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Finite Element Modelling and Analysis of Hot Turning Operation

Prakash.S[1], Jithendra Naik.S[2]
[1]*M.Tech Student Dept. Of Mechanical Engg.*
[2]*Assoc. Prof. Dept. Of Mechanical Engg., PVKKIT*

Abstract: There is a requirement for materials of high hardness and protection from cutting. As we probably am aware the machining of these materials has dependably been an incredible test. Machining of these composites and materials required for cutting high-quality, which now and again isn't prudent and in some cases even illogical. Also, even the non-ordinary procedures are by and large constrained to the perspective of efficiency. The benefits of simple part assembling of exorbitant hard materials can be considerable as far as decreasing expenses and lead times machined contrasted with the customary one includes the warmth treatment, granulating and manual completing/cleaning. In the hot working at a temperature of workpiece is expanded in order to decrease its shear quality. This paper will center around hot working of high manganese steel with oil fuel. A few parameters, for example, cutting pace, feed, profundity of cut and the temperature of the workpiece are taken. An investigation was led. Indeed, even the machining proceess was reproduced in ANSYS and Disfigure 2D to discover relating distortion, rate of hardware wear, cutting power and the temperature dissemination.
***Keywords**: FEA, hot machining, non-conventional processes, feed, Tool wear*

I. INTRODUCTION

The Finite Element Analysis (FEA) was created in 1943 by R. Courant, who utilized the Ritz technique for numerical investigation and minimization of variational math to get rough answers for frameworks of vibration. Not long after, an article distributed in 1956 by MJ Turner, RW Clough, HC Martin, and LJ Topp set up a more extensive meaning of numerical examination. The paper fixated on the "solidness and disfigurement of complex structures".

FEA comprises of a PC model of a material or plan that is focused and examined for particular outcomes. It is utilized as a part of the plan of new items, and refinement of the current item. An organization can confirm a proposed plan and will have the capacity to play out the determination of the customer before creation or development. Changing a current item or structure is utilized to qualify the item or structure of another state of administration. On account of auxiliary disappointment, FEA might be utilized to help decide the outline adjustments to meet the new condition.

II. FINITE ELEMENT ANALYSIS

A. Problem Statement

Issue Proclamation: A cylindrical and hollow workpiece of dia 50 mm and length of 500 mm is pivoted in a turning focused RPM at 600 rpm. The workpiece is continually warmed with a warmth source in development which is a fire (LPG + O2). We need to plan a model in CFD and do examination to discover the temperature dispersion of the workpiece, instrument and chip. The temperature of the workpiece surface in contact with the fire is shifted from 200-600°C.

Workpiece material= High manganese steel,
Workpiece length= 500 mm,
Workpiece diameter= 50mm,
Rotational speed N= 600 rpm,
Flame travel= 0.1 mm/rev,
Feed = 0.1 mm/rev.

Table 4.1 Chemical Composition of Workpiece (High Manganese steel)

Metal	Mn	C	Si	Cr	P	S	Fe
%	12.5	1.2	4	1.6	.058	.01	84.23

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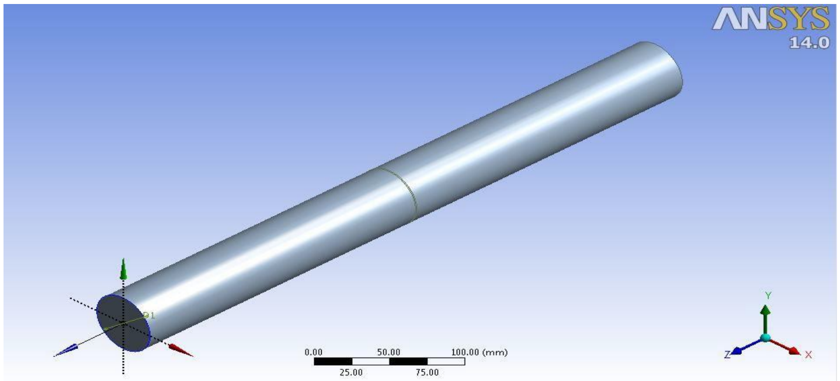
Table 4.2 Work material properties

Work material	Density (Kg/mm^3)	Specific heat (J/Kg-K)	Thermal conductivity(W/mm-k)
High Manganese Steel	7.8×10^{-6}	Cp= 420+ 0.67T	0.05

A cylindrical work piece is modeled in Ansys having the following dimensions.
Diameter: 50 mm and Height: 500 mm

Fig .1 Model of Workpiece



In this analysis we assume a uniform heat source of temperature 5000°C acting along a width of 10 mm along the surface of the workpiece. In the above figure a small circle can be seen (from z=245 mm to z= 255 mm) which is the heat affected region.

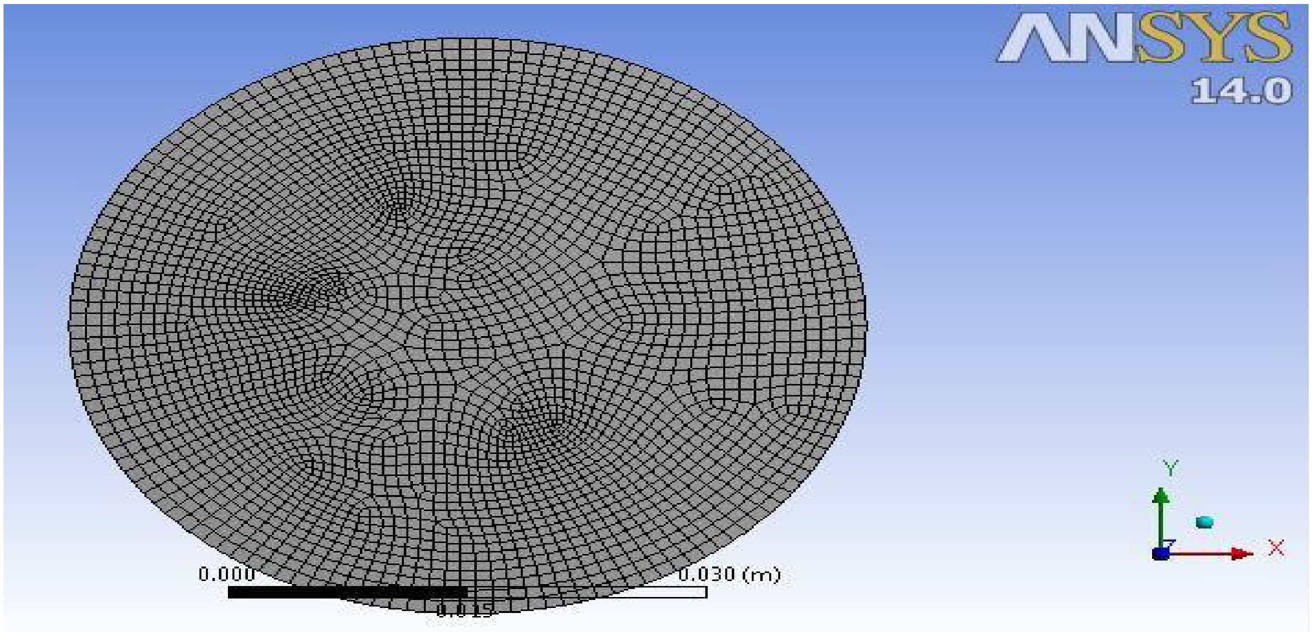
Since the heat source is uniform and heat flows uniformly through the workpiece 2D analysis is conducted by taking the following:

1) Radial cross section (Circular cross section)
2) Axial cross section (Axisymmetric Rectangular cross section)

B. Circular cross section

A circle of radius 50 mm is taken. Material properties of High manganese steel as mentioned above is applied. The surface is meshed by taking element size equal to .25 mm. The element taken is Quad 4 Node 55.

