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IN DEEP DRAWING PROCESS, EXPERIMENTALLY INVESTIGATION OF THE CUP HEIGHT, WRINKLING AND TEARING LIMIT RELATED TO THE BLANK HOLDING

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Abstract

In this study, experimental studies, which directed to prevent the wrinkling and the tearing of the AA 1050 aluminum cups during in deep drawing process, are investigated. The aluminum blank samples, which have 2 mm thickness and 150 mm diameter, are formed under differant blank-holder pressures (BHP) in a deep drawing mechanism. The starting points of the wrinkling and the tearing are investigated on the drawn cups. The height of each cup is measured as well. While it is observed the wrinkling under the 0.65 MPa blank holding, it is observed the tearing over the 10.5 MPa blank holding, too. Between these two limits, no problem is observed in point of wrinkling or tearing. An increase in the cup height is seen according to increase of the blank holding. The conclusion, which obtained in this study, are compared with the previous studies.

Key words: Deep drawing, wrinkling, tearing, blank-holder pressure

1. Introduction

Deep drawing is a sheet metal forming process in which a sheet metal blank is radially drawn into a forming die by the mechanical action of a punch[1,2]. It is thus a shape transformation process with material retention. The flange region (sheet metal in the die shoulder area) experiences a radial drawing stress and a tangential compressive stress due to the material retention property. These compressive stresses (hoop stresses) result in flange wrinkles (wrinkles of the first order). Wrinkles can be prevented by using a blank-holder, the function of which is to facilitate controlled material flow into the die radius.

The total drawing load consists of the ideal forming load and an additional component to compensate for friction in the contacting areas of the flange region and bending forces at the die radius. The forming load is transferred from the punch radius through the drawn part wall into the deformation region (sheet metal flange). Due to tensile forces acting in the part wall, wall thinning is prominent and results in an uneven part wall thickness. It can be observed that the part wall thickness is lowest at the point where the part wall loses contact with the punch, i.e. at the punch radius. The thinnest part thickness determines the maximum stress that can be transferred to the deformation zone. Due to material volume constancy, the flange thickens and results in blank-holder contact at the outer boundary rather than on the entire surface. The maximum stress that can be safely transferred from the punch to the blank sets a limit on the maximum blank size (initial blank diameter in the case of rotationally symmetrical blanks). An indicator of material formability is the limiting drawing ratio (LDR), defined as the ratio of the maximum blank diameter that can be safely drawn into a cup without flange to the punch diameter. Determination of the LDR for complex components is difficult and hence the part is inspected for critical areas for which an approximation is possible[3-5].

Commercial applications of this metal shaping process often involve complex geometries with straight sides and radii. In such a case, the term stamping is used in order to distinguish between the deep drawing (radial tension-tangential compression) and stretch-and-bend (along the straight sides) components.

Industrial uses of deep drawing processes include automotive body and structural parts, aircraft components, utensils and white goods. Complex parts are normally formed using progressive dies in a single forming press or by using a press line

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1.1 Purpose of the Study

In manufacturing industry, fixed blank holding is widely used during deep drawing because easy design and low cost. The selection of a suitable blank holding, depend on material type and geometric properties, is affecting the vessel yield about wrinkle, tear, cup height and earing. In order to have deeper vessel, the preference of the heigh blank force may cause tearings. In order to have more smooth vessel, the preference of low blank force may cause wrinkling as well[6]. The blank forces, between these two regions, are acceptable for non-problem vessel, but determination of the best blank-holder forces (BHF) is the best essential in terms of minimum energy consumption. To obtain these blank-holder forces is the main purpose of the study.

1.2 The Importance of the Study and the Place of Literature

Researchers[6-7] have realized that some parameters, which are controlled during deep drawing, have provided significant improvements in the yield of vessel. So, in this way they have conducted a versatile research. Most basically, as a result of forming, without blank-holder or low blank holding, corrugations occure on the surface of vessel as shown in Figure 1.

(a) (b)

Figure 1: Wrinkled vessel samples. a) without blank-holder b) low blank holding

Tears occur because the vessels, which is drawn above a certain blank-holding value, can not easily slip between die and blank-holder, so drawing process can not be achieved as shown in Figure 2.

Figure 2: Ruptured vessel image

For the drawing sheet, there is a drawing region expressed by blank-holder forces. These forces are between minumum BHF, used for forming without earing, and maximum BHF, used for forming without tearing. Providing stay within this region, the cup height increase when BHF increase. Meanwhile, the forming energy increase. To obtain maximum cup height, with the minumum forming energy, is the target of this experiment. In this regard, this study has a great importance.

