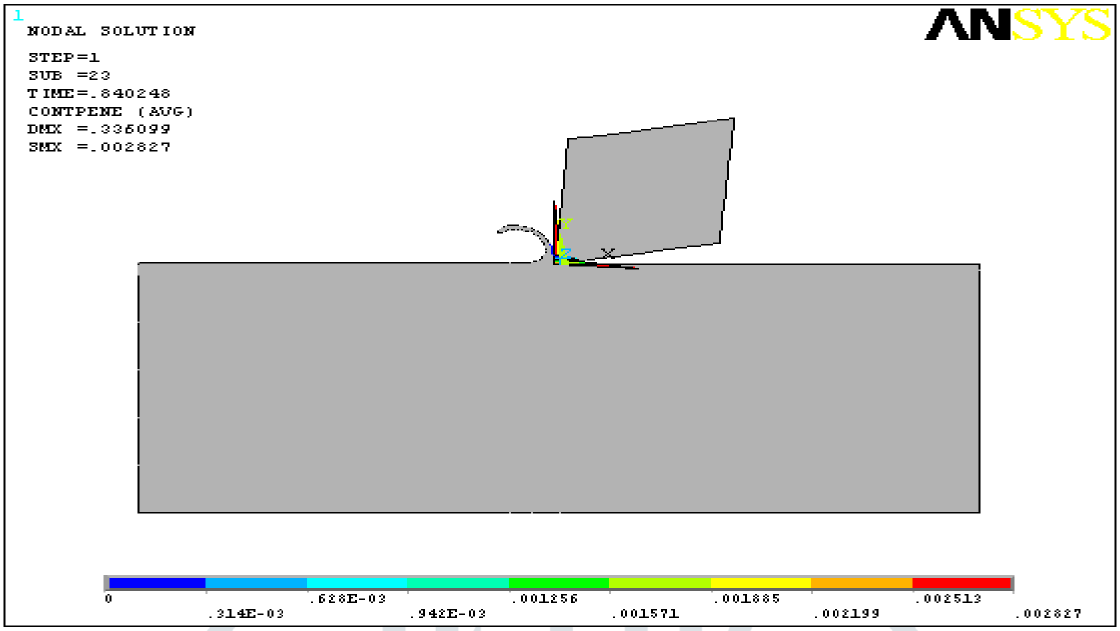


Figure.4.13:WearCoefficient :1.537e-4

Table.4.15:Comparison of Experimental and Finite element analysis of Wear rate.

Material	Experimental(10^{-4})	Finite Element Analysis(10^{-4})	%Error
SS316	1.08	1.168	7.5
TI-6AL-4V	1.35	1.48	8.7
HSS	1.26	1.395	9.6
SS304	1.15	1.312	12
SS410	1.45	1.69	14.2
SS440C	1.35	1.537	12

Table.4.16:Comparison of Experimental and Finite element cutting forces

Material	ExperimentalCutting Force	Finite Element Cutting Force	%Error
HSS Tool	196.2	205.68	4.6
SS440	127.53	135.23	5.6
Titanium	156.96	162.19	3.2
SS316	206.01	212.87	3.2
SS304	195.25	208.62	6.4
SS410	121.22	131.62	7.9

Table.4.17:Comparison of Experimental and Finite element Thrust Force

Material	nental Thrust Force	inite Element Thrust Force	%Error
HSS Tool	173.7	190.25	8.6
Ss440c	39.24	43.62	10
Titanium	140.43	148.82	5.64
SS316	192.77	201.68	4.4
SS304	182.67	195.28	6.5
SS410	39.24	46.21	1.5

Conclusion: From the Experimental result of Thrust Force and Finite Element Thrust Force compared and percentage (%) error is less than 10%.Similarly, From the Experimental result of Cutting Force and Finite Element Cutting Force compared and percentage (%) error is less than 10%. Finally the cutting tool Titanium alloy (Ti-6Al-4V) (S6) and HSS (S5) is good compare to other alloy materials.

REFERENCES:-

[1].A finite element analysis of orthogonal machining using different tool edge geometries Yung-Chang Yen, Anurag Jain, Taylan AltanJournal of Materials Processing Tech. 2004 -146 - 1 - 72-81-ISSN-0924-0136

[2]Tugrul Özel Department of Industrial and Systems Engineering, Rutgers, The State University of New Jersey, Piscataway, New Jersey 08854 USA International Journal of Machine Tools and ManufactureVolume 46, Issue 5, April 2006, Pages 518-530

[3]Numerical analysis of the tool wear effect in the machining induced residual stresses February 2011 Simulation Modelling Practice and Theory 19(2):872-886 DOI:10.1016/j.simpat.2010.11.011A. Muñoz-Sánchez

[4].STUDY AND ANALYSIS OF SINGLE POINT CUTTING TOOL UNDER VARIABLE RAKE ANGLE Deepak Lathwal1, Mr. Deepak Bhardwaj2 1Bhiwani Institute Of Technology & Sciences, Maharshi Dayanand University, Bhiwani, Indiadipak329@gmail.com2 Bhiwani Institute Of Technology & Sciences, Maharshi Dayanand University, Bhiwani, Indiawww.ijraset.com Vol. 1 Issue I, August 2013ISSN: 2321-9653. Page 34I N T E R N A T I O N A L J O U R N A L F O R R E S E A R C H I N A P P L I E D S C I E N C E AN D E N G I N E E R I N G T E C H N O L O G Y (I J R A S E T)

[5]FINITE ELEMENT ANALYSIS OF SINGLE POINT CUTTING TOOL International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 04 Issue: 09 | Sep -2017 www.irjet.net p-ISSN: 2395-0072 © 2017, IRJET | Impact Factor value: 5.181 | ISO 9001:2008 Certified Journal | Page 264 Poonam D. Kurekar1, S. D. Khamankar2 *1M-Tech Student, Mechanical Engineering, Rajiv Gandhi College of Engineering and Research Technology, MH, India 2Associate Professor, Mechanical Engineering, Rajiv Gandhi College of Engineering and Research Technology, MH, India*

[6]https://wikipedia.com

[7]Explain Cutting Tools, https://mechanicalsite.com, retrieved 2019-05-12.

[8]https://wikipedia.com

[9] http://www.yourarticlelibrary.com/metallurgy/7-main-properties-of-good-tool-materials-metal-cutting/96127

[10].https://www.harveyperformance.com/in-the-loupe/avoiding-tool-wear/

[11] Text Book: FEM BY Chandrapatla TIRUPATHI R. CHANDRUPATLA Rowan University Glassboro, New Jersey ASHOK D. BELEGUNDU The Pennsylvania State University University Park, Pennsylvania 3rd edition Prentice Hall, Upper Saddle River, New Jersey 07458