Prediction of Forming Limit Diagrams of AA5052-H36 at Different Temperatures

G Prashanth*, R Raman Goud1

1,2 Department of Mechanical Engineering, Gokaraju Rangaraju Institute of Engineering and Technology, Hyderabad, India

prasanth2youall@gmail.com1

Abstract—Sheet metal formability, which is the capacity of a material to be framed into a particular shape without disappointment, is an essential property of sheet metals to create complex sheet segments/parts effectively. As of late, Al-Sxxx Alloy materials have been created to fulfill the interest for phenomenal formability and these are appropriate for exceptionally basic framing applications because of their brilliant properties. Formability of late material sheets has been one of the key issues in the car business1 progress to more strain protection vehicle parts. In the present work, the aluminum alloy 5052-H36 material of various clear measurements is extended framed and its formability will be researched at various temperatures. Forming limit diagrams have been dictated by using suitable die-punch assembly. Forming limit diagrams (FLD) will be constructed by measuring the strains at different temperatures. Forming limit diagrams will be developed by estimating endure distinctive temperatures. The temperature assumes an essential part on formability of late material sheets separated from the mechanical properties, so the experimentations would be completed on sheets at room temperature and at high temperatures for dissecting the formability. Validation of experimental results with simulation results using Auto form software.

Keywords—AA5052-H36 Sheets, Metal forming, Stretch forming, Stereo Microscope, Forming Limit Diagrams, Auto form software

1. INTRODUCTION

Formability is a term pertinent to sheet metal shaping. Sheet metal operations, for example, stretching, deep drawing, cup drawing, bending and so forth include broad ductile distortion. Accordingly, the issues of confined deformation called necking and break because of weakening are normal in numerous sheet framing operations. Anisotropy likewise is a worry in sheet metal operations. Formability is the straightforwardness with which a sheet metal could be framed into the required shape without experiencing restricted necking or diminishing or break. The trademark properties of aluminum, high quality solidity to weight proportion, great formability, great consumption protection, and reusing potential make it the perfect contender to supplant heavier materials (steel or copper) in the auto to react to the weight diminishment request inside the car business. Presently, the formable 5000 composites are utilized generally for inward panel applications.

The present headways in aluminum composites to improve formability, surface quality in 5000 alloys (1) Sheet metal is a standout amongst the most critical semi-completed items utilized as a part of the car business, and sheet metal framing innovation is along these lines an essential building discipline inside the region of mechanical designing. Sheet metals are portrayed by a high proportion of surface zone to thickness. In sheet metal forming procedures the assessment of strains by roundabout network examination is acquired through roundabout framework checking, which has been utilized successfully to tackle the issues in metal forming. At the point when sheet metal is framed, its surface is subjected to various stresses. These outcomes are into non-uniform strains to be created in the formed part. Along these lines there will be districts of high strains and in addition low strains, which may prompt wrinkling or cracking of the material.

The grid marking strategy can undoubtedly distinguish the zones of high strain. The sheet is set apart with the framework before forming procedure is done. After the sheet metal is deformed into wanted shape, strain dissemination can be imagined and basic territories of strain will be found by Forming Limit Diagram (FLD). FLD shows the constraining strains that sheet metal can manage over an extensive variety of major to minor strains proportions.

Truth be told, amid the outline phase of any new sheet metal part, FLD is utilized broadly to plan the last segment and tooling shape and to advance the framing procedure parameters. In automobiles the sheet metal is distorted into the coveted and brought into the expected shape to get auto body pressings like hat, guards, entryways, and so forth. In aircraft’s sheet metal is used for making the entire fuselage wings and body. In households applications sheet metal is utilized for influencing numerous parts to like clothes washer body and covers, press tops, timepiece cases, fan edges and packaging, cooking utensils etc.

The items made by sheet-framing forms incorporate a vast assortment of shapes and sizes, running from straightforward twists to twofold ebbs and flows with shallow or profound breaks. Run of the mill illustrations are metal work areas, apparatus bodies, aircraft panels, drink jars, auto bodies, and cracks at certain point. The reasons for
disappointment are parameters identified with forming procedure and kitchen utensils. Much of the time while distorting the sheet metal, the segment cracks at certain point. The reasons for disappointment are parameters identified with forming process [2]. The present work concentrate on as far as possible Formability limit diagrams of AA5052-H36 utilizing the stretch forming technique.

