Simulation of Turning Process using Explicit Dynamics

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Abstract - *Chip formation is one of the primary characteristics in the machining of ductile materials. Modelling of metal cutting is performed using different tools in turning process. Simulation of chip formation process is performed by using a Tungsten and steel-4340 tools where Aluminium-1100 is used as work piece. ANSYS explicit dynamics is used to simulate metal cutting for a turning process under dry cutting conditions. The effect of different velocities and depth of cuts (DOC) are studied. This paper discusses in detail the working of simulation in ANSYS workbench and also presented the results obtained for shear stress and equivalent plastic strain at various depth of cuts and velocities when the tool is in flexible conditions.*

Key Words: Ductile, Modelling, Simulation Tungsten, Depth of cut, Ansys, Flexible.

1. INTRODUCTION

As metal cutting is mainly a chip formation process, one of the most important considerations when modeling is the approach by which elements of the work piece material separate as the cutter advances. Metal components are made into different shapes and dimensions by using various metal working processes. Metal working processes are classified into two major groups. One is non-cutting shaping or metal forming process where no chip formation takes place and metal is shaped under action of heat, pressure or both. Example: forging, rolling, pressing, etc. and the other is Cutting shaping or metal cutting or chip forming process where the components are brought to desired shape and size by removing the unwanted material from the parent metal in the form of chip through machining. Example: turning, drilling, milling, etc. Additionally some environment called cutting fluid is generally used to ease machining by cooling and lubrication.

- Machining is an essential process of finishing by which work pieces are produced to the desired dimensions and surface finish by gradually removing the excess material.
- Metal components are made into different shapes and dimensions by using various metal working processes.
- Turing is one of the basic machining processes. It is used to remove the work piece material with the help of the cutting tool.

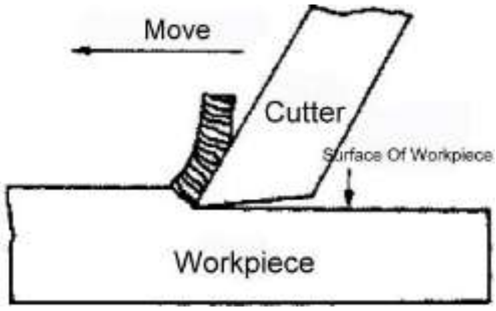


Fig 1: metal cutting

2. ANSYS EXPLICIT DYNAMICS

ANSYS explicit dynamics engineering simulation solutions are ideal for simulating physical events that occur in a short period of time and may result in material damage or failure. ANSYS Explicit STR, like ANSYS Mechanical, simulates the response of structures to loadings. Explicit STR extends the capabilities of Mechanical to problems involving short-duration severe loading, large material deformation and material failure. The explicit solution method can handle geometries with complex non-linear contact that may cause difficulty with the implicit solver in ANSYS Mechanical. It is an analysis system integrated within ANSYS Workbench, using the same familiar graphical user interface (GUI) as ANSYS Mechanical and other integrated analysis systems. If you already use ANSYS Mechanical, shifting to Explicit STR is fairly quick, so you can produce results without a lot of learning effort.
Explicit STR easily handles the response of materials from impacts, high pressures, and other forms of loading that result in deformation, failure and fragmentation. Companies in aerospace, automotive, electronics, manufacturing, consumer products and other industries use Explicit STR to improve their designs through simulation.

The solution method used by ANSYS Explicit STR software is based on the robust and time-tested Lagrange solver of the ANSYS AUTODYN analysis program.
ANSYS Explicit STR software uses the same graphical user interface (GUI) as the widely popular ANSYS Mechanical™ solver and all other analysis systems in the ANSYS Workbench environment.

3. DESIGN AND MODELLING

- The basic tool parameters are taken for modelling tool geometry as the first step.
- The tool geometry models are then modelled using CATIA and ANSYS Design Modeller**.**
- After modeling, the tool geometries are saved and imported into ANSYS for simulation.