Fig .2Circular Cross Section



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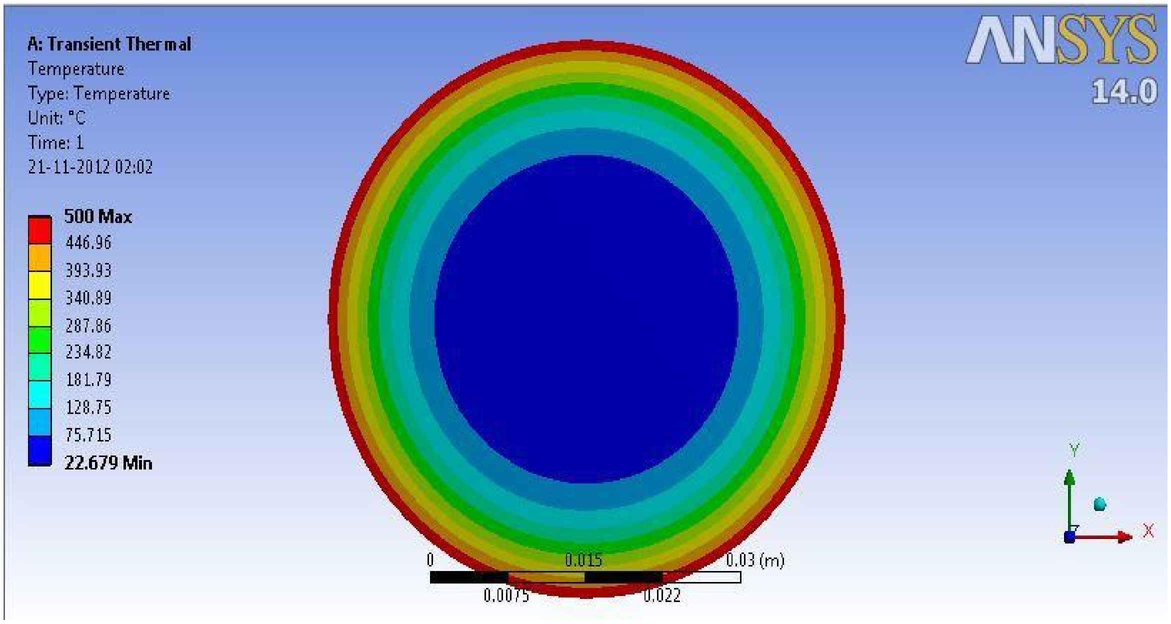
Initial temperature of the material is 220C. A temperature of 5000C is applied on the outer surface for 1 second.

Fig .3 Temp Distribution along the Circular Cross Section

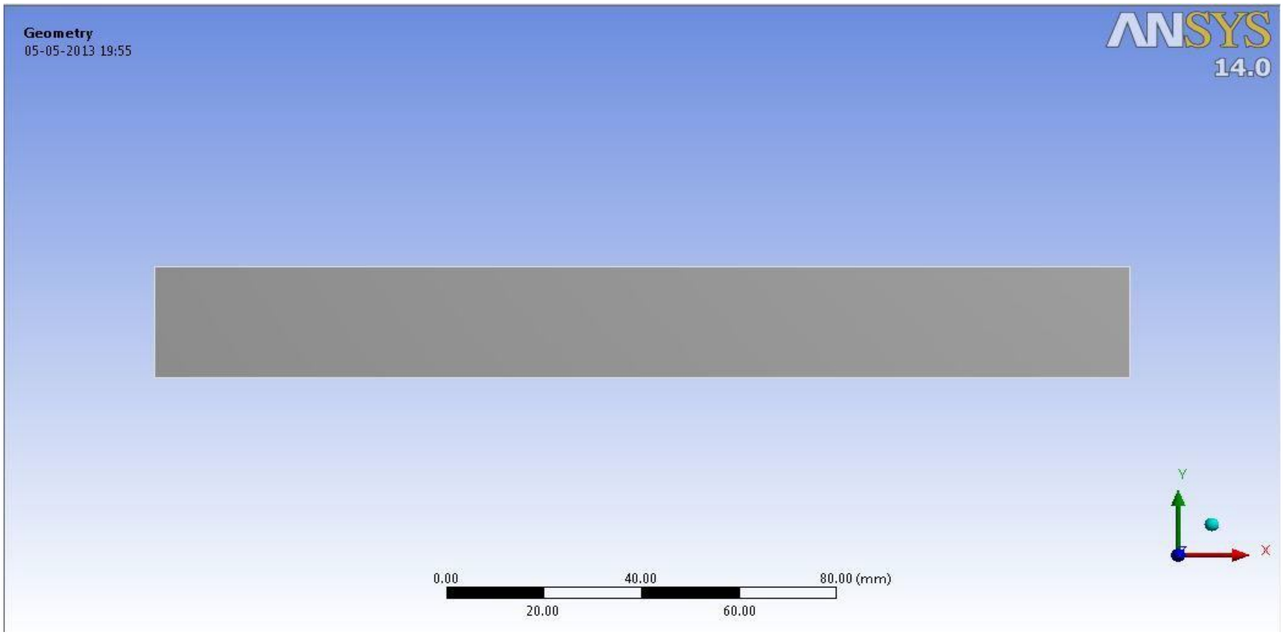


C. Axisymmetric Rectangular Cross Section

A rectangle of dimensions 200 X 25 mm is taken. Material properties of High manganese steel as mentioned above is applied. The surface is meshed by taking element size equal to 1 mm. The element taken is Quad 4 Node 55.

For a symmetric body axisymmetric modelling gives the same result as the 3D model. It is preferred over the 3D model as for the same result computational time required is less. Rotating the axisymmetric planar model about the axis gives the complete 3D model.

Fig .4 Axisymmetric Rectangular Cross section



Initial temperature of the material is 220C. A temperature of 2000C is maintained at the heat affected zone for 60 seconds. The following figure shows the temperature distribution after 60 seconds.

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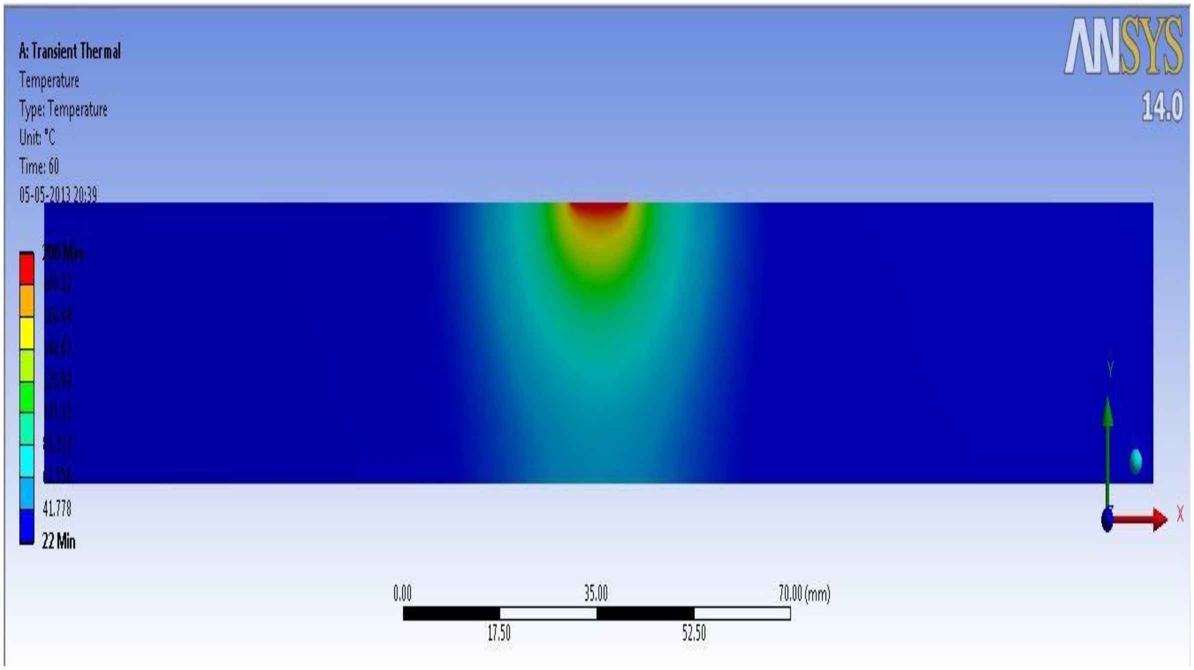
Fig .5 Temp Distribution

