A STUDY ON DRAWING BIMETALLIC BRAZED SHEET PARTS

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Abstract: This paper presents the study of the process of assembling metal sheets by using brazing of joints through cold welding. The processing technology is a normal drawing procedure. This paper explains schematically the drawing process. Aluminium and copper zinc alloys were used in order to observe the increase of the age-hardening response in brazed alloys. Of great importance is the filler material and especially the way in which it diffuses in the base materials. In this study, the material used was correctly selected, the bimetallic sheets were brazed properly and the behavior of the assembled sheets was according to standards.

Keywords: sheet, bimetallic, brazed, drawing, deformation

1. INTRODUCTION

The drawing process consists in using a combination of deep drawing and stretch forming, in order to control how the material flows into the blank holder. The drawing methods are varied, but they can be applied individually or in combinations: the blank form, using lubricants, crimping clamps, influencing the frictional forces. Generally, using a more complex surface leads to using higher frictional forces [1, 2].

An accepted method is to apply to the bimetallic brazed sheets a non-uniform layer of lubricant; the quantity of the lubricant and whether there is a need for additional lubrication prior to drawing depends on the processed area. Crimping clamps prevents the material from flowing into unwanted directions, whereas the flow depends on the shape and size of the processed part [3].

Generally, in the drawing process, it is possible to reduce the blank holder force by increasing the pressure on the punch. By regulating the pressure on the blank holder, it is possible to control the flow of material under it; this effect is obtained by varying the distance between the blank holder and the drawing ring [4].

In this paper, we have studied the way in which bimetallic brazed parts may be drawn through cold welding and a normal drawing procedure. The materials used in the tests were thin sheets of 1 mm thickness (AA6016-T4 and CuZn37). Our purpose was to study the increase of the age-hardening response in brazed alloys.

2. THE PROCEDURE OF DRAWING PARTS

This paper aims at determining the deformation capacity by drawing brazed sheets of different materials, with thicknesses up to 1 mm and the diameter of 100 mm (Figure 1). Different shapes and sizes of parts may be used. In our study, we have used the simple cylindrical shape with a small height, leading to complex asymmetric shapes as a result of the drawing process.
Sheets deformability expresses the sheets’ deformation ability, by taking other shapes without the occurrence of defects in the final piece. The deformability dimension represents the degree to which a material in its initial state may be deformed, without the occurrence of cracks in the final state of the material.

The schematic diagram of drawing applications is shown in Figure 2. Brazed plates are cut to a diameter of 100 mm and fixed in the blank holder with the drawing ring. Then, a force F is applied by the drawing punch on the blank brazed sheet, until it reaches its final form.

Drawing sheet tools consist of three main elements: the drawing punch (1) and the blank holder (3) which limits the outer contour of the piece (4), the retaining/drawing ring (2) which presses the metal onto the blank holder, to prevent wrinkling and to control its flow into the opening.

The drawing punch delimits the inner contour of the part and applies the necessary force for sheet deformation (drawing force). The deformation method depends on how the retaining ring works. In process of deep drawing, the metal sheet is blocked between the blank holder and the retaining ring.

One element from the material was used in order to analyze the drawing process (Figure 3). We may observe that the material located on the die radius and positioned in a transverse direction at the beginning of the pressing operation, is shortened due to compressive stresses $s_1$, whereas the radial direction of tensile stress $s_2$ lengthens.

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Fig. 1. Drawing bimetallic parts.

Fig. 2. Schematic drawing procedure.

Fig. 3. Distribution of stresses and deformations.
As the drawing punch advances, its volume leads to an inside movement (towards the inner edge of the blank holder) of the material from the flange. Thus, the compression stress $\sigma_1$ decreases and the stretching stress $\sigma_2$ increases, giving rise to a significant radial deformation.

### 3. BRAZING MATERIALS

We have used two different materials for the study of brazing bimetallic sheet parts: AA6016-T4 and CuZn37, and alloy 4043 as filler metal for brazing. The chemical compositions of these materials are presented in Tables 1 ÷ 3.

**Table 1. Chemical composition (%) of aluminium alloy, type AA6016-T4 [5].**

<table>
<thead>
<tr>
<th>Element</th>
<th>Mg</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Cr</th>
<th>Ti</th>
<th>Mn</th>
<th>Zn</th>
<th>Others</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>0.25-0.6</td>
<td>1.0-1.5</td>
<td>0.5</td>
<td>0.2</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td>0.20</td>
<td>$\leq$0.15</td>
<td>Balanced</td>
</tr>
</tbody>
</table>

**Table 2. Chemical composition (%) of copper-zinc alloy, type CuZn37 [6].**

<table>
<thead>
<tr>
<th>Element</th>
<th>Cu</th>
<th>Ni</th>
<th>Cu</th>
<th>Fe</th>
<th>Sn</th>
<th>Al</th>
<th>Others</th>
<th>Zn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>62-65</td>
<td>0.25</td>
<td>$\leq$1</td>
<td>$\leq$0.1</td>
<td>$\leq$0.1</td>
<td>0.05</td>
<td>$\leq$0.1</td>
<td>Balanced</td>
</tr>
</tbody>
</table>

Alloy 4043 is one of the oldest and most widely used brazing metal fillers. The silicon additions result in improved fluidity (wetting action), which makes the alloy a preferred choice by welders. The 4043 alloy is less sensitive to weld cracking and produces brighter, almost smut free welds.