2. Experimental Study

In order to perform drawing tests an experimental apparatus has set up as shown in Figure 3. For this study, a 60-ton hydraulic press is equipped with deep drawing dies. Four of the guide bar is used in order that the blank-holder apply uniform pressure on the sheet. In addition, a pair of hydraulic cylinders, which have the same characteristics, have used. Directional control of the cylinders is provided by a three-position four-way valve. In addition, in order to limit the amount of blank-holder, one pressure control valve has been used

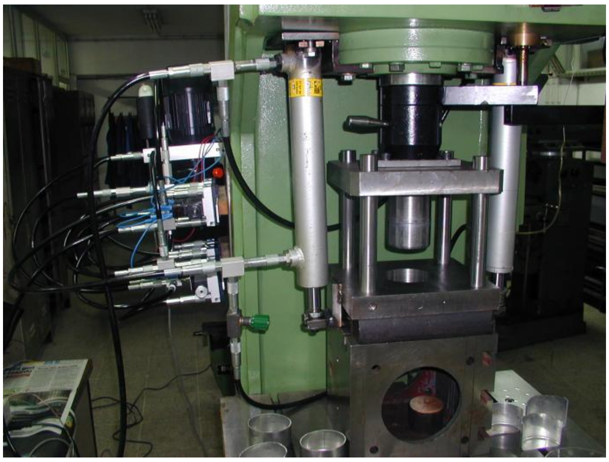

Figure 3: Test equipment for the photo image

150 mm diameter cylindrical sheets, chosen as model, have been prepared in a way that are cut. Drawing exxperiments have carried out by changing the BHF from small to large. At the beginning of drawing, the sheet and the mold surface is lubricated with sledge oil. three drawings are made for each BHF. Average height of all three vessels were calculated. In additional, it is observed that, whether the cups have wrinkling or tearing symptoms or no

Figure 4: Wrinkled vessels because of the low BHF

The vessels which are drawn without being wrinkled and ruptured due to high blank holding are displayed in Figure 5. The values, written on the surface of vessels, are expressed the amount of blank-holder pressure.

Figure 5: The properly formed vessels and ruptured vessels because of the heigh BHP

3. Results And Discussion

Depending on the BHF change, height graph of the measured vessels has shown in Figure 6. Some folding tendencies are observed on the vessels which are drawn under 0-0.4 MPa blank holding. But, due to lack of the cavity, instead of folding some wrinklings and fluctuations have been observed. Earing occurred abnormally.

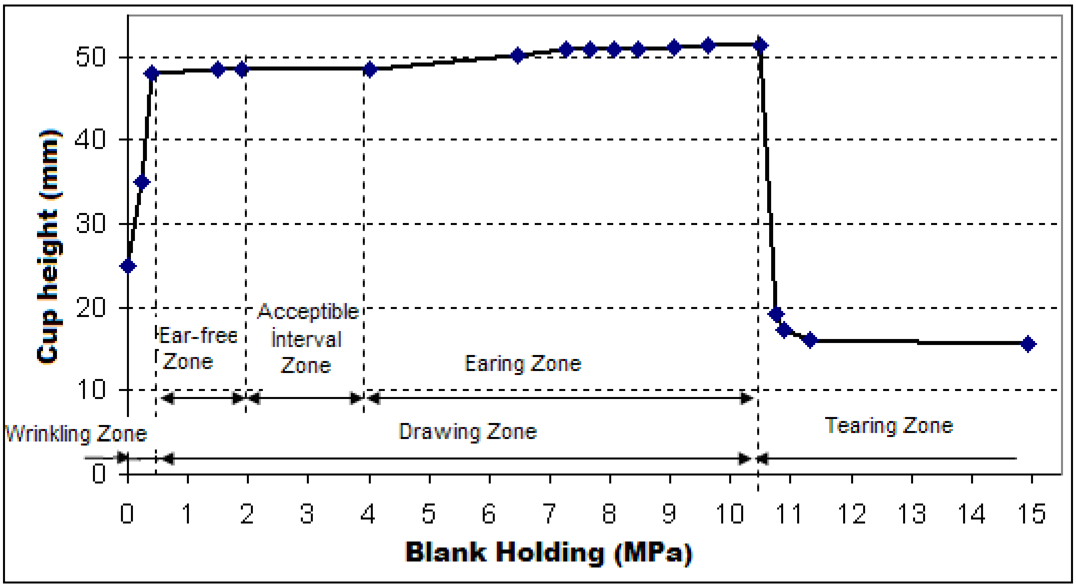

Figure 6: The experimentally obtained tear and wrinkle formation, due to blank holding