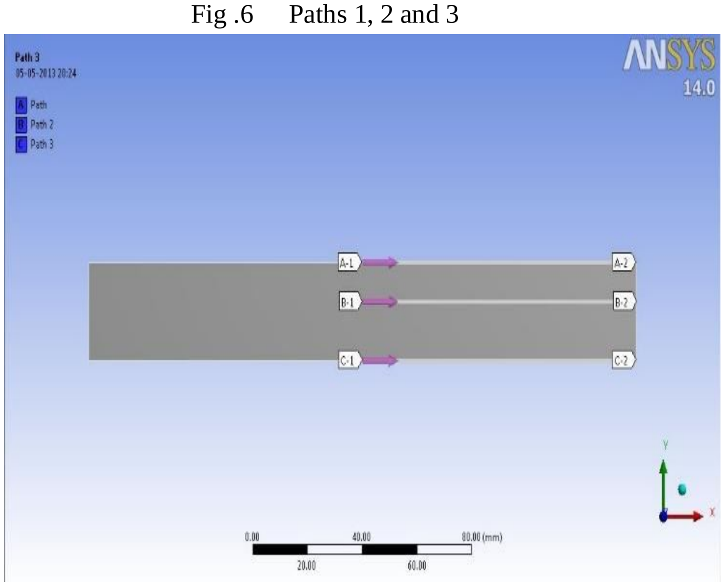


D. Temperature Distribution Along Specific Regions Using PATHS

A path is categorized as a form of construction geometry and is represented as a spatial curve to which one can scope path result. The results are evaluated at discrete points along this curve.To analyse the temperature distribution six paths are being created. The centre of the flame is taken as the starting point (0, 0).

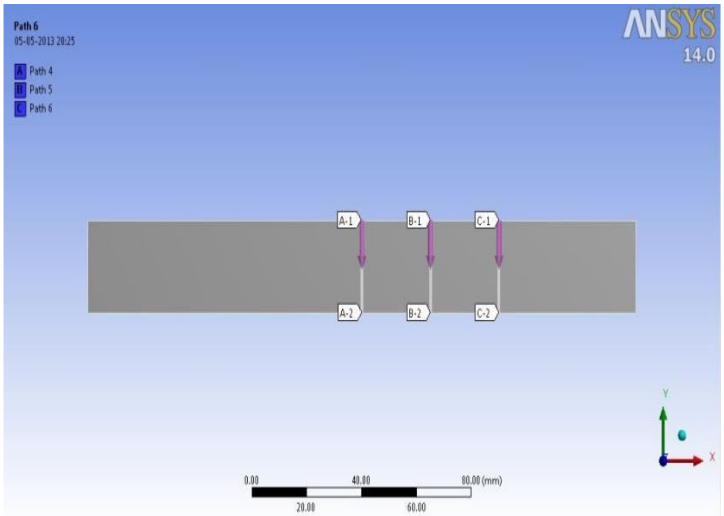
1) *Path 1:* From centre of the flame (0, 0) to x = 100 mm.
2) *Path 2:* From 15 mm below the surface (0, -15) to x = 100mm (100, -15).
3) *Path 3:* From 25 mm below the surface (0, -25) to x = 100mm (100, -25) i.e. along the axis.

Fig .6 Paths 1, 2 and 3



4) *Path 4:* From centre of the flame (0, 0) downwards to y = -25 (0, -25).
5) *Path 5:* From (25, 0) to (25, -25)
6) *Path 6:* From (50, 0) to (50, -25)