The design and model of tool1 (Tungsten) and tool2 (steel4340) and work piece (Alumimium-1100) is as shown below

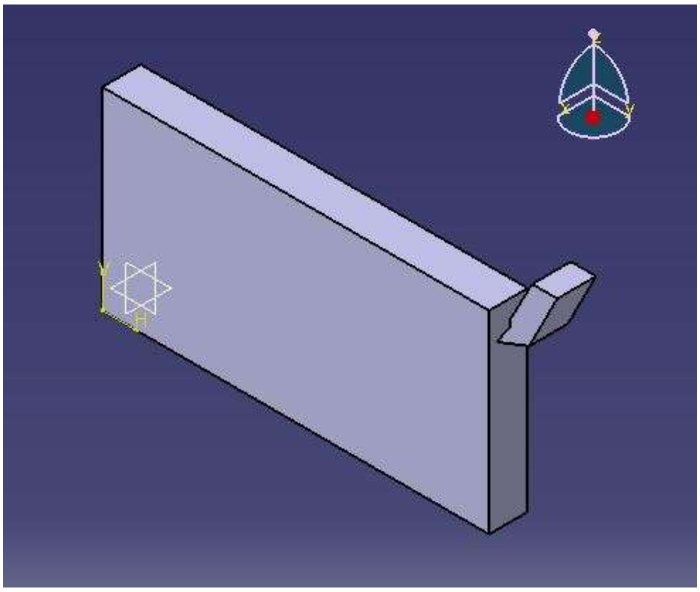


Fig 2: Designed in catia

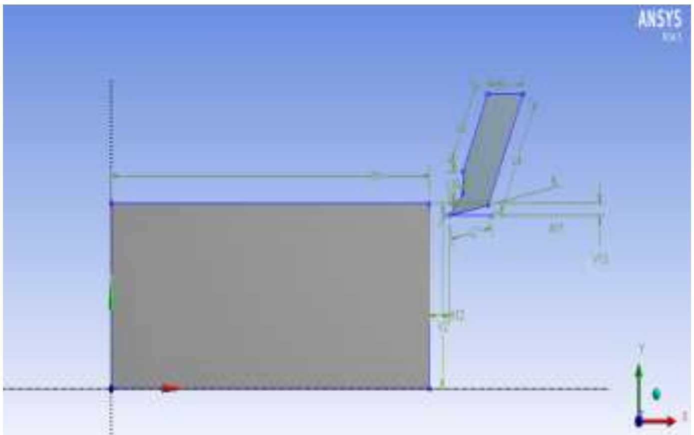


Fig 3: Designed in Ansys

The tools which are designed in catia are drawn with rake angle, back rake angle, relief angle, tool nose radius, tool length and also for work piece.

