Optimization of Process Parameters For Warm Deep Drawing of Aluminium Alloy 1100

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Abstract *:* - Deep drawing involves the conversion of flat thin sheet metal blanks into parts of the desired shape. Although applications of deep drawing processes at different elevated temperatures have not yet been used effectively, it is clear that this process is going to be a very dominant manufacturing application of quality cups produced by this process in this future.

Al is primarily used in domestic and also in nuclear applications. Presently high numbers of experiments are conducted to study the formability of this material and heat the specimen to the different temperature of 200,250,300.In the present investigation, the load and displacement, temperature relationship are given and found that the load increases as the depth increased, and after reaching the maximum, load gradually decreases in case of the successful cups, but in case of failure, the load decreases suddenly change.

***Keywords* -** Aluminium alloy 1100, Formability, Deep drawing, Temperature, load, Displacement.

I. INTRODUCTION

Sheet metal forming involves the conversion of flat-thin sheet metal blanks into parts of the desired shape. Sheet metal forming processes like deep drawing, bending, etc. are widely used to produce a large number of simple to complex components in automobile and aircraft industries. In the deep drawing which is also called cup drawing or radial drawing, a thin flat sheet is formed into the cup-shaped component by pressing the centre portion of the sheet into die to open using a punch to draw the metal into the desired shape.

The blank can be circular or rectangular or some complex shape. Blank holder is loaded by a blank holder force, which is necessary to prevent wrinkle and to control the material flow rate into the die cavity. The punch is pushed into the die cavity simultaneously transferring the particular shape of the punch and dies in the blank holder-die region and is subjected to compressive and tensile stresses on that portion. When very high blank holding force is applied, the deep drawing process becomes the stretching process. Schematic diagram of deep drawing operation is shown in Fig.1

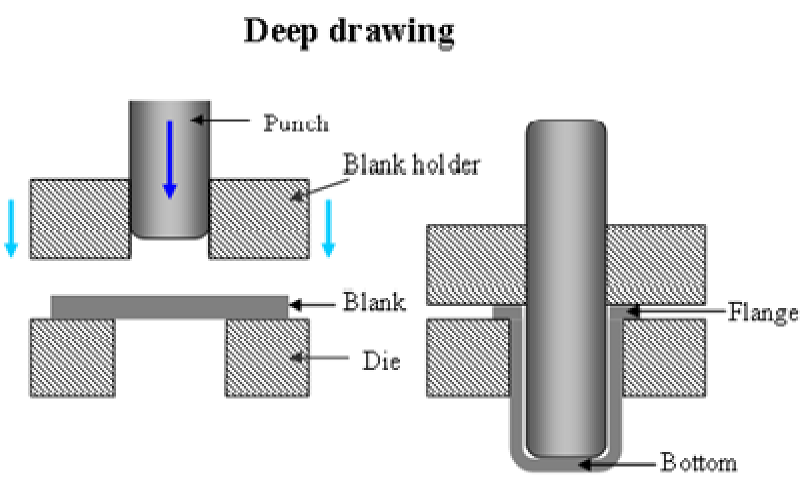


Fig.1. Schematic diagram of deep drawing process

In deep drawing, the majority of the deformation occurs in a flange of the cup. The metal is subjected to three types of stresses. This stress influences thickness variation in the drawn cup. The primary deformation zone is bending around the die radius, while third deformation zone is uni-axial stretching in the cup wall (plane strain) which causes thinning of metal. In the cup bottom which is subjected to bi-axial tension, the thickness is more or less equal to the initial sheet thickness as shown in the Fig.2.

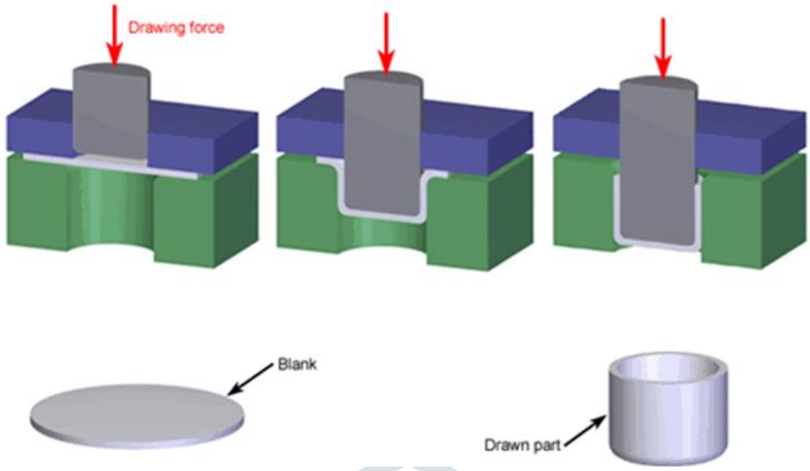


Fig.2. Deep drawing operation

The Draw Ratio of a deep drawing activity is calculated as the ratio of blank diameter to the cup diameter. For achieving a very high draw ratio, redrawing and ironing or annealing between successive drawings is performed. The maximum draw ratio can that can be obtained under perfect deep drawing condition is called limiting drawing ratio the LDR and is considered as a good measure of draw ability of the material.