Fig .7 Paths 4, 5 and6



Following figures show the temperature distributions

Fig .8 Path1

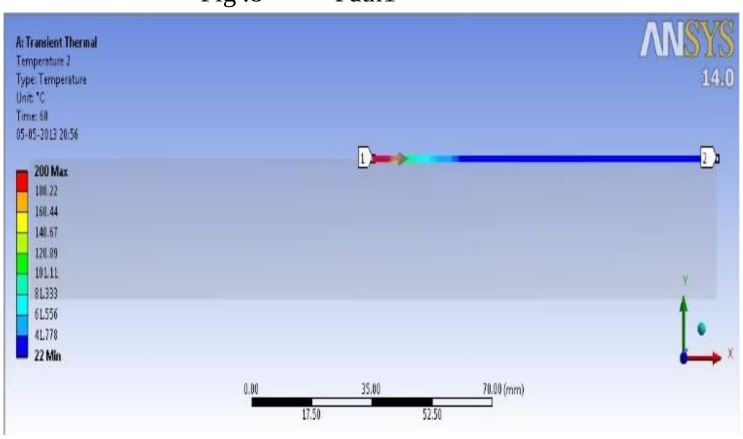


Fig .9 Path2

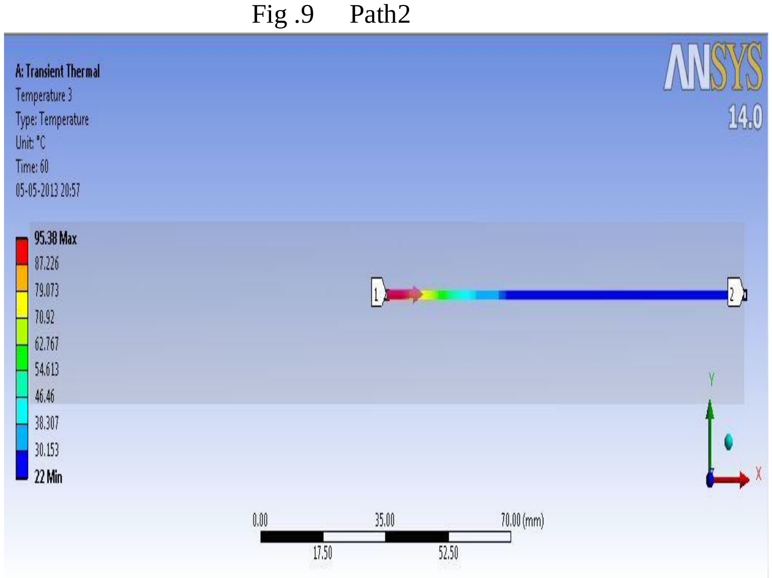


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Fig .10 Path3

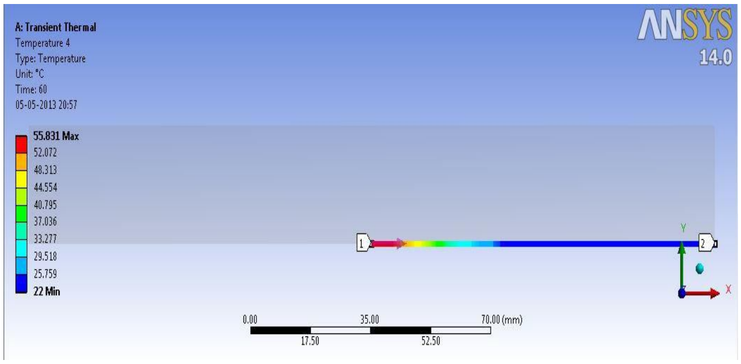

Fig .11 Path4

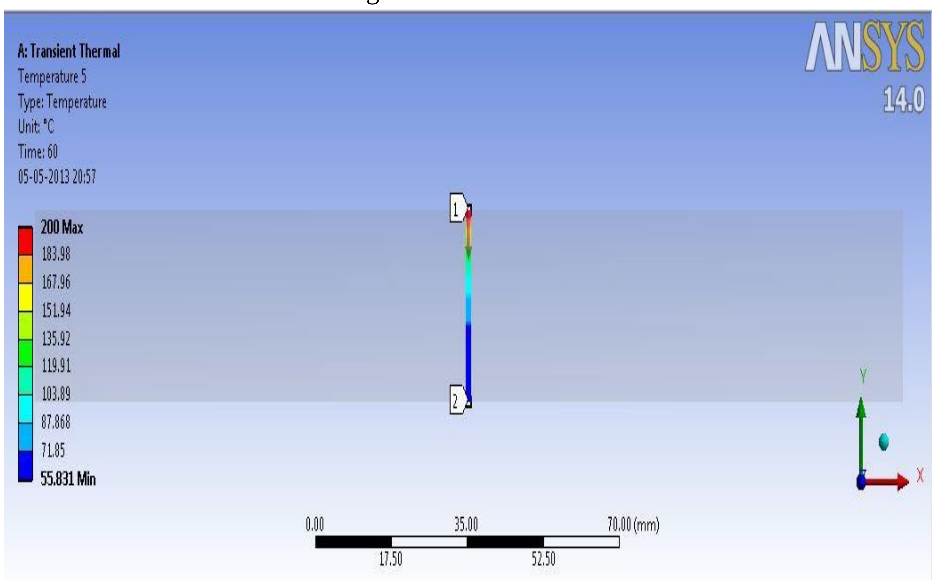

Fig .12 Path 5

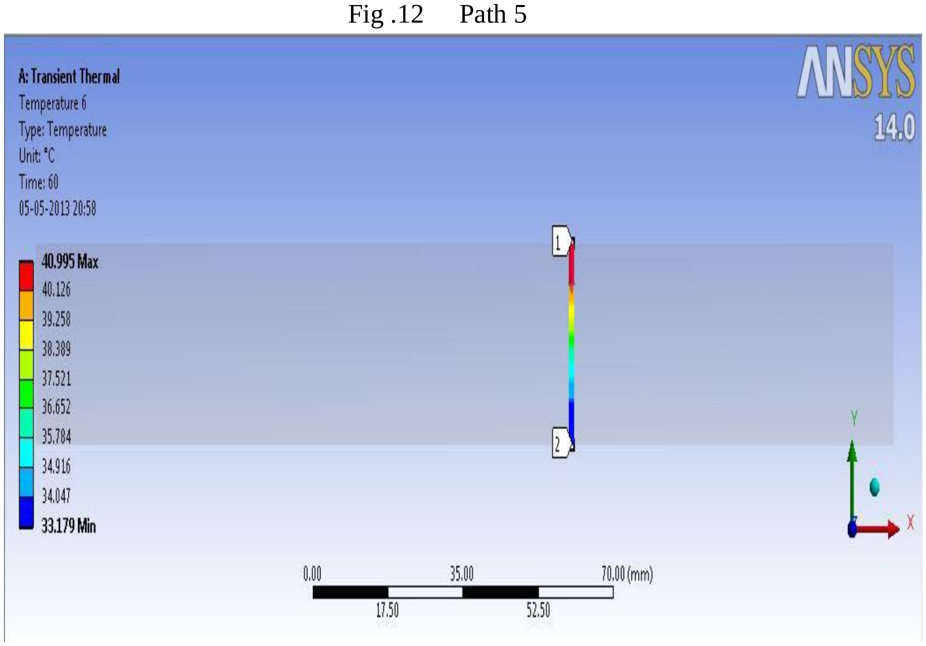

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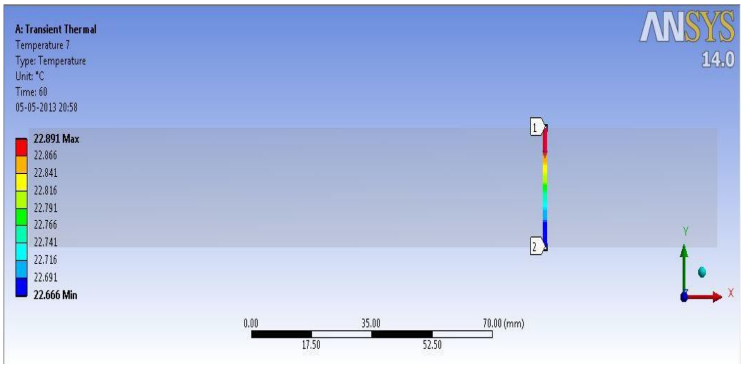
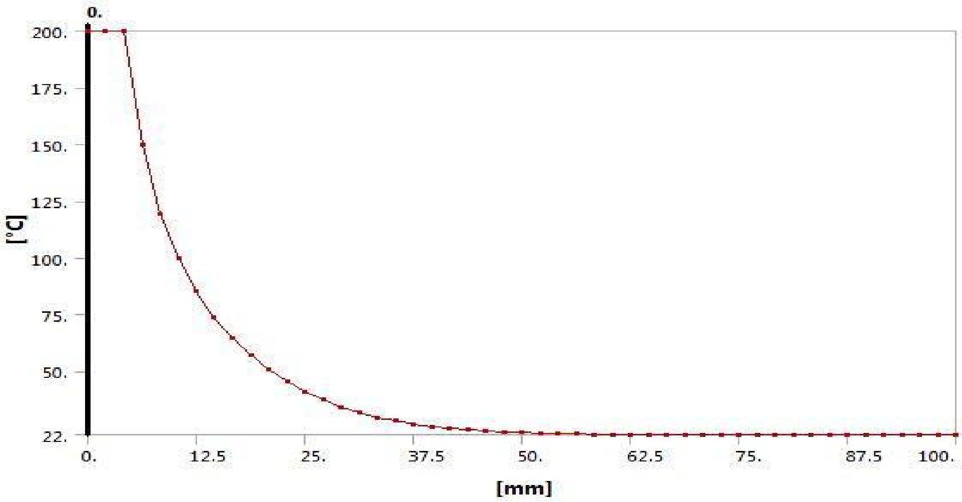
Fig .13 Path6

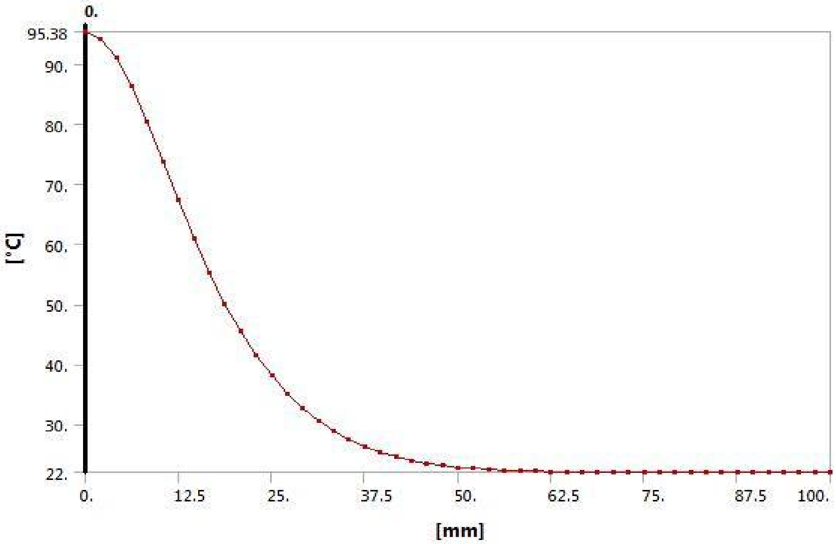


The values are obtained from the above analysis and the following graphs are plotted.