2. FORMING LIMIT DIAGRAM (FLD)

Forming limit diagram (FLD) is utilized to contemplate the conduct of sheet metal. Forming of sheet metal is utilized as a part of car, biomedical and aviation ventures. The formability of the sheet metal can be anticipated by forming limit diagram (FLD) which isolates the forming locale and disappointment district. It is spoken to as far as significant strain and minor strain under plane pressure condition. Enthusiasm for use of aluminum composites has created to deliver light weight vehicles with high fuel economy [3] since aluminum magnesium alloys have great erosion protection and high formability AA5052-H36 have been exceptionally used in aviation and car ventures. The regular forming limit diagram (FLD) is depicted as a plot of real strain versus minor strain. Notwithstanding, FLD is subject to forming history and strain way.

2.1 Aluminium Alloy 5052-H36

Aluminum alloy 5052-H36 belongs to the family of 5xxx series which has magnesium as the major alloying element. Aluminum composite 5052-H36 is a non-warm treatable combination and solidified for higher quality by cold work. Composite 5052 have amazing attributes with a high exhaustion quality it is utilized for structures which are liable to exorbitant vibrations. Magnesium is a standout amongst the best and broadly utilized alloying components for aluminum, and is the primary component in the 5XXX arrangement compounds. These combinations regularly contain little increments of progress components, for example, chromium or manganese, and less often zirconium to control the grain or sub grain structure and iron and silicon deasements that are generally present as intermetallic particles (4). The protection of 5052-H36 to consumption in marine airs is astounding, surpassing that of 5005 and is in this manner generally utilized as a part of vessels, marine segments, fuel and oil tubing. The protection of 5052-H36 to consumption in marine climates is astounding, surpassing that of 5005 and is in this manner ordinarily utilized as a part of water crafts, marine segments, fuel and oil tubing. AA5052-H36 is promptly machined by ordinary techniques.

2.2 Advantages of AA5052-H36

Low density, High strength to weight ratio, Wear resistance, High thermal conductivity, Finishability, High electrical conductivity, Good weldability and resistance to corrosion etc.

2.3 Applications of AA5052-H36

Automotive parts, Aircraft wing skin panels, Railroad cars, Marine applications, Architectural uses, Highway signs, Hospital and medical equipment, Agricultural applications, Utilizations incorporate weight vessels, fan cutting edges, tanks, electronic boards, electronic body.

The chemical composition of AA5052-H36 is as shown in the Table 1.

<table>
<thead>
<tr>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Mn</th>
<th>Mg</th>
<th>Cr</th>
<th>Zn</th>
<th>Ti</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.06</td>
<td>0.24</td>
<td>0.05</td>
<td>0.011</td>
<td>2.56</td>
<td>0.2</td>
<td>0.10</td>
<td>0.007</td>
<td>Remains</td>
</tr>
</tbody>
</table>

3. EXPERIMENTATION

In this procedure the aluminum sheet metal is set apart with line examples of circles utilizing laser etching strategy. Sheet metal is clamped at edges between the upper die and lower die. This sheet metal is stretched over a die. The stretching operations directed at three distinct temperatures (RT, 100°C, 200°C). At the point when sheet metal is formed, it is subjected to different stresses. These stresses create non-uniform strains and may prompt wrinkling or cracking in the shaped part. The forming procedure causes the line patterns to disfigure by a sum which relies upon the neighborhood twisting experienced by the sheet metal. After the sheet metal is shaped, the circles will turn into an oval unless disfigurement is unadulterated biaxial stretching.

The longest measurement of the circle is the significant hub and the measurement opposite to the real hub is called as the minor pivot. Estimation of major and minor hub of extended is circles (oval) by utilizing Art measure microscope. By the utilizing major and minor pivot esteems figuring the estimations of real strain and minor strains and plotting FLD of AA5052-H36. The experimental set-up was as shown in Fig. 2.

Fig. 1 Circular grids on AA5052-H36 sheet
4. RESULTS

4.1 Experimental Results

A total of 75 experiments were performed and the results were plotted in Fig. 6, Fig. 7 and Fig. 8.

From the above Fig. 6, FLC can be spoken to as a curve of the major and minor strains. The right branch of FLC, which is substantial for positive major and minor strains. The left branch of FLC is pertinent for positive major and negative minor strains. The FLD is isolated into locales by a curve, as far as possible curve (FLC) at room temperature. The district beneath the FLC compares to safe strain states though that over the FLC speaks to failure strain states.