II. LITERATURE SURVEY

It had been realized that the use of lightweight structures for aerospace, automotive and other industrial usage are vividly increased for economising the fuel consumption and minimizing the emission of hazardous gases into the atmosphere. Indeed, among the light weight metals, magnesium has gained much attention in recent years due to its light weight, i.e. 36 % lighter (by unit volume) than aluminium and 78 % lighter than iron. When magnesium is properly alloyed, attains the highest strength-to-weight ratio among all the structural metals. In addition, it is having superior qualities like easy of recycling, better thermal properties, better manufacturability and close dimensional stability. As magnesium is having superior formability at higher temperatures is thus necessary to activate deformation mechanism at higher temperatures during forming process. There are many significant forming parameters that are influencing of deep drawing process and they are punch nose radius, die shoulder radius, blank holder force, coefficient of friction, strain hardening exponent, strain rate sensitivity index, forming temperature and clearance between punch and die. Among these, forming temperature plays a vital role in warm forming process and needs to study the formability by means of limiting drawing ratio which is one of the formability assessment methods for deep drawing process[1].

The use of light weight structures in aerospace, automotive and other industrial applications have been dramatically increased for fuel economy and in reduction of emission of hazardous exhaust gases into the atmosphere. Among the light weight materials, aluminium has been gained much importance for the last couple of decades and continues in the future. As it is extensively used in the present automobile environment for production of cup shaped articles like fuel tanks, involves large number of forming parameters influencing formability and Limiting Drawing Ratio (LDR) as well as LDR is also considered as bench mark test for measuring the formability of sheet material, especially in deep drawing should be required to assess it effortlessly. An experimental and simulation tests have been conducted in determination of LDR by economical way where it requires only three blanks: two of the undersize and one of the oversized blank [2].

III. MATERIAL SELECTION AND DEEP DRAWING PROCESS

Aluminium 1100 **:** Aluminium is the most usual and familiar types of stainless steel. They are easily identified as non-magnetic. They are extremely weldable and formable and can be successfully used from cryogenic temperatures to the red-hot temperatures of furnaces and jet engines. They contain between about 0.05% to 0.2% copper, and they can also contain silicon, zinc and manganese, both of which contribute to their significant corrosion resistance. Were it not for the cost of the nickel that helps stabilize their austenitic structure; these alloys would be used even more widely. 1100 Aluminium has excellent finishing capabilities, which is under investigation, is listed in the table below.

Chemical composition of Aluminium 1100

Si + Fe	Cu	Mn	Zn	Al
0.95	0.05-0.20	0.05	0.10	99

Deep Drawing Process **:**

The experiments were carried out on experimental test rig which is specially designed for deep drawing operations at 200,250,300ºcentigrade temperatures. Aluminium blanks of 0.9mm thickness were cut into circular shape using EDM wire cutting, and deep drawing was carried out on blank diameters ranging from 100mm to 150mm.Hydraulic press of 20 Tons capacity was used for deep drawing on ASS-316 blanks. Since there is the tendency in the material to change dimensions at higher temperatures, Inconel-600 is used in designing and producing die, punch and blank holder. High-density electrical heaters eight in number are inserted into die holder for heating of empty and die holder. Electrical setup helps to heat specimen plates up to 300º C. Blank is fixed rigidly between the upper and lower dies. Punch is then ramped down to deep draw the blank into a cup. Different temperatures can be achieved for load management and qualitatively bring cups.

Fig.3 Ton hydraulic press test rig

Cup of Diameter 100 mm

Cup of diameter 110 mm

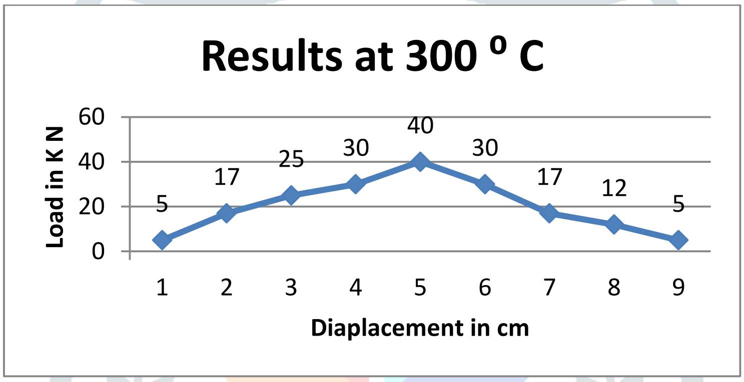
Cup of diameter 120 mm

The above three images show us the effects of annealing on the drawing material, the top plate was not subjected to any heat and was drawn under the room temperature whereas the bottom cup was subjected to heat treatment in a heating furnace, cooled down to room temperature and then drawn.