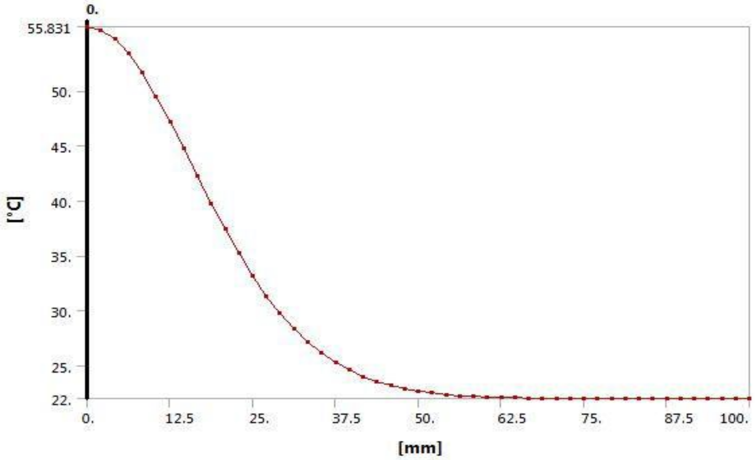
Graph 1. Path 1



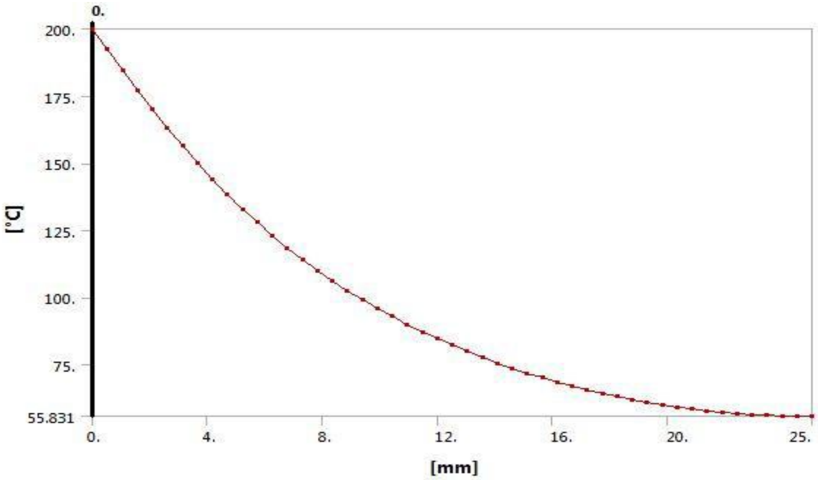
Graph 2. Path 2



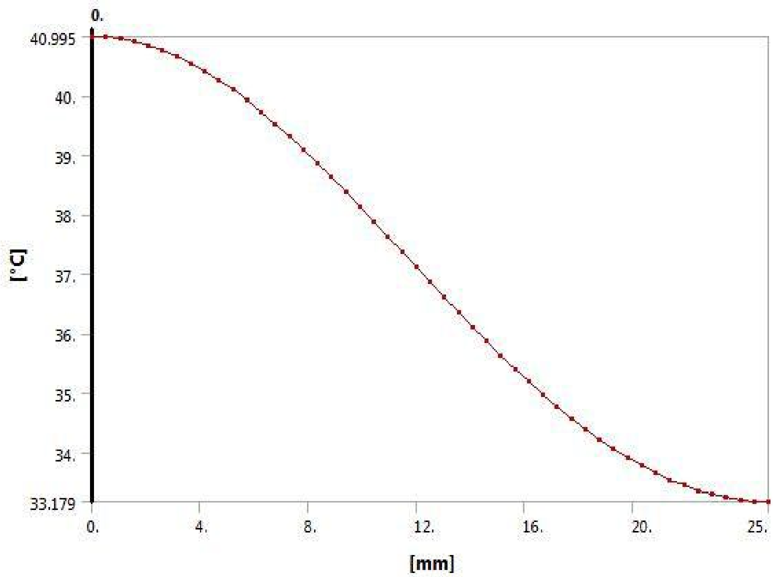
Graph 3. Path 3



Graph 4. Path 4



Graph 5. Path 5



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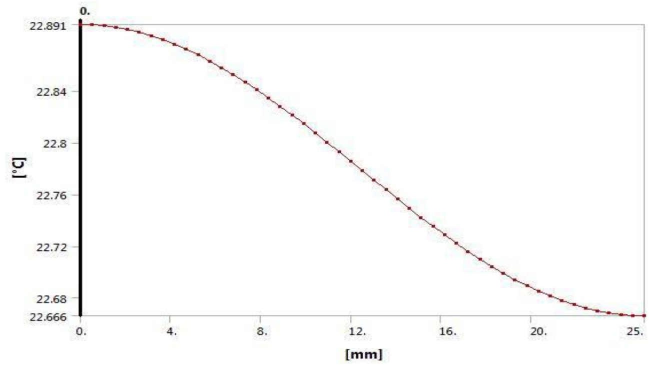
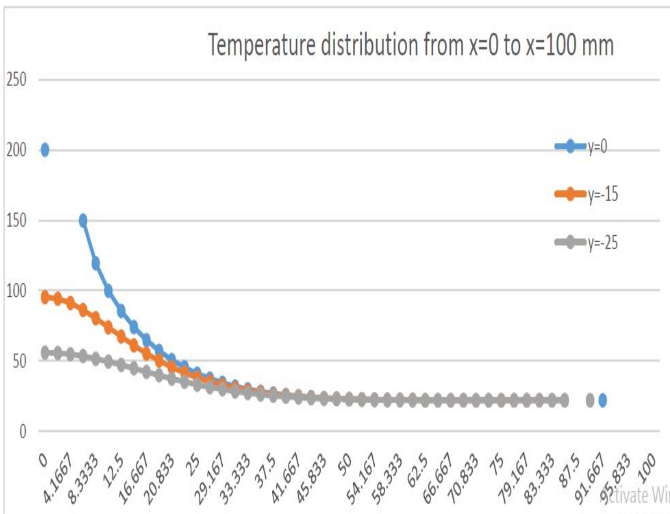
Graph 6. Path6



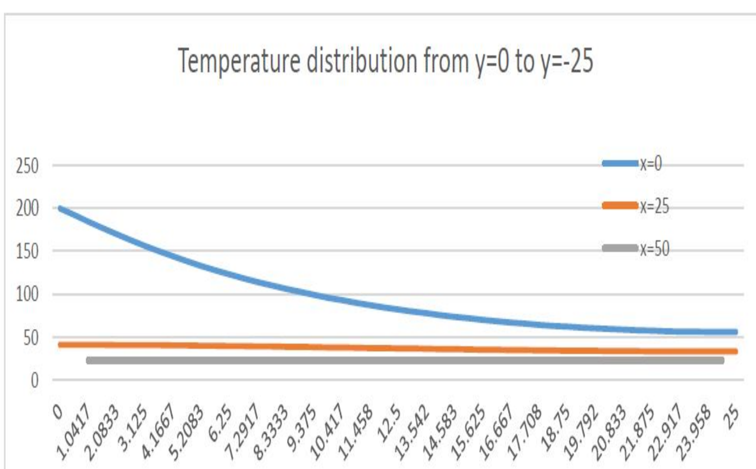
Graph 7. Combining Fig 5.14, 5.15 and 5.16



