Experimentation and Simulation of Single Point Incremental Sheet Forming Metal by Using the ANSYS

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Abstract - The single point incremental forming process is commonly used for the production of sheet metal. Unlike die-based processes, this method does not require a die to be used. It is a highly versatile process that can be easily implemented in the small and batch production. The analysis of this process by ANSYS is performed to determine the optimal design and implementation of the process. Although there are many software available for analyzing the various aspects of the process, the use of the simulation by ANSYS ensures that the results are better. By using the Ansys work bench to see the deformation of titanium sheet is possible or not. The various parameters of the process are analyzed in order to determine their optimal implementation.

***Keywords*: Sheet metal forming, Deformation, Surface deformation, Sheet metal, Experiment, and Simulation and analysis.**

I. INTRODUCTION

In previous works, there were various kinds of software used. For instance, in the works of Abaqus Jeswiet et al., 2005, Fuetal 2010, and LS-Dyna, other FEM simulation software was used instead of Solid works. There are also some works that use Solid works software for the CAE phase, while other FEM software is used for the analysis phase. In 2012, the authors of Solid works discussed the use of different modules for different design stages. For instance, the design stage is represented by the Solid works CAM, while the analysis stage is represented by the LS-Dyna software.

The Solidworks software has never been used for performing FEM simulation of single point incremental forming processes. In fact, LS-DYNA is a general-pur-pose simulation software that is used by various industries such as aeronautics, aerospace, and manufacturing in biomedical field also used the simulation is must important. In the simulation getting the accurate results, by using the analysis of the explicit dynamic deformation results getting. This sheet forming process is very usefull for the small batch size production as compared to the conventional manufacturing. Mostly applicable for the biomedical field.

The process of biologic plants using molecular biology techniques has been known to producevarious biocompatible materials, such as titanium. The main objective of this process is to increase the cost-effectiveness of the production by incremental sheet forming. Despite its high strength to weight ratio, titanium has been neglected for some applications due to its low formability. Due to the increasing demand for this process in the biomedical and aerospace fields, a dedicated effort has been made to improve the simulation and analysis of the process. This workwas carried out through the development of a numerical value simulation program for the steel sheet forming process using LS-Dyna software. The main objective of this project is to provide a better understanding of the mechanics involved in the process. This discipline provides an important method for analysing complex systems. It can be used in various disciplines and industries to provide valuable insight into complex systems.

II. NEED OF COMPUTER-AIDED ENGINEERING (CAE) AND FEM SIMULATIONS

Through simulation software, users can easily visualize and analyze computer models while running. This allows them to experiment with a system digital representation. Simulation and there model representation solve the real world problem and give the safe signal before the experiment. Simulation is very easy method analysis and the finding the proper the value of the model.

The simulation consisted of a hemispherical tool for the deform a Titanium sheet. The tool describes a pyramidal with a circular base path. All the degrees of freedom constrain in the sheet edges imitating, in this way, an experimental blank holder effect. The blank holder, the titanium sheet, and the hemispherical tool design was created in the CAD module. This scenario was reproduced in Simulation and a dynamic and non-linear study was opened [1].

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The following steps were to carried out the FEM Simulation.The CAE simulation process consists of four main steps

(1) Create Geometry
(2) Apply Boundary Condition

(3) Support, Displacement

(4) result in analysis and evaluation.

After the simulation, the simulation results need to be analyse and evaluated. If the results and solutions are satisfactory, then changes and modifications may be suggested for the metal forming system (part design, tooling design, process configuration, and material selection) which can be made for the next round of the simulation study.

III. EXPERIMENT WORK

In this study, the experiments were performed using a CNC vertical milling machine and a pure titanium sheet.Single point Incremental sheet metal forming (ISMF) experiments were carried out using a 3-axes CNC vertical milling machine and corresponding surface roughness and maximum sheet forming angle measure[11]. The material used for the present investigation is a pure Titanium sheet with has been 150mm×170mm size. Thin Titanium sheets, 0.05 mm sheet were used in this study.SPIF experiments were conducted at room temperature on three-axis CNC milling vertical machining centre . Single point incremental forming has the advantage of simple machine setup cost and it can be done on CNC machines with limited fixture and tools costs. A square clamp frame with a free edge of 110 mm was used and all the tests were conducted with a variable feed rate range from 1000 to 1500 mm/min [11].

Figure:1 Experimental set up

There are two tools with a diameter of 1,and 2 mm with a hemispherical end were used to conduct the experiments. These Single Point Incremental Forming Tools are made up of AaISI H13. Coconut oil is the best as a lubricant, to reduce friction and finding the deformation of the sheet is possible or not possible and if possible the deformation at what condition the risk of failure.