**Table 3. Chemical composition (%) of 4043 alloy [5].**

<table>
<thead>
<tr>
<th>Element</th>
<th>Si</th>
<th>Fe</th>
<th>Cu</th>
<th>Fe</th>
<th>Mg</th>
<th>Zn</th>
<th>Ti</th>
<th>Be</th>
<th>Others</th>
<th>Al</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>4.5-6</td>
<td>0.8</td>
<td>0.3</td>
<td>$\leq$0.1</td>
<td>0.05</td>
<td>0.1</td>
<td>0.2</td>
<td>0.0003</td>
<td>$\leq$0.1</td>
<td>Balanced</td>
</tr>
</tbody>
</table>

### 4. DISCUSSIONS

By analyzing the volume element in relation to the edge of the blankholder, we have observed the fact that it is also subjected to a bending deformation. The approximation of the volume element on the centre of the blankholder leads to the identification of a main axial stretching. If we consider a polar reference system, the tensions $\sigma_1$ and $\sigma_2$ will be the main normal stresses. Displacement of the volume element during the drawing application is the result of applying the drawing action to all the points in the solid [7]:

$$\sigma_i = [(\sigma_2 + \sigma_j) e^{\mu t} + \sigma_j] \sin \alpha$$

where $\sigma_i$ is the radial tension derived from the friction between the sheet and the blankholder; $\sigma_r$ is the radial tension derived from the material bending at the contact with the drawing plate.

The clearance between the active elements during drawing is higher than the thickness g (or the piece may be a cone), an aspect which is taken into consideration through angle $\alpha$; for the sake of simplicity, we shall consider $j \geq g$ and therefore, $\alpha = \pi/2$.

To determine the radial pressure $\sigma_2$, considering the stress of the element like a plane state of stresses, the equation of its tension equilibrium will be [8]:

$$r \frac{d\sigma_2}{dr} + \sigma_2 - \sigma_i = 0$$

The plasticity condition is [8]:

$$\sigma_2 - \sigma_i = \beta R_{def}$$

where $R_{def}$ is the deformability resistance; $\beta = 1.1$, in general.
From equations (2) and (3), there results:

\[ r \frac{d \sigma_z}{dr} + \beta R_{def} = 0 \]  

(4)

After the integration, there results:

\[ \sigma_z = R_{def} \ln \frac{R}{r} \]  

(5)

The brazing temperature and the brazing time influence the way in which the base materials are diffused with the filler material, influencing the homogeneity, composition and microstructure of the brazed joint. Figure 4 shows the increase of the age-hardening response of base materials AA6016-T4 and CuZn37, with the brazing alloy 4043 used as filler metal.

In these relationships \( R_{def} \) is the expression of the real tension deformation, which determines the deformation degree in that area by the hardening characteristic of the material.

![Graph showing the increase of the age-hardening response of brazing alloys.](image)

**Fig. 4. Increase of the age-hardening response of brazing alloys.**

The materials used in the test, in the form of thin sheets of 1 mm thickness (AA6016-T4 and CuZn37), were polished and cleaned with abrasive grain-size silicon paper SiC 1200, then placed in a bath of acetone and then subjected to the brazing procedure. The test was performed using a conventional brazing procedure at temperatures of approximately 500°C, with duration of 0-1100 seconds for brazing bimetallic sheet parts.

From the presented graph (regarding the age-hardening response of brazing alloys), we may conclude that these materials can be brazed properly and subsequently drawn well. The curve of the graph for the 4043 alloy in the brazing zone is similar to the shape of the curve for the base material AA6016-T4. The graph for the CuZn37 alloy registers a constant curve around the value of 100 MPa of yielded strength.

**CONCLUSIONS**

In this paper, we have studied the drawing of bimetallic brazed sheet parts using two different base materials: AA6016-T4, CuZn37, as well as a brazing filler metal (the 4043 alloy).

The brazed parts, with a small thickness and the dimensions mentioned in this work behave very well during the brazing process, as can be seen from the graph. As can be seen from the chart, the effect of the brazing time on the joint shear strength and thickness leads to increased age-hardening response of the brazing alloys.
Making a correct assembly by using brazing temperature and time properly may be described as resulting into good homogeneity, composition and microstructure of the final work piece.

The graph shows that the choice of the filler material was appropriate. The graphic distribution of the increase of the age-hardening response of brazing alloys is represented by well-defined curves. These graphic values of the age-hardening response were found, with narrow ranges, to have a correct distribution of the curves for all the three different materials. Improper choice of materials results, after the brazing process, in an improperly brazed joint, which may represent a difficult area for the drawing process. Particularly in this brazed joint, there may occur manufacturing imperfections.

From this analysis, we may conclude that the base material is not the most important element in the brazing operation. Of great importance is the filler material and especially the way in which it diffuses with the base materials. There are cases of successful and durable joints even with composite materials used as base materials, which display a behavior similar to that of the commonly brazed sheet parts based on aluminium and zinc alloys.

Studying papers on the production of brazed aluminium parts reveals the fact the process of drawing aluminium sheet parts is used in manufacturing auto components. The process of manufacturing car body components or carcasses involves the use of metal sheets processes through a mixture of drawing and shaping by stretching.

ACKNOWLEDGMENT

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REFERENCES