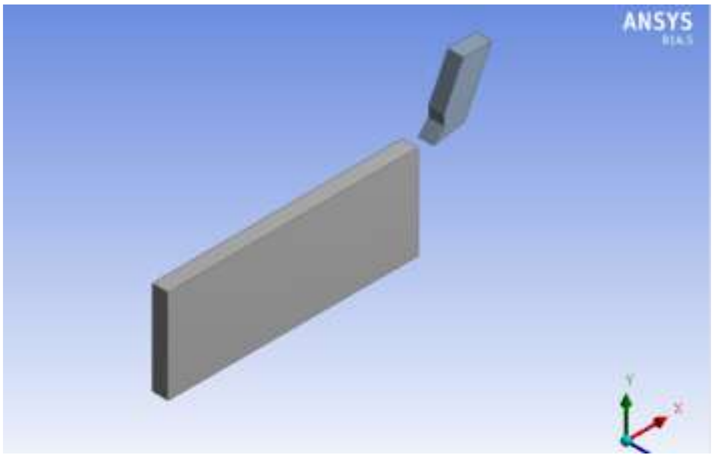


Fig 4: Imported geometry from catia

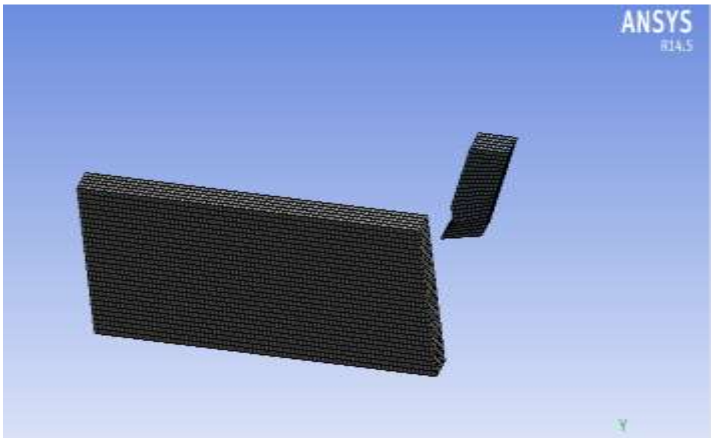


Fig 5: Meshing for work piece and tungsten tool

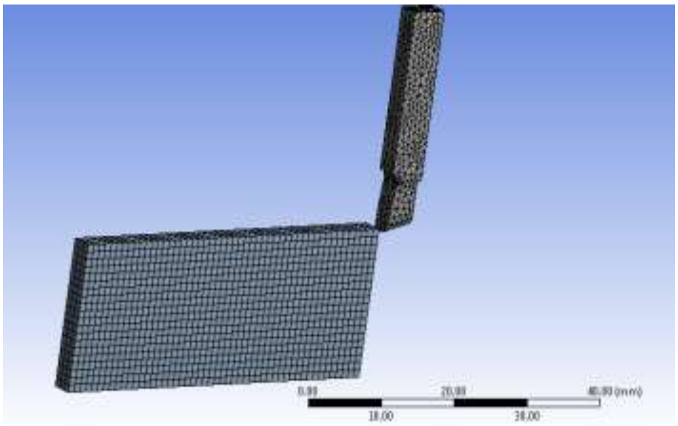


Fig 6: Meshing for work piece and steel4340 tool

Meshing is made for the tool and work piece by assigning element size or by default meshing size.

4. SIMULATION RESULTS

Here in this paper two types of material are used for cutting tool. One is Tungsten and the other is Steel 4340 where the only work piece material used is Aluminium-1100.The results obtained in ANSYS simulation for depth of cut of 1mm and 2mm for tool in flexible condition are evaluated. Results for shear stress and equivalent stress are evaluated.

The table shows the variation between two different depths of cut at various velocities. Equivalent plastic strain at 1mm and 2mm depth of cuts at 20m/s, 40m/s, and 70m/s are taken from simulations.

TOOL 1 –TUNGSTEN

WORKPIECE-ALUMININUM-1100

Tab-1: Equivalent plastic strain at 1mm&2mm DOC

S.NO	VELOCITY (m/s)	EQUIVALENT PLASTIC STRAIN	
		DOC-1mm	DOC-2mm
1.	20	1.251	1.3046
2.	40	1.4138	1.6135
3.	70	1.6545	1.7657

Tab-2: Shear stress at 1mm&2mm DOC

S.NO	VELOCITY (m/s)	SHEAR STRESS (pa) FLEXIBLE TOOL	
		DOC-1mm	DOC-2mm
1.	20	63.618	73.054
2.	40	53.254	58.348
3.	70	66.3188	66.317

