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Finite element analysis of Incremental sheet forming

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ABSTRACT

Incremental sheet metal forming is a relatively new technology developed to fabricate complex geometries which simultaneously streamlines the process by reducing the manufacturing time as well as the set-up cost. The process is carried out with a CNC machine with a rotating forming tool following predefined trajectories defined by the contour of the aforementioned geometries. In this work we use a laboratory scale incremental forming to design and form geometries with a vertical head CNC machine. Three dimensional models of the parts required will be modelled and corresponding NC codes were generated accordingly. Simulations are created and would be verified by comparing it with the experimental procedure.

Keywords— *Incremental Forming, Complex Geometries, Forming Angle, Formability, Simulation*

1. INTRODUCTION

Incremental Sheet metal forming is an advanced manufacturing process and is well known as Die less sheet metal forming. A sheet is formed into its final geometry by a series of very small incremental deformations. Requirement of numerically controlled tool can easily be fulfilled by CNC milling machines. The use of numerically controlled tool in Incremental Sheet Forming allows user to follow any complex path and composite geometrical parts can be formed with ease than any conventional forming process.

2. LITERATURE REVIEW

[1] Leszak E (1967) patented his apparatus for incremental dieless metal forming.

[2] Jeswiet (2005) showed the procedure of asymmerical incremental forming.

[3] Durgun et al (2014) pointed out that implicit form of finite element analysis provided accurate data sets, and the forming direction optimization in single point incremental forming.

[4] Tegan McAnulty (2017) showed results regarding material thickness, spindle and feed rates and evidence of an ideal range and interdependency of parameters.

[5] Rauch (08) investigated path strategies and showed the relation between the feed rate and forming force.

[6] Liu Z, Li Y, Meehan P (2013) investigated the formability and forming force for aluminum alloy sheets in Incremental forming.

[7] Yanamundra (18) compared the process of finite element analysis and experimental data of incremental forming.

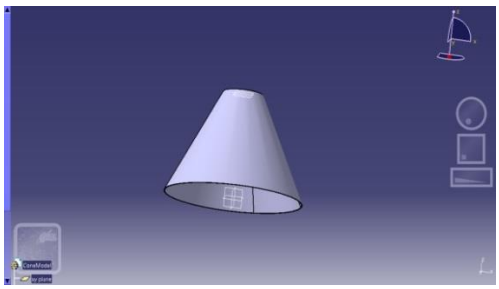
3. METHODOLOGY

We used a blank of 170mm x 170mm commercially pure titanium grade 2 sheet of thickness 1mm for our Incremental deformation process on a CNC milling lathe machine. α alloys, like commercially pure titanium (Cp-Ti) are corrosion resistant and they are stable below 882 ℃ and the β phase above 882 ℃.

In our work on finite element analysis of Cp-Ti based incremental sheet model, we conduct the experiment in CAM Software on Simulation and Analysis and then proceed for the implementation of the incremental sheet metal forming process under a milling CNC lathe machine. There are several important parameters such as tool path forming and the forming angle especially is important for its relation of failure of formation at edges, the feed rate and the formation are crucial for accuracy. Also the major factor of coefficient of friction must be taken into account during formation and hence proper foam lubriction is used while the formation process.

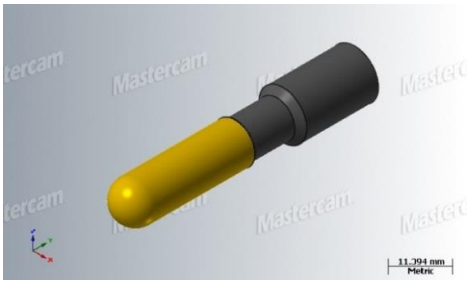
3.1 Design of Cone

The 3D model of a hollow frustum of a cone is designed with 1mm thickness and of a diameter of 90mm. The thickness of the whole cone is uniform and the dimensions are scaled. The model is exported with 3d annotations in ISOed3 STEP format for development of toolpath generation in contours for incremental sheet metal forming. The STEP file has one instruction per line and is widely used for computer aided manufacturing process.