The following graphs shows the variation of temperature distribution from x = 0 to x = 100 along three different paths (1, 2 and 3) i.e. y = 0, y = -15, y = -25. (Combining first three graphs)

The following graph shows the variation of temperature distribution from y = 0 to y = -25 along three different paths (4, 5 and 6) i.e. x = 0, x = 25, x = 50. (Combining last three graphs)

Graph 8. Combining Fig 5.17, 5.18 and 5.19



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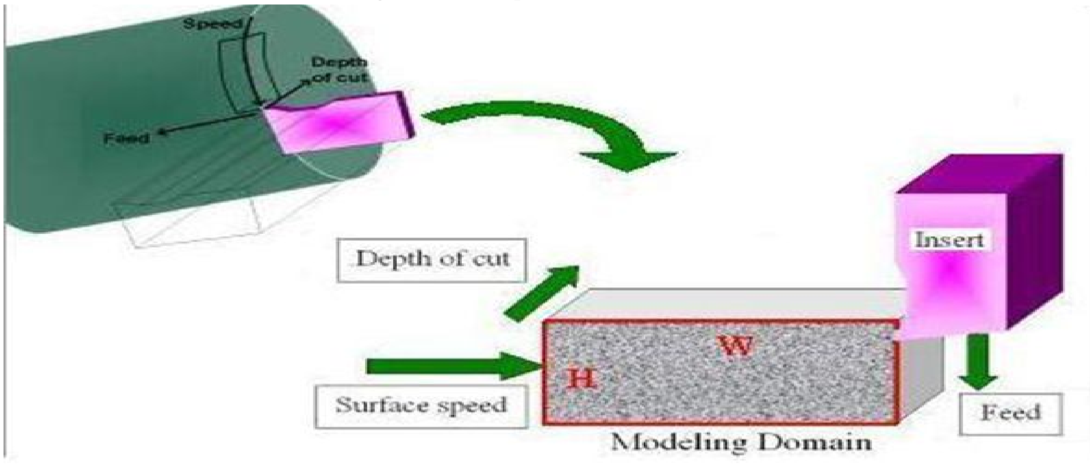
E. Chip Tool Interface

Fig .14 Chip tool Interface



H = 5 mm
W = 1 mm

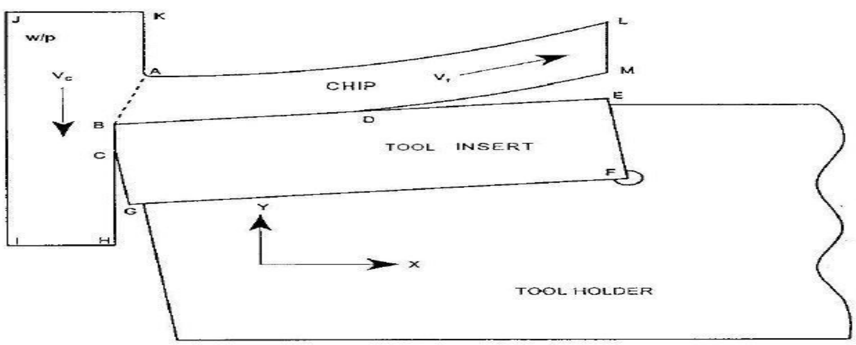


Fig .15 Chip tool Interface (2D View)

DEFORM 2D was used to model the tool and workpiece. Various input parameters such as cutting vel°City, feed and workpiece temperature were taken. The output parameters obtained are given below.

a) Temperature of chip tool interface
b) Effective strain
c) Effective stress
d) Cutting force
e) Thrust force
f) Tool wear rate

The input parameters were varied shown in the following table 5.3.

Cutting speed m/min FC	Feed (mm/rev) s		Temperature (°C) t
1..	21	.05	200
2.	43	.7	600

For the 1st model: FC = 21 m/min
S = .05 mm/rev
T = 200°C

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For the 2nd model: FC = 21 m/min
S = .05 mm/rev
T = 600°C

The following figure are obtained for different temperature values i.e. t=200°C and t=600°C.

1) Temperature Distribution

Fig .16 200°C

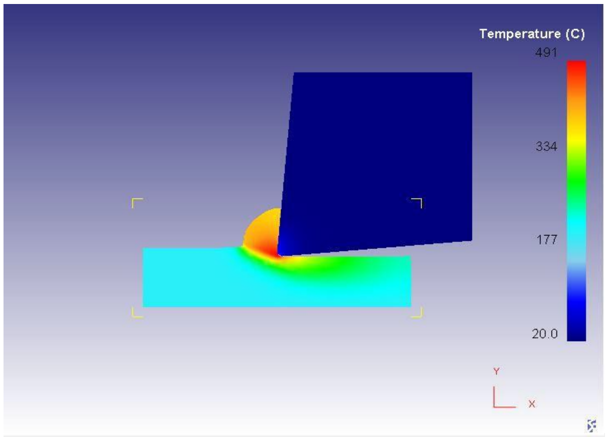
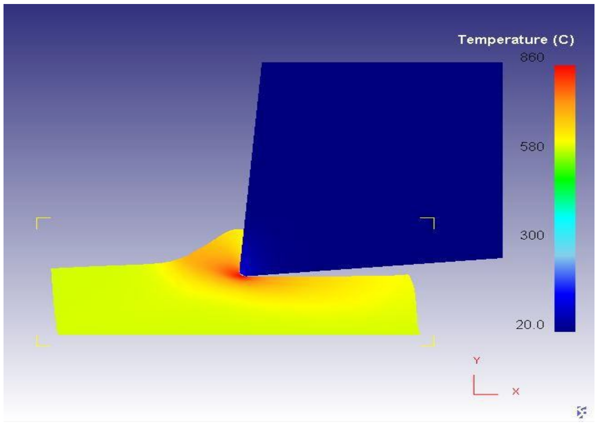


Fig .17 600°C



2) Effective Strain

Fig .18 200°C

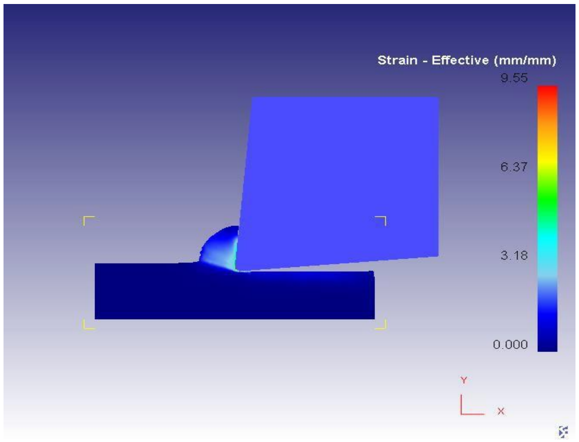
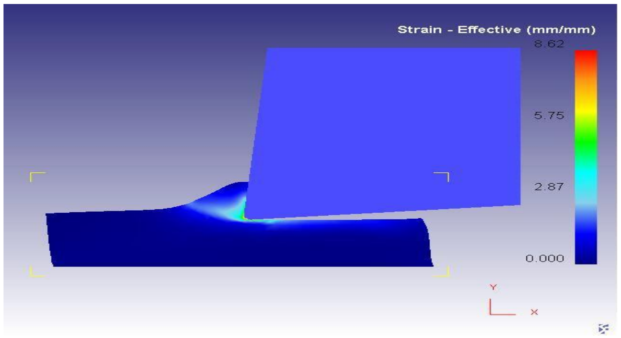