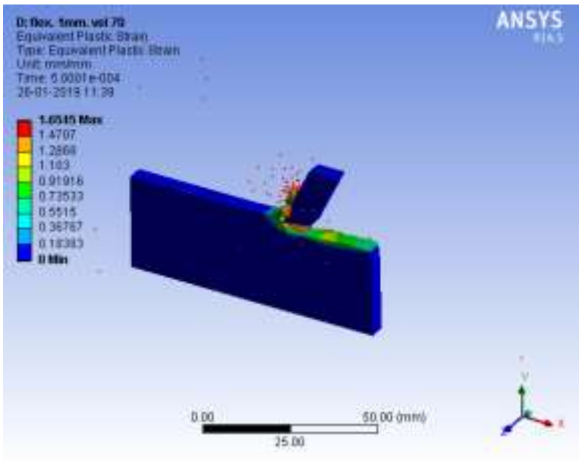


Fig 7: Equivalent plastic strain at 70m/s & DOC 1mm

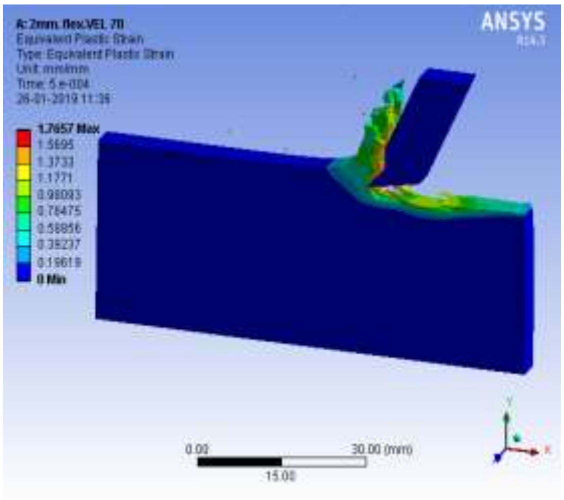


Fig 8: Equivalent plastic strain at 70m/s & DOC 2mm

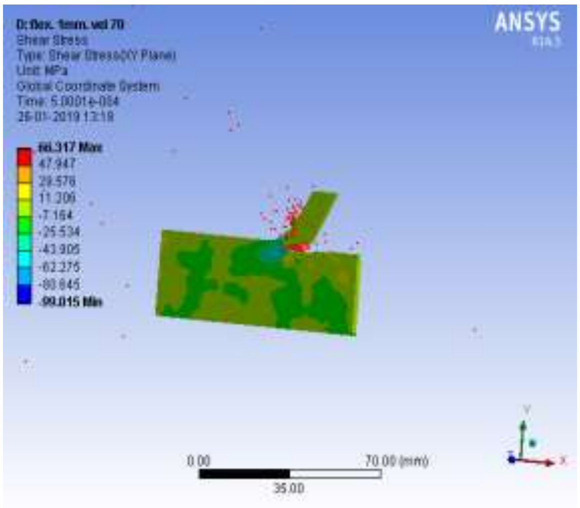


Fig 9: shear stress at 70m/s & DOC 1mm

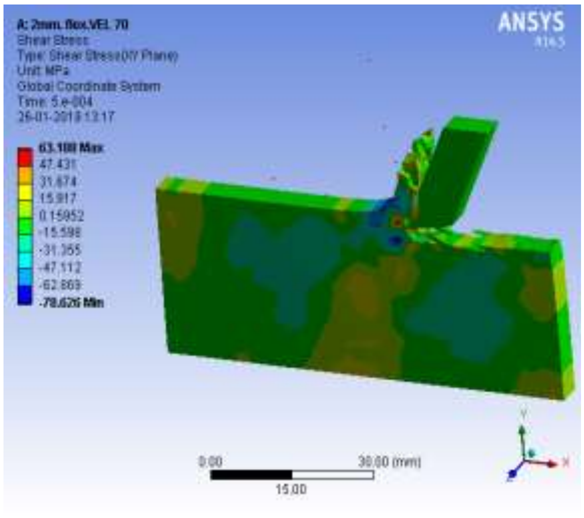


Fig 10: shear stress at 70m/s & DOC 2mm

TOOL 2 –STEEL4340

WORKPIECE-ALUMININUM-1100

Tab-3: Equivalent plastic strain at 1mm&2mm DOC

S.NO	VELOCITY (m/s)	EQUIVALENT PLASTIC STRAIN	
		DOC-1mm	DOC-2mm
1.	20	1.4021	1.9103
2.	40	1.689	2.6862
3.	70	1.6159	1.7697