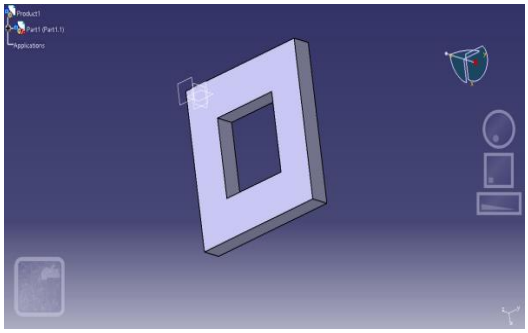


3.2 Forming Tool and Blank Holder

A hemispherical tool of diameter 10mm made of carbide, overall length of 60mm, neck about 12mm long.

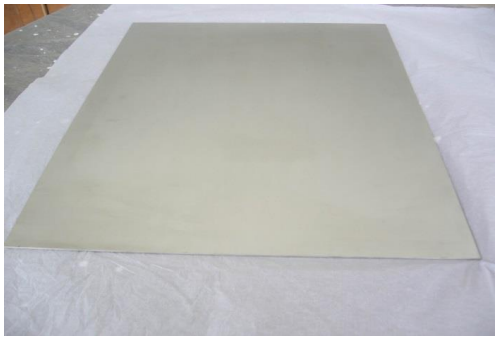


The blank holder we used here is a square plate of thickness of 25.4mm. The square plate is developed symmerically with inner side of 100mm x 100mm and outer side about 200mm x 200mm. This square plate is drilled based on the specific make of the lathe machine for the holder, overall the holder is based for the size of our blank sheet.



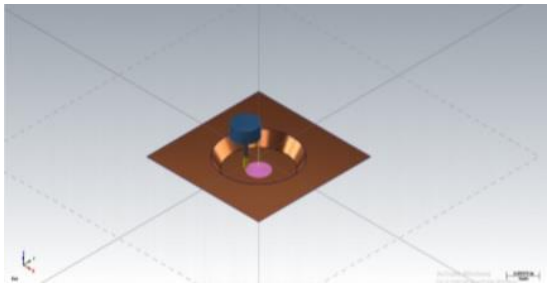
3.3 Sheet Material(Cp-Ti Grade 2)

A blank of 170mm x 170mm of cp-ti sheet of thickness 1mm is used as the workpiece.



3.4 ToolPath Generation

Toolpath generation is complex process which is used for automated forming of the geometry by computer aided manufacturing, where we import and mark the annotations and the model is construced from the B Splines and enumerate points of symmetry, All this data is obtained from the STEP File developed in the Design of Cone. The model and the tool base is imported into mastercam and tool path generation for the incremental metal forming on a CNC lathe machine is developed and the corresponding NC files are simulated for NC machining review.

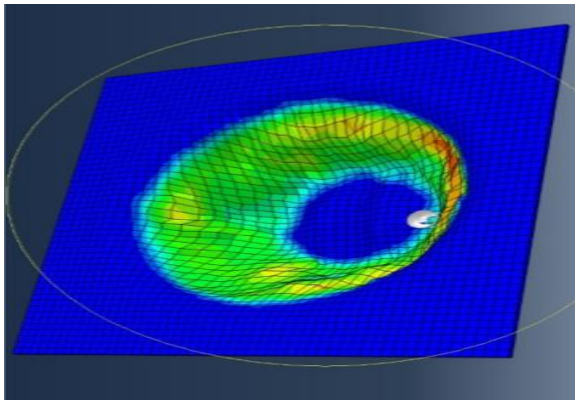


4. EXPERIMENTATION

The titanium sheet is placed below the holder to fit the symmetry, the blank holder is placed on the workpiece sheet and it is fixed. The NC Codes are fed into the CNC lathe and the operations of contour deformations start from the middle and deformations are performed based on the toolpath trajectories.The rotating tool deforms the plate into the specified geometry and incremental sheet forming process is finised.

5. SIMULATION AND FINITE ELEMENT ANALYSIS

In the simulation process, the appropriate boundry conditions are provided in the simulation and finite element analysis is performed with mesh size of .5cm and the resulting strain data is tabulated and are compared to the strain data with different sizes. The maximum range of strain was peak is noted.



6. CONCLUSION

The objective of our work was to understand the basics of incremental sheet forming which is a flexible and can be easily used for simulation of complex geometries. Material properties and its evaluation is of high importance for critical control and accurate objectives. Despite the shortcomings of incremental metal forming in large scale manufacturing, we believe and it would be a viable and reliable alternative to many traditional processes.

7. ACKNOWLEDGEMENTS

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