FORMABILITY AND THICKNESS DISTRIBUTION ANALYSIS ON ALUMINIUM ALLOY 5052 USING SINGLE POINT INCREMENTAL FORMING

S. JOSEPH IRUDAYA RAJA[1], A. ARULMANIKANDAN[2], G. SATHISHKUMAR[3] & S. SIVAGANESAN[4]

[1,3] Faculty of Mechanical Engineering, Vels Institute of Science Technology & Advanced Studies, Chennai, Tamil Nadu, India
[2,4] Department of Mechanical Engineering, Rrase College of engineering, Chennai, Tamil Nadu, India

ABSTRACT

This project aims to analyze the formability by single point incremental forming on AA-5052 sheet metal using with and without pre-cut holes. Forming limit diagram is based on the formability, which separates the forming region and failure region. It represent the terms of major strain and minor strain under plane stress condition. The process parameters involved in the single point incremental forming are sheet thickness, forming speed, and tool diameter, step depth and wall angle. Tool path influences the formability and surface finish of the sheet metal. This emphasizes the study of forming parameters to prevent failure in the sheet metals. This project aims to compare the wall thickness and formability on AA-5052 sheet metal at annealed conditions by using Single Point Incremental Forming.

KEYWORDS: Sheet Metal, AA-5052 & Single Point Incremental

Original Article

INTRODUCTION

Sheet metal forming process have been used to manufacture require sheet metal product in many applications example automobiles, aircraft industries due to high strength compare to light weight products. The sheet forming processes of automobile and aerospace covering parts included drawing, trimming, stamping, shaping and flanking processes. Formability is the ability of sheet metal to undergo shape change without failure by necking or tearing[1,2].Single Point Incremental forming is a sheet metal forming technique where a sheet is formed into the final work piece by a series of small incremental deformations[5]. The sheet is formed by a round tipped tool, typically 5 to 20mm in diameter. The tool, indents into the sheet by about 1 mm and follows a contour for the desired part. It then indents further and draws the next contour for the part into the sheet and continues to do this until the full part is formed

Incremental Sheet metal Forming (ISMF) is an important process is emerged in recent trends in manufacturing of compound sheet metal parts. The process can be performed on CNC milling centers using simply forming tools incrementally deform the sheet metal products. The computer numerical control system through direct guidance of data, by reducing the use of important tooling punches. In this process is sound flexible and tool cost is very less as well as enhanced formability, it is specifically attractive for manufacturing value added materials in the form of small batches and customized sheet metal parts especially in pharmaceutical and aerospace industries.Forming – Limit Diagramis used to describe the formability of sheet metals obtained by forming a specimens like square cup and cone by AA-5052 sheet material.Sheet metal is formed by huge in complex state of strain paths[8,9,10]. There is no theoretical method to find the formability processes. The forming limit diagram is find the value of certain ratio of strains without failing.The most famous and common

manufacturing process in many industrial and civil sectors is sheet metal forming which are capable of producing good quality complex part with nowadays technology. However, the demand of the customers could have effects on many conventional forming methods when small production batch with high product quality are required. With economic competitiveness, manufacturing companies must find new solutions that are more flexible to satisfy different market segments. In most of the manufacturing processes, prototype is very important to start exact operation in massive production. Prototype allows the improvement and development of the product, changing its design in early steps of product development. Producing prototypes in some manufacturing processes may consume a lot of money and time to tryout, especially particular dies are required in sheet metal components. As a result of new emerging trends called Incremental Sheet Metal Forming (ISMF) been developed now a days[15,17]. The process can be performed on CNC machining canters using simple forming tools to incrementally deform the sheet until the part is produced. The main point of this process is to reduce the lead-time of tooling development and investment cost. ISMF has an ability to form difficult complex parts economically not requiring specific dies and expensive tool set up. Furthermore, ISMF can be performed in a wide range of materials such as steels, polymers, thermoplastics, titanium, etc. Although the process requires higher manufacturing times when compared to conventional forming process, it is suitable for producing complex parts in small batches, such as prototype parts for aeronautical, automotive and medical applications. The following process parameters namely thickness, Formability, Wall angle and Forming Depth constant have been involved in Single point Incremental Forming on AA5052 sheet metal using with and without pre-cut holes.

MATERIAL

Material used in this experimental work is Aluminium Alloy which is widely used in aircraft and automobile application. It has less dense and good strength to weight ratio. Aluminium Alloy AA5052 to be chosen in this study due to its good corrosion resistance and possess good fluidity.

ALUMINIUM ALLOY 5052

AA- 5052 is annon-heat-treatable 2.5% mg, 0.25% cr alloy commonly available in the form of flat rolled coil, sheet and plates. Aluminum 5xxx-series contains high magnesium content as shown in table-1.AA 5052 high strength and it has enable to significant cold working, and its recommend to forming a different structures. The chemical characteristics of AA-5052 sheet metal with Actual weight % and nominal weight % are shown in the table 3.1 the mechanical behaviors of AA-5052 sheet metal are shown in table 1.