Fig .19 600°C



3) *Effective Stress*

Fig .20 200°C

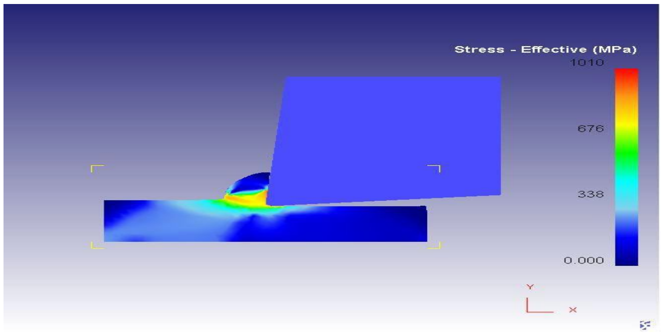
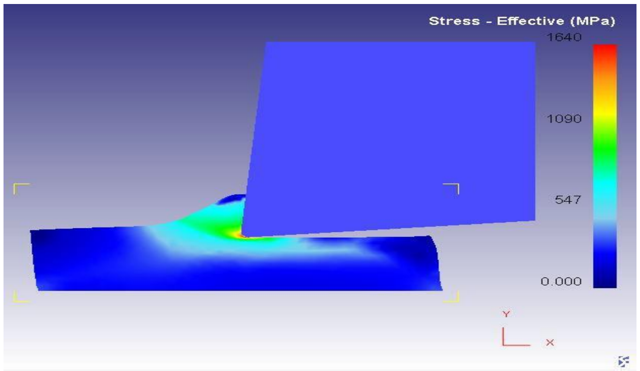


Fig .21 600°C



4) *Tool Wear Rate*

Fig .22 200°C

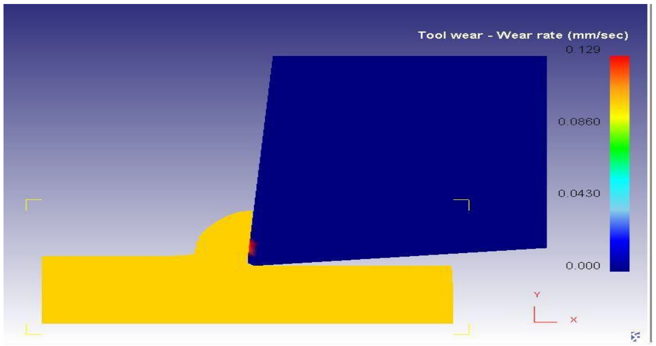


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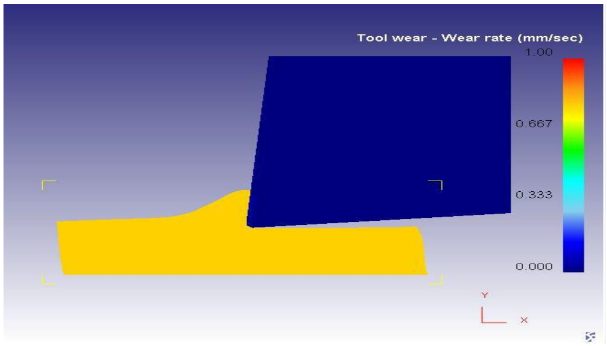
Fig .23 600°C



5) Cutting Force Force

Fig .24 200°C

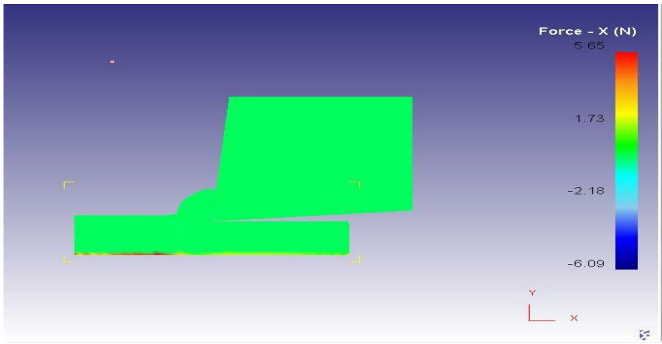
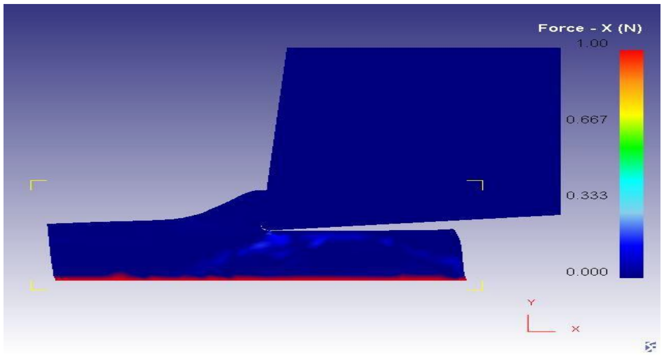


Fig .25 600°C



6) Thrust Force

Fig .26 200°C

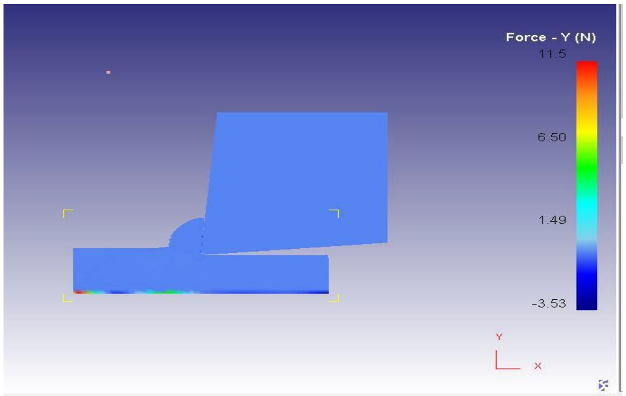


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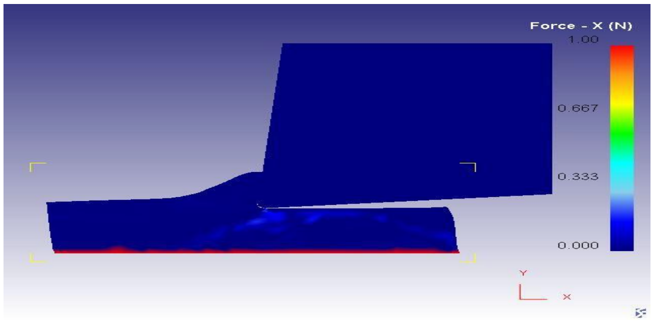
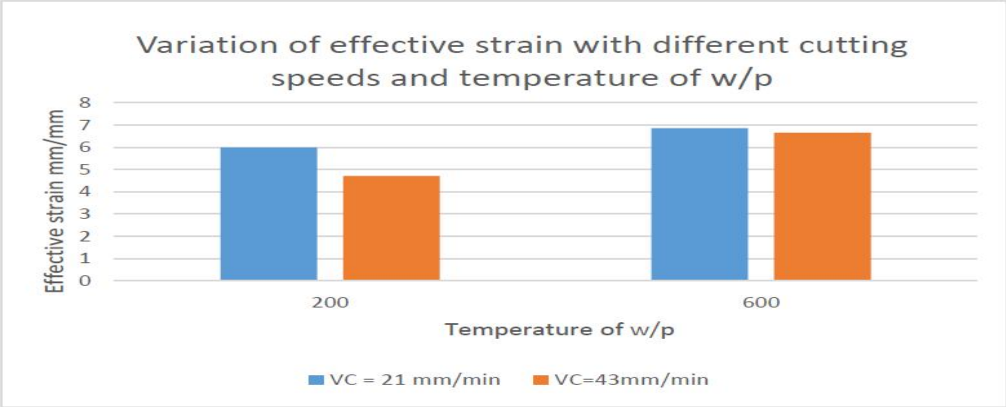
Fig .27 600°C