The shape of the sheet metal incrementally form part affected the strains and, therefore, the material's formability. Geometry were accepted that has not been covered in this literature review due to the complexity of analysing the many different shapes and dimensions use across the studied papers. For the manufacturing of industrial products, the proper draft value is be given. It ensures the manufacturing of the product in a single pass. Draft value can be computed with help of CAD software[11].

Single point incremental forming were be used in this raw sheet is clamping on the fixture and then the whole setup is fix on the CNC machine table and the hemispherical tool will be used to carry out deformations. A fixture is designed according to the required size of the product. Fixture design and calculations are shown below. The Incremental Forming Fixture is fabricated using Mild Steel. Table 1 shows a list of materials used in fixture formation. Figure 2 shows a formed pure Titanium sheet of thickness 0.05mm with a dome -type toolpath[11].

Table 1. Chemical composition of material

Parameter %	C	**S**	**Cr**	**Mn**	**Ni**	**P**	**Si**
Titanium Sheet	0.369	-	0.0099	-	<0.0010	-	0.0222
AISI H13	<0.45	0.03	<5.50	<0.50	0.3	0.03	<1.20

Table 2 Materials for the fixture

Sr. No	**Component**	**Material Selected**
1	Fixture and base plate	Mild steel Tensile strength σt = 370MPa
2	C-Clamps	Alloy Steel
3	Vertical Supports	Mild Steel Young's Modulus E = 2.1×105N/mm2

The Material of a hemispherical end is using to conduct the experiments. These Single Point Incremental Forming Tools are made up of AaISI H13. The material used for the present investigation is a pure Titanium sheet with has 150mm×170mm in size[11].

Table 3 Material properties of TOOL AND sheet used for simulation

Parameters	**Titanium Sheet**	**AISI H13**
Poisson Ratio	0.34	0.027-0.3
Hardness	70	53HV
Elasticity Modulus	116Gpa	215Gpa
Thermal Conductivity	17W/MK	28.8(w/m.k)
Yield	880Mpa	1000-1380Mpa
Ultimate tensile Strength	1459Mpa	1200-1590Mpa
Density	4.6(g/cm^3)	7000kg/m^3

IV. ANALYSIS

ANSYS Workbench allow to introduced as initial data either load on the element or its deformation. In this case, the deformation of the sheet was defined as the position of the tool during the process. Fig.2 it is presented an example of the definition of the position, that is, the deformation of the sheet along with the test corresponding

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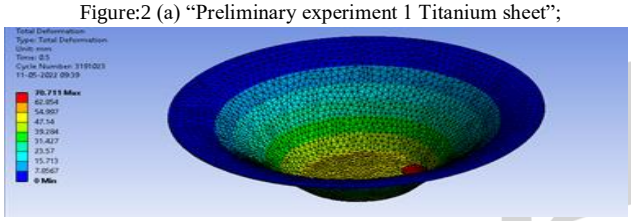
to a square-based pyramid. Thus the simulation throws as results the force in the tool and the external reactions of the sheet. Logically it was considered fixed support along the boundary of the sheet as an external support condition. For obtaining the results, that is loads, it is necessary to ask the software which are the forces involved with the fixed support[1][2].

V. RESULTS AND DISCUSSION

By applying all boundary condition and selection of the material for the sheet and tool we get the better results as compare to the other material. Following results are getting after analysis.

Figure:2 (a) "Preliminary experiment 1 Titanium sheet";



(b) ANSYS simulation solver

1. Total Deformation

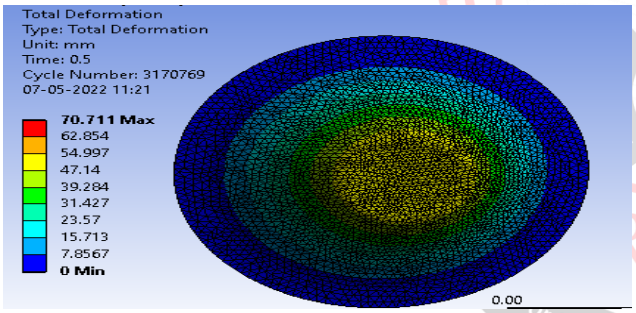


Fig:3 ANSYS simulation For Total Deformation

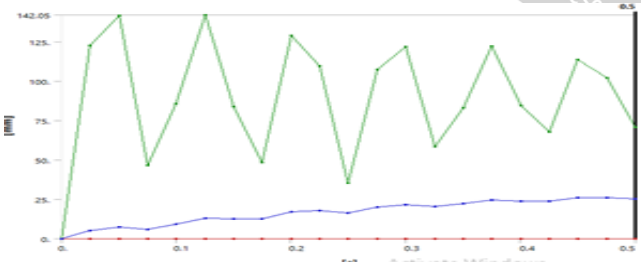


Fig:4 ANSYS simulation For Total Deformation

Fig.3 and Fig 4 shows that simulation and graphical presentation of simulations of single point incremental sheet forming metal. show the total deformation got. By observing the result 70.71 max and 7.67 min in between that we get total deformation. And equivalent stress was also found during the simulation as compared to the other material titanium sheet gives the better result and according to the observation this using this material we get the long term product use.