Table 1: Chemical Characteristics of AA5052

Characteristics	% by weight
Mg	2.2-2.8(2.23)
Cr	0.15-0.35(0.18)
Si	0.25Max(0.14)
Fe	0.40Max(0.31)
Cu	0.10Max(0.01)
Mn	0.10Max(0.05)
Zn	0.10Max(0.001)
Al	Remaining

Table 2: Mechanical Behavior of AA5052 Sheet Metal

Properties	Values	Units
Ultimate Yield Strength	193	MPa
Ultimate Tensile Strength (UTS)	228	MPa
% of Elongation	13	%
Average hardness	96.63	HAAS V2

EXPERIMENTAL

The forming parameters used for single point incremental forming process was identified through literature survey. The material was chosen as AA5052 alloy which is mostly widely used in automobile and aerospace structure. The sheet metal of 1 mm thickness was cut into 175mm x175mm and laser etching of 0.01mm was done over the sheet metal. Figure 1 represents the Positioning of AA5052 Sheet metal

Figure 1: Positioning of AA5052 Sheet Metal

To carry out the experimental value of AA5052 sheet metal Aluminium Alloy with cold rolled condition thickness of the sheet is 1 mm by using numerical controlled milling machine. The blank with 180 x 180mm was held in fixture. A conical shape of size 175mm x 175mm angle of 65º and 72mm depth was formed incrementally in AA5052 Aluminium sheet. The experiments are carried out using various process parameters (spindle speed, feed rate and depth of cut). The high speed hemispherical end tool of 10mm diameter is used to perform the experiments. During machining, the tool path moves on the sheet metal in circular manner. The sheet metal used in the incremental forming process at room temperature and annealing temperature.

The following sheet metal has been inserted into the induction furnace with the help of tongs and has to be soaked at a temperature at which the sheet metal has to be annealed at the temperature of 200ºC and 300ºC for a time pan of 1 hour respectively till which it reaches the annealed condition which this process is known as soaking temperature.

Two types of deformations occurs in these forming methods. Biaxial stretching tool path is straight on a X-axis, at the starting and ending points of the deformations is occurs in this method. At the circular sheet metal the corners of the materials also deformed by biaxial stretching. At circular sheet metal, the corners of the materials also deform biaxial stretching. The other characteristic is the formability of deformation. Fracture curve, plotted in yield surface curves plot is valid only for specific type and thickness of the material. It is evident that at incremental sheet metal forming, yield surface curve is a straight line with negative incline and is higher than the usual sheet metal forming yield surface curves. As the single point tool diameter or the step depth decreases, the formability increases as shown in figure 2.

Figure 2: After Forming

RESULTS AND DISCUSSIONS

Formability (Formed Components)

The formability of sheet metal operation is based on deep drawing, bending and cup drawing involve tensile extensive deformation is called necking and fracture. Sheet metal annealed and formed at 200^0C, 300^0C and room temperature with 72mm, 54.3mm and 22mm depth.

SHEET METAL ANNEALED AND FORMED AT 200ºC WITH DIFFERENT VIEWS

Figure 3: Annealed Sheet Metal before   **Figure 4: Annealed Sheet Metal after**
Forming at 200ºC   **Forming at 200ºC**

The Annealed sheet metal before and after forming at 200ºC as shown in figure 3 and 4 respectively.Annealing increases ductility. Increase in ductility, leads to increase in formability. While forming using sheet annealed at 200^0c, the crack occurs at a depth of 54.3 mm. This shows that the ductility has been improved.

SHEET METAL ANNEALED AND FORMED AT 300ºC WITH DIFFERENT VIEWS

Figure 5: Annealed Sheet Metal before   **Figure 6: Annealed Sheet Metal after**
Forming at 300ºC   **Forming at 300ºC**

The Annealed sheet metal before and after forming at 300ºC as shown in figure 5and 6 respectively. While using sheet annealed at 300ºc no crack has been observed upto a depth of 72mm

SHEET METAL FORMED AT ROOM TEMPERATURE WITH DIFFERENT VIEWS

Figure 7: Sheet Metal Formed at Room Temperature

The Annealed sheet metal forming at room temperature as shown in figure 7.At room temperature, the crack occurs at a depth of 22mm. This show poor ductility at room temperature.