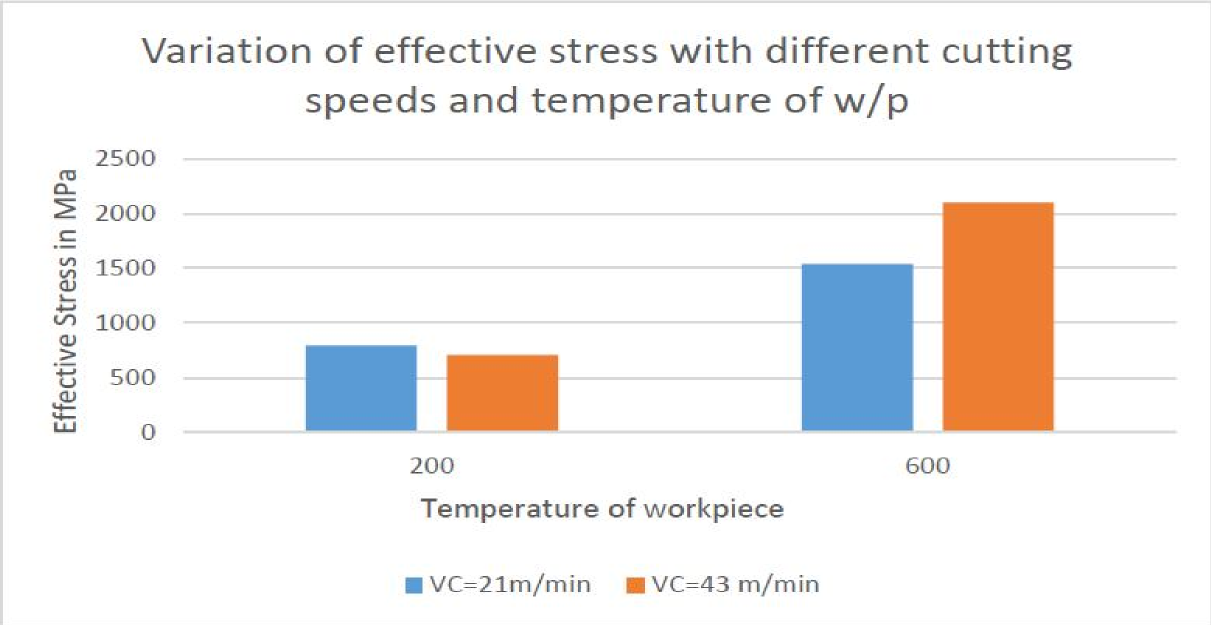
III. CONCLUSION

Graph 1. Variation of effective strain with different cutting speeds and temperature of workpiece



It can be seen that the effective strain decreases with increase in cutting speed, other parameters remaining same. But for a given cutting speed the effective strain increases with increase in temperature of workpiece.

Graph 2. Variation of effective stress with different cutting speeds and temperature of workpiece



A. Tool Wear Rate and Cutting Forces

It can be observed from the figures of tool wear that a minute red region representing high tool wear rate is seen on the model where the temperature of the workpiece is taken to be 200°C. On increasing the temperature to 600°C this region vanishes. Hence it can be concluded that on increasing the temperature of the workpiece the tool wear rate decreases.

Similarly from the figure of Cutting force and thrust force it can be concluded the on increasing the temperature of workpiece the cutting forces decrease.

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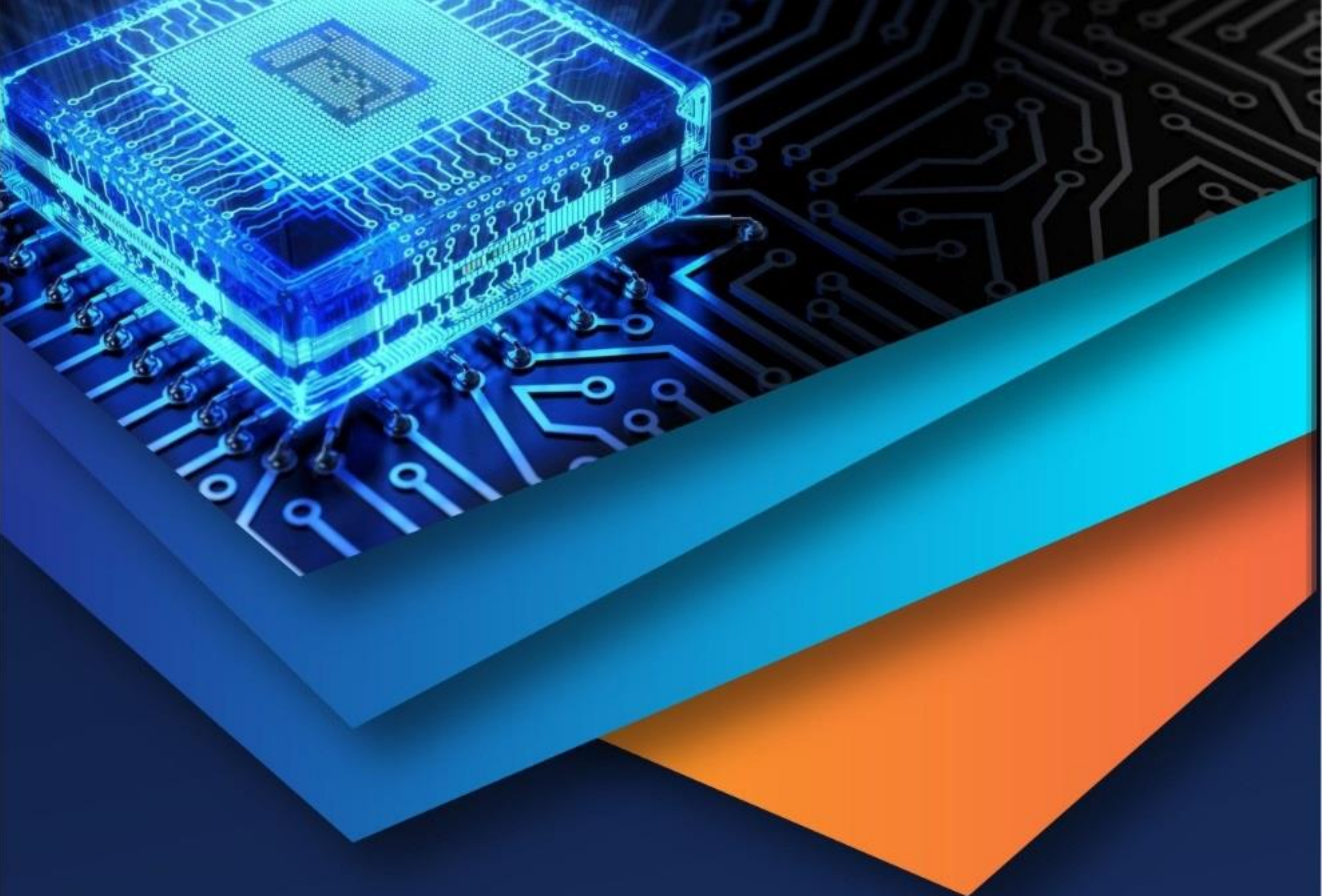

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