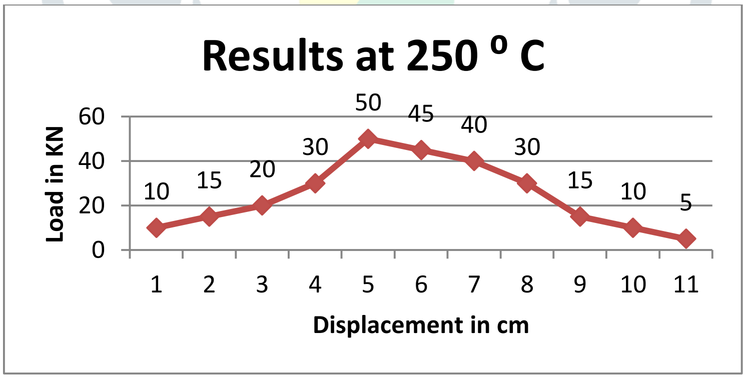
IV. RESULTS

Different types of temperature performed deep drawing process by using the high-density electrical heaters for heating of blank at 200,250,300, temperature forming limit diagram of the cup graph between load, displacement and temperature. The punch capacity increases as the movement of the punch increases, and after reaching the maximum amount, it gradually decreases the gradual decreases of punch load observed. It was also pointed out that the maximum punch pressure increases with new size and it almost linear up to the maximum size of the blank that can be drawn successfully. But the maximum load remains constant whatever may be the size of the blank after limiting the size of the blank for drawn.18 shows the drawn cup from the blanks of 130 mm diameter at room temperature and forming limit diagram (FLD) of the cup. FLD is a graph between the minor strain and significant strain of the sheet metal.

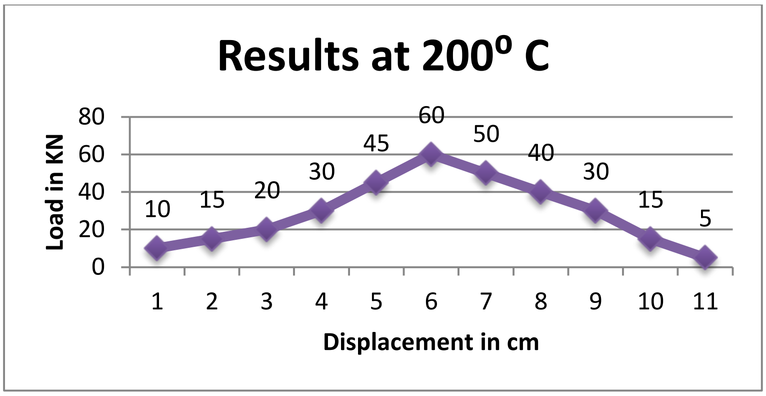
The possibility of fracture in the cup can analyze and can be compared with the forming limit curve (FLC), which appeared in FLD. It shows that the strain in the cup is bellowing FLC, which indicates that the drawing is in the safe zone. There is no indication of fracture in the container walls. The thickness of the cup at punch corner was reduced to 0.9 mm without necking. At 300^{0}C temperatures when the 140mm blank was drawn, with the effect of temperature the strain in the cup has crossed the FLC as shown in Fig. 19 which is not safe. The thickness at punch corner was reduced to less than 0.2 mm and leads to fracture. This breach occurred at the punch corner due to increase in the tensile strain. At room temperature maximum of 130 mm.



Graph: .Load vs Displacement curve for cup of diameter 120at 300ºC



Graph: Load vs Displacement curve for cup of diameter 110at 250ºC



Graph: Load vs Displacement curve for cup of diameter 100at 200ºC

The experiments have been performed with utmost care, and the results have been plotted into the curves. As per the study, the LDR ratio has been found out to be 2.2 for given punch diameter, i.e. 80 mm. With this information, it can be easily predicted that the blank sizes up to 130 mm at room temperature can be deep drawn conveniently.

V. CONCLUSION

The Limiting Drawing Ratio with punch diameter 80 mm has been found out to be 2.2 and the safest new size which can be conveniently deep drawn is up to 120 mm with given specifications. When the Aluminium material was subjected to heat treatment before the deep drawing process and heat 250 º C to 300º C temperature within the die holder with the help of electrical heaters. Just before the deep drawing process.The material which annealed showed us fewer wrinkles, and it was easy to draw. The Aluminium sheet which was not subjected to heat treatment and heating process of blank had more wrinkles. The test was conducted on ALUMINIUM 1100, and its work hardening exponent was found to be quite high. It makes it a highly formable material to be used in industries and future applications.This in turns results in better product quality and improved productivity. This process is being employed in industries to produce different types of components like air filter, missile cone for fighter air crafts, shock observes covers etc. It can be extended to numerous other products and materials. It provides the challenge to researchers to improve the process and equipment for specific industrial applications.

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