FLD ANALYSIS

The components are formed and the strain distribution developed after forming is measured. The forming limit diagram is plotted in Figure 8
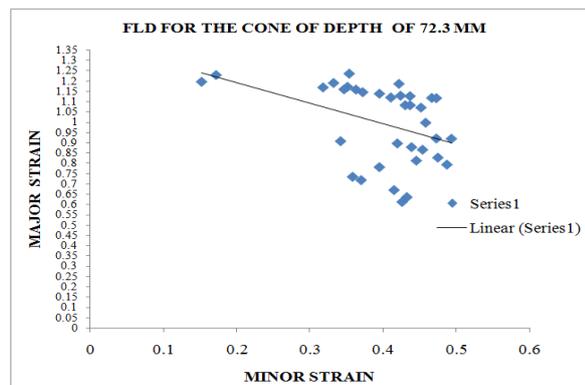
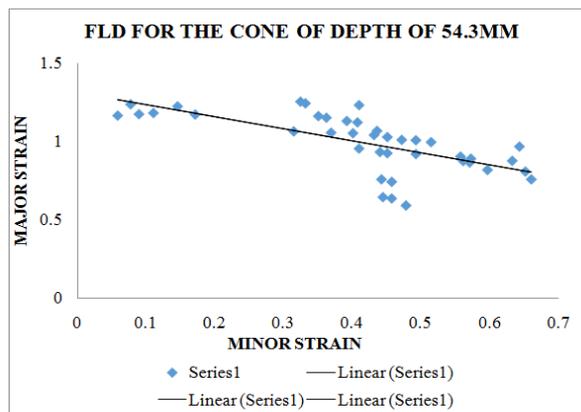**Figure 8: FLD Analysis for the Cone of Depth 72mm at 300ºC**

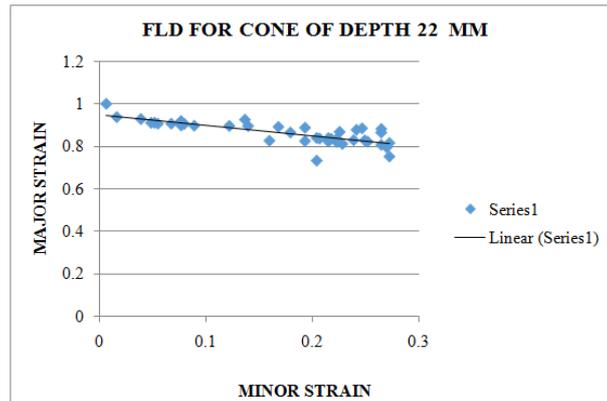**Figure 9: FLD Analysis for the Cone of Depth 54.3mm at 200ºC**

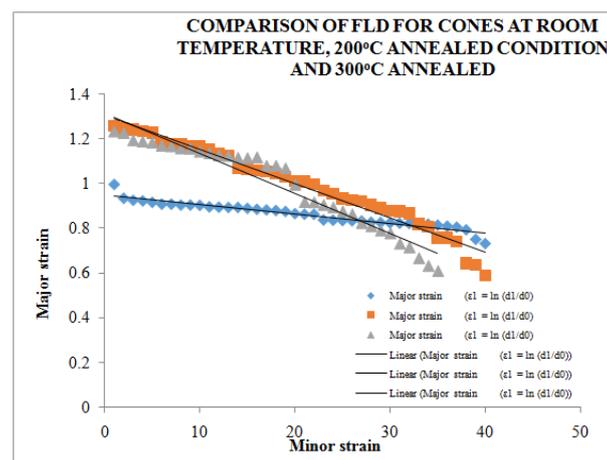**Figure 10: FLD Analysis for the Cone of Depth 22mm at Room Temperature**

Figure 11: Comparison of FLD for Cones at Room Temperature, 200°C Annealed Condition and 300°Cannealed Condition

The components of Forming Limit curve are formed at room temperature and sheets annealed with 200ºc and 300ºC as shown in Figure 9, 10 and 11respectively. Comparison shows that the forming limit curve obtained for sheet annealed at 300ºC shows a better formability. This is mainly due to grain refinement during annealing process

THICKNESS STRIP

The thickness strip values of annealed sheet as shown as figure 12, 13 and 14.From the given type of formed components sheet metal is cut into different type of strips namely at room temperature, at 200ºC sheet annealed and at 300ºC sheets annealed respectively.
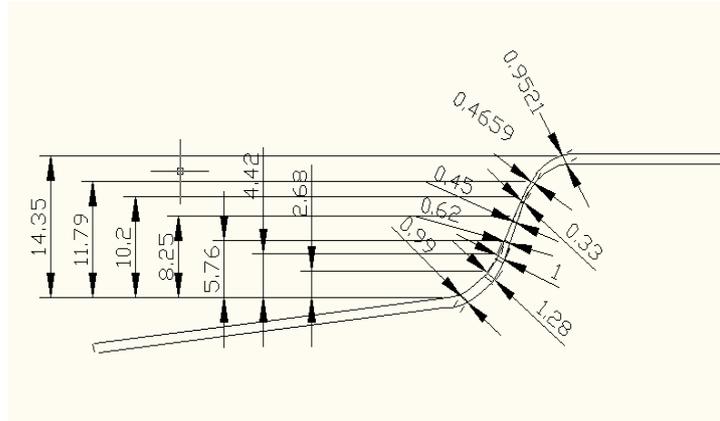
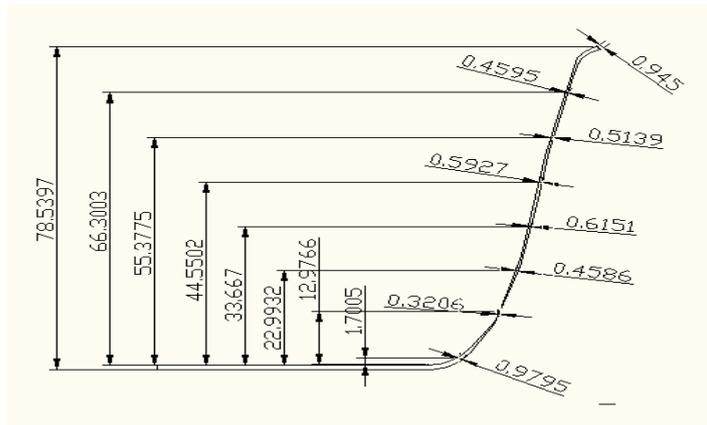**Figure 12: Thickness Strip Measured with Respect to Height at Room Temperature**

Figure 13: Thickness Strip Measured with Respect to Height for Sheet Annealed at 200ºC
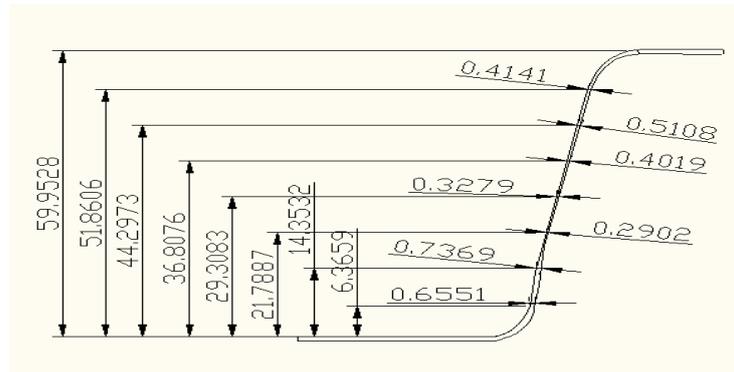

Figure 14: Thickness Strip Measured with Respect to Height for Sheet Annealed at 300ºC

THICKNESS DISTRIBUTION

The comparison of thickness distribution was done and the graphs are plotted for sheets formed at room temperature and sheets annealed at 200ºC and 300ºC as shown as figure 15.

Comparison shows that better thickness distribution is obtained for the sheet annealed at 300ºC which is mainly due to better ductility during annealing process. Figure 15 represents Comparison of Thickness distribution experimentally plotted at 300ºC, 200ºC sheets annealed and room temperature
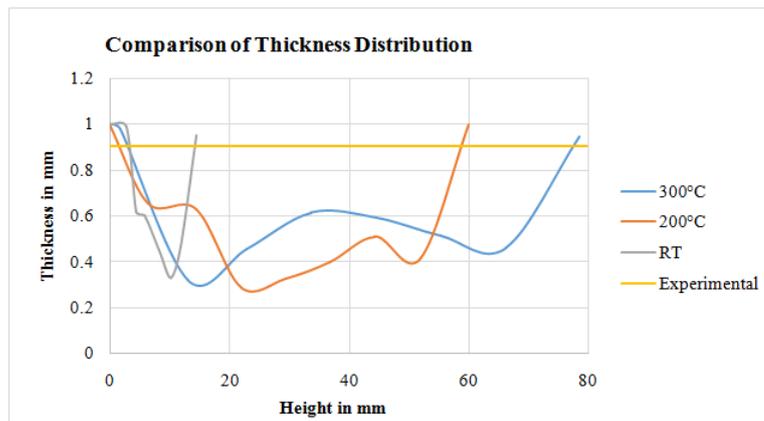
Figure 15: Comparison of Thickness Distribution Experimentally Plotted at 300ºC, 200ºC Sheets Annealed and Room Temperature

CONCLUSIONS

In this study analysis of Formability and thickness distribution were achieved by using single point Incremental forming for various formed components and material thickness namely at room temperature, 200ºC sheets annealed, 300ºC sheet annealed were formed and measured using Video measuring machine and Wire cut EDM. Comparison analysis of FLD and thickness distribution shows that sheets annealed at 300ºC shows a better formability and ductility which is mainly due to grain refinement during annealing process.

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