Determination of LDR in deep drawing by reduced number of blanks

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ABSTRACT

Indeed, deep drawing is one of the important sheet metal forming processes widely used in production of cup shaped articles having applications in different engineering and domestic areas such as aerospace, automobile, beverage, kitchenware etc. It is essential for manufacturing to determine the quality characteristics for minimization of rejection and cost involved in testing. LDR is one such quality characteristic essential to evaluate thoroughly with reduced number of steps in deep drawing. Here, the LDR is determined by means of experimental and simulation method by using the concept of " punch force is proportional to blank diameter up to limiting drawing ratio" and remains constant for oversized blanks causing failure. Hence, in this research, an attempt have been made to establish a standard and quick method for determination of LDR. The LDR tests have been conducted with the use of only three blanks of different sizes; i.e., two of undersize and one blank of oversize. The LDR found through experiments and simulation are in good agreement with only 5.4% variation and this variation may be due to variation in lubrication conditions among the experimental and simulation methods.

1. INTRODUCTION

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 continue 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 over sized blank.

2. LITERATURE REVIEW

The earlier research work published by various authors on LDR revealed that the punch load is proportional to blank size as shown in Figure 1[1]. Influence of geometry variations in micro deep drawing were conducted by G Beherans et al. [2] and revealed that LDR increases with increase in die shoulder radius.

The deep drawing tests conducted by Xiao-bo Fan et al. [3] show that the limiting drawing ratio increased as temperature rose to 200^o C and decreased afterwards for the magnesium alloy Al-Mg-Fan et al. [3] and the drawability could be achieved at 200^oC. The corresponding limiting drawing ratio was 1.9.

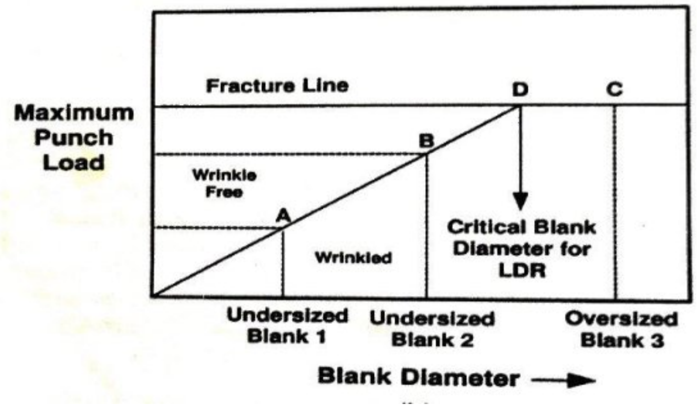

Fig 1. Punch limit load at different blank sizes (source:M.Jain.et.al [1])

The LDR for AA5754 aluminum sheet was found by hydroforming by Farhang Pourboghrat et al. [4] found to be 1.33 and 2.21 for sharp and round die corner radii, respectively. It was concluded that SHF is most ideal for deep drawing of aluminum sheets with sharp radii features. The influence of process parameters such as punch velocity, blank holder force (BHF), friction coefficient and initial forming temperature of blank on drawing characteristics were investigated by Ma et al. [5] with the help of design of experiments (DOE). Based on the results of ANOVA, it was shown that the blank holder force has the greatest influence on minimum thickness. Lucian Lazarescu et.al [6] studied the influence of constant and variable blank holder force influence on thickness distribution of the drawn cup. The finite element model was developed using Autoform software and the results shows that variable blank holder force usage reduced the drawing force.

In the study conducted by Demirci et al. [7], no earing and wrinkling have occurred in BHF's between 1.3 and 8 MPa in square deep drawing process, and that tears have occurred in forces exceeding 18 MPa. It has further been observed that the best forming has occurred at 5 MPa, and that the numerical and experimental model developed is in harmony with one another at a rate of 85%. A C S Reddy et al. [8] studied drawability of magnesium alloy and found that limiting drawing ratio (LDR) increased significantly with increase in temperature and maximum at 300^oC and experimental and simulation results are in good agreement. In the experimental study by A C S Reddy et al. [9] in single stage deep drawing process for assessment of radial strain, circumferential strain and thickness variation in aluminum alloyAA6061 found that found that deeper cups were produced by selecting the optimum design parameters for punch nose radius, blank holder force and die shoulder radius.

2. METHODOLOGY

Deep drawing tests were conducted using die set with die profile radius of 5.5 mm , punch nose radius of 5.5 mm and blank holder force of 7kN. The blank size of 100 mm, 140 mm and 200 mm were used for drawing while keeping all the tool and processes parameters remains unchanged. The blanks were prepared from the aluminum (commercial grade)sheet of 0.9 mm thickness. The exact sizes of blanks were prepared by cutting from sheet by laser cutting. The laser cut blank have no burrs and avoids stress concentration leading to failure by wrinkling while drawing.

2.1. DEEP DRAW TOOL SETUP

The design of deep drawing tool setup is a highly specialized task. It consists of number of important activities that sequentially starts with determination of blabk size, selection of process parameters and die assembly. The tool setup is as shown in figure 1. The components of deep draw tool setup are die holder, blank holder, punch and punchholder. The blank holder load can be varied by applying the compressive force over the open coiled helical spring housed over the blankholder by means of tightening the nut provided for it. As the spring index is known by testing can easily determine the blank force applied on the blank holder. The tool parameters have been fixed and are as shown in table 1. From the punch force and blank displacement curves the maximum punch loads were recorded and based of the concept of " punch load is proportional to blank diameter within the safe drawing limits. Maximum punch loads were plotted in determination of LDR as shown in Figures 2,3 and 4.

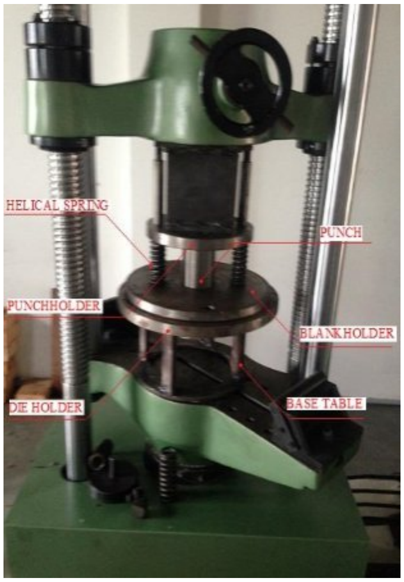

Figure 1. Deep drawing tool setup

Table 1: Tool parameters used for testing

S. No	Blank dia (mm)	Max load recorded (kN)	
		Experiment	Simulation
1	100	23.45	25.68
2	140	56.05	59.67
3	200	64.70	67.59

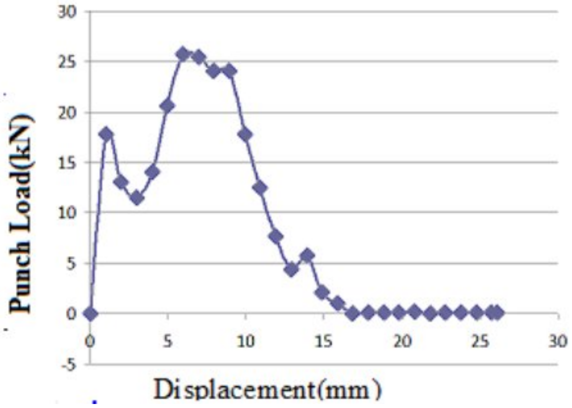

Fig 2:Punch load vs.punch displacement curve for 100 mm diameter