Tab-4: Shear stress at 1mm&2mm DOC

S.NO	VELOCITY (m/s)	SHEAR STRESS (pa)	
		DOC-1mm	DOC-2mm
1.	20	42.819	49.86
2.	40	23.327	42.695
3.	70	36.024	84.053

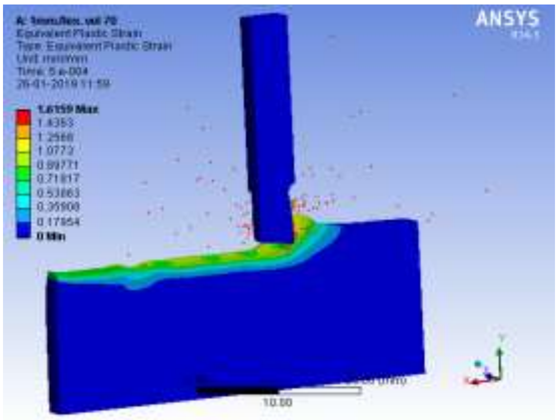


Fig 11: Equivalent plastic strain at 70m/s & DOC 1mm

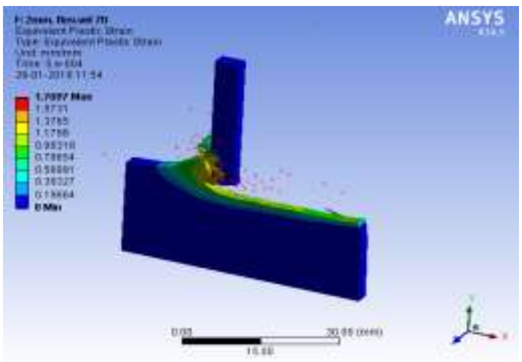


Fig 12: Equivalent plastic strain at 70m/s & DOC 2mm

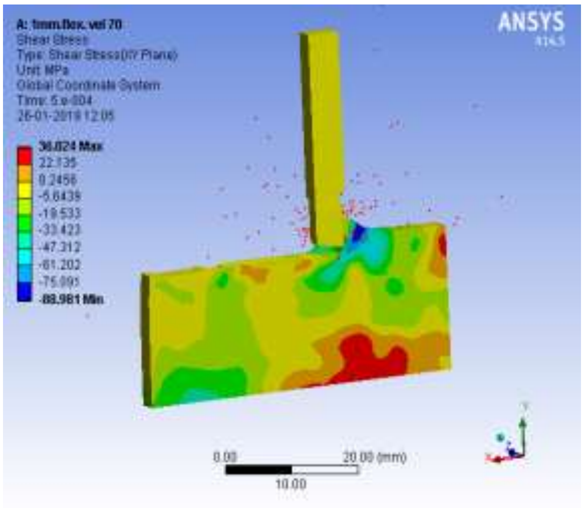


Fig 13: shear stress at 70m/s & DOC 1mm

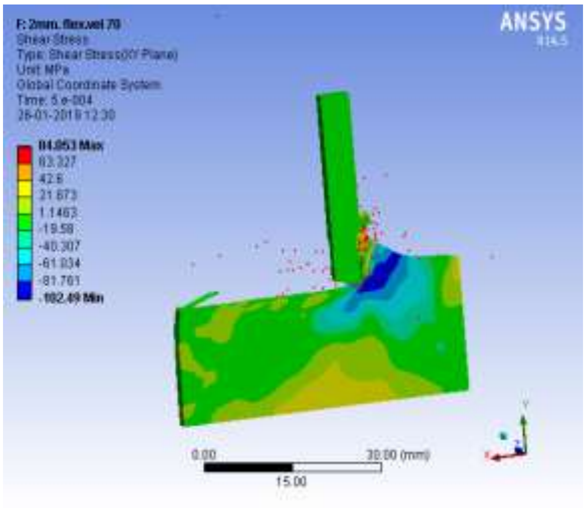
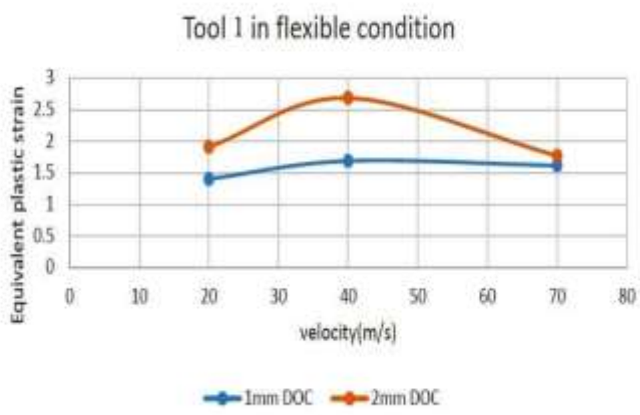
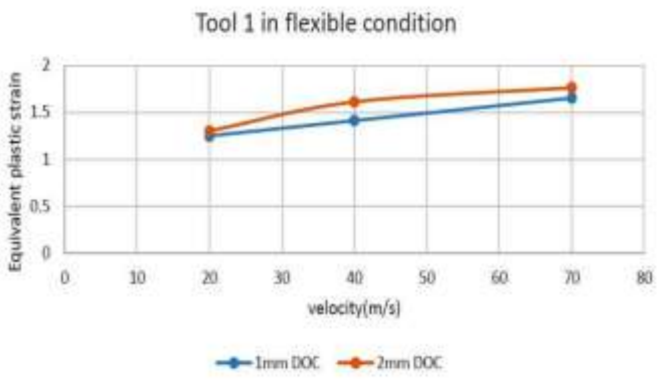


Fig 14: shear stress at 70m/s & DOC 2mm

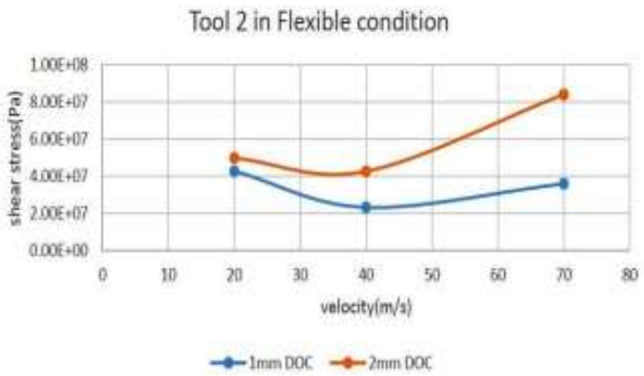
The simulation values which are obtained are plotted, on graphs to know the difference for various depth of cut (DOC) and various velocities.



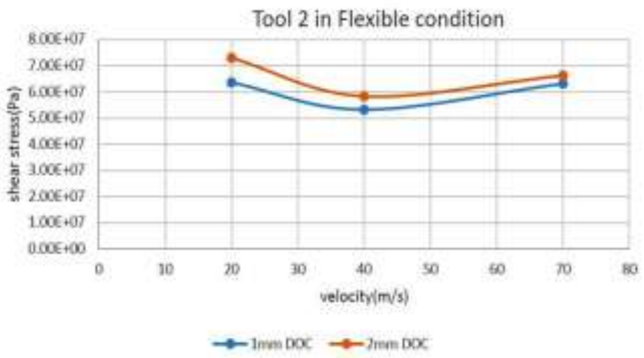
Graph-1



Graph-2



Graph-3



Graph-4

Graph 1 & 2 shows the equivalent plastic strain at various velocities (20, 40 & 70m/s) at 1mm and 2mm depth of cut.

Graph 3 & 4 shows shear stress at various velocities (20, 40 & 70m/s) at 1mm and 2mm depth of cut.

CONCLUSION

All the results are obtained from simulation performed in Ansys explicit dynamics. The results of simulation are shown in figures and also tabulated for various velocities and tool conditions. We observe that equivalent plastic strain increases with increase in depth of cut and increase in velocities. In the same way the shear stress also increases with increase in depth of cut and velocities.

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BIOGRAPHIES

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