2. Equivalent Stress

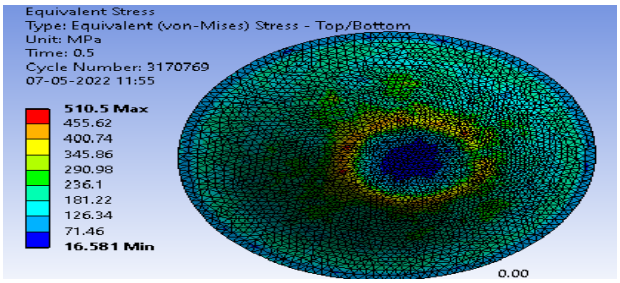


Figure:5. ANSYS simulation Equivalent Stress

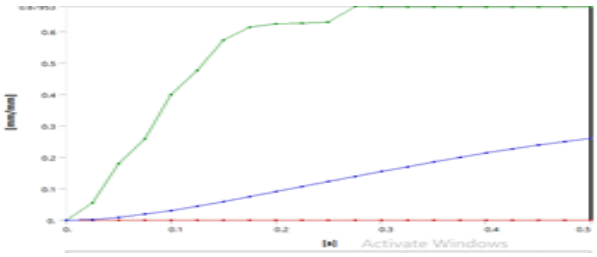


Figure:6. ANSYS simulation Equivalent Stress Strain

Fig.5 and Fig 6 shows that simulation and graphical presentation Equivalent Stress is, also called distortion energy theory or von-Mises theory states that maximum equivalent stress at stress elements on material or part must be smaller from the yield strength of that used material. Maximum equivalent stress theory applies to ductile materials.

3. Equivalent Elastic Strain

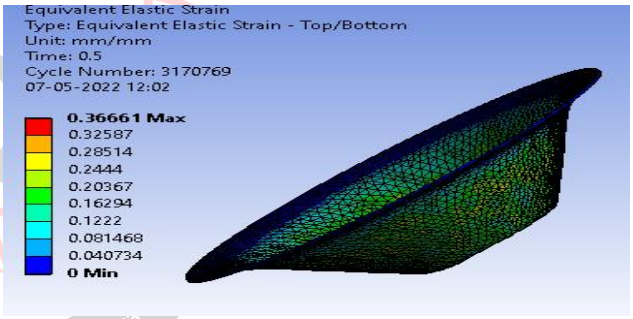


Figure:7 ANSYS simulation Equivalent Elastic Strain

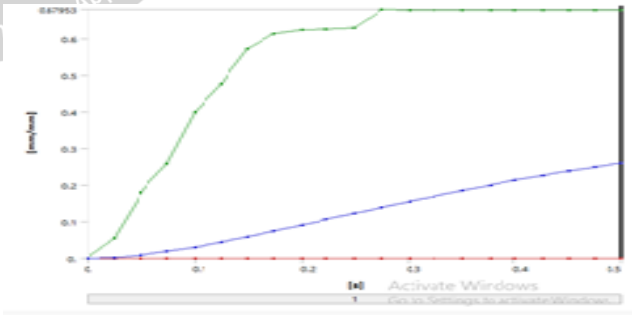


Figure:8 ANSYS simulation Equivalent Elastic Strain

Fig.7 and Fig 8 shows that simulation and graphical presentation of Elasticity is a property of the material when we ally the force body change its shape and size it gets deform after remove the force it gets its original shape and size. In this titanium sheet metal simulation get the value of equivalent Elastic strain here we observed that the maximum to the minimum value.

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Table:3 Output Results

Parameters	Output Value
Total Deformation	70.17 mm
Equivalent Stress	510 Mpa
Equivalent Elastic Strain	0.36 mm/mm

VI. CONCLUSIONS

The paper was meant to learn the simulation of a pure Titanium sheet of a thickness of 0.5 mm by using the single point incremental sheet forming metal process for getting the result like total deformation, equivalent stress, Equivalent Elastic Strain, and Equivalent Plastic Strain. After applying all boundary conditions as Compared to the other material sheets titanium gives better and long duration results, which is useful to the automobile industry and the biomedical field. In the main things that happen in the analysis, deformation is possible for a thickness of sheet 0.5mm, and also deformation is carried out in experimentation.

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