The stretching ratio of AA5052-H36 increased with the increasing die temperature. It can be seen from the Fig. 6-8. Forming limit diagrams that forming temperature impacts forming utmost curves of AA5052-H36. Identified that at optimum forming temperature, the FLC curves are shifted up.
significantly along the major strain axis. By increasing the forming temperature the formability is increasing.

4.2 Simulation Results

i) Forming Limit Diagram of 110 x 110 mm work piece

![Forming Limit Diagram of 110 x 110 mm work piece](image1)

Fig. 9 Forming Limit Diagram of 110 x 110 work piece

ii) Formability of 110 x 1100 work piece

![Formability of 110 x 1100 work piece](image2)

Fig. 10 Formability of 110 x 110 work piece

iii) Forming Limit Diagram of 110 x 70 work piece

![Forming Limit Diagram of 110 x 70 work piece](image3)

Fig. 11 Forming Limit Diagram of 110 x 70 work piece

iv) Formability of 110 x 70 work piece

![Formability of 110 x 70 work piece](image4)

Fig. 12 Formability of 110 x 70 work piece

v) Forming Limit Diagram of 110 x 30 work piece

![Forming Limit Diagram of 110 x 30 work piece](image5)

Fig. 13 Forming Limit Diagram of 110x30 work piece

vi) Formability of 110 x 30 work piece

![Formability of 110 x 30 work piece](image6)

Fig. 14 Formability of 110x30 work piece

vii) Forming Limit Diagram of 110 x 20 work piece

![Forming Limit Diagram of 110 x 20 work piece](image7)

Fig. 15 Forming Limit Diagram of 110 x 20 work piece
viii) Formability of 110 x 20 work piece

Forming Limit Diagrams speak to as far as possible in the organize arrangement of major and minor strains as appeared in the Figs. 9, 11, 13, 15. Over the nearby necking zone, the red zone shows the crack district of typical shaping conditions as far as major and minor strains. The zone between the crack and as far as possible bend is called as the scope of nearby necking. At certain level of compressive stresses a neighborhood precariousness of sheet can likewise happen as wrinkling. As far as possible forming limit diagram with these point of confinement bends and zones is appeared in the Fig. 11. Beneath the neighborhood necking zone, the green zone demonstrates the protected locale of ordinary shaping conditions as far as major and minor strains.

5. DISCUSSION

In this paper, the formability of AA5052-H36 was investigated at elevated temperatures. The formability of any materials is a quite complex phenomenon influenced by several parameters, besides the material grade like strain path, deformation history, strain-rate effects and failure mode, etc. However, within a limited the parameters range the focus was given to construct the formability limit diagrams at room and warm temperatures. In this paper, we mainly analyzed the Formability Limit Diagrams (FLD) of AA5052-H36. Using the FLD as a formability issue may be explained by the fact that all the numerical modeling programs that are more and more widely used not only in the academic research but in the everyday industrial practice as well, are based among others on the Formability Limit Diagrams. By increasing the forming temperature the formability is increasing. Studying the effect of the temperature on the formability of aluminium alloys, we found that for the investigated aluminium alloy an optimum forming temperature exists where the formability has a maximum value. To find these optimum forming temperatures for the investigated aluminium alloys, we performed formability investigations from room temperature up to the temperature range 200°C. Identified that at the optimum forming temperature, the FLC curves are shifted up significantly along the major strain axis.

6. CONCLUSION

In stretch forming, the AA5052-H36 sheets exhibited higher limit strains at 200°C than the 100°C and RT sheets. As the temperature increases the level FLD is increases up to 200°C, identified that at the forming temperature 100°C, 200°C, the FLC curves are shifted up significantly along the major strain axis. Auto form post processor was also used to extract forming limit diagrams in stretch forming for all the specimens of blank sizes ranging from 110 mm X 20 mm to 110 mm X 110 mm at all the temperatures and compared with experimental results. It is found that extracted results good agreement with the experimental results. After experimentation and theoretical analysis on AA5052-H36 from stretch forming, it can be concluded that the working temperature of AA5052-H36 material is between 150C to 200C for producing quality products and smooth operations for AA5052-H36 materials. Forming limit diagram (FLD) is utilized to consider the conduct of sheet metal. During the outline phase of any new sheet metal segment, FLD is utilized broadly to plan the last part, tooling shape and to enhance the framing procedure.

REFERENCES