For the values of blank holding between 0.4-10.5 MPa, any wrinkling or tearing hasn't been seen. This region is named as "drawing zone". But when the cups, obtained in this zone, is examined most regular cup mouth has been obtained between 2-4 MPa. This zone is named as "acceptible interval zone". Although, partial earing occurs on the vessels which are drawn under 4-10.5 MPa blank holding, it is shown deeper cup height. After 10.5 MPa the cups has been ruptured and drawing operation is not able to be achieved.

A similar study was conducted in an article named "How to Draw Round Cups Deeper". In the study, for maximum cup height, but without wrinkling and without trearing, was investigated. As a result of the study, general-purpose graphics was obtained as shown in Figure 7. The form, direction and position of the curves, which was obtained in the study, shows a great similarity that we examine

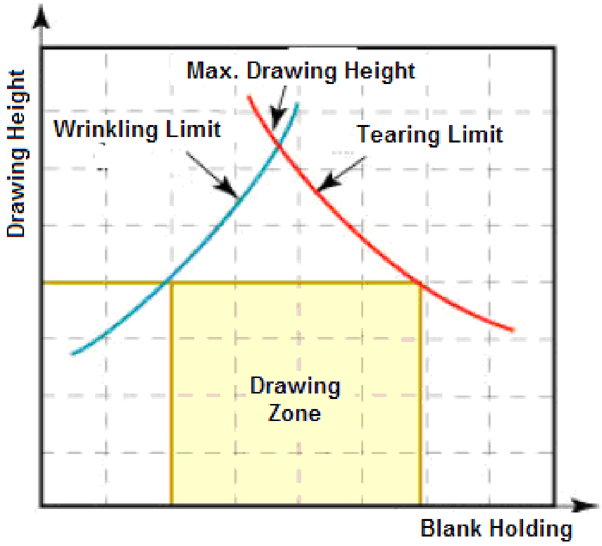

Figure 7: Drawing zone between the wrinkling and tearing [6]

Also, in a study shown in Figure 8, an experimental and numerical studies was conducted for determining the depth of rupture related to blank holding. In this study, rupture depth of A5052 aluminum alloy material was investigated. In which BHF and which depth to be ruptured was important.

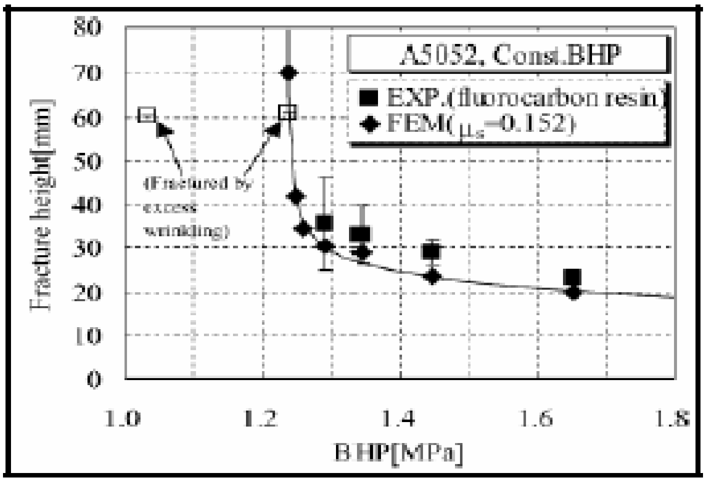

Figure 8: BHP effect on rupture depth [7]

A great similarities is seen between the tearing curves (in this study and our study).

4. Conclusion

In our study, Al 1050 aluminium alloy has been conducted in view of BHP, tearing limit, wrinkling limit, earing and cup height. The relationship amoung these parameters have been investigated. These parameters include in literature widely. Our study has been compared with the similar studies. That concrete proposals can be said:

- If the purpose is to obtain deeper cup, so the blank-holder pressure should be close to 10.5 MPa
- If the purpose is to have more smooth cup mouth, so the blank-holder pressure should be between 2-4 MPa
- Under 0.65 MPa and over 10.5 MPa for blank holding, the drawing operations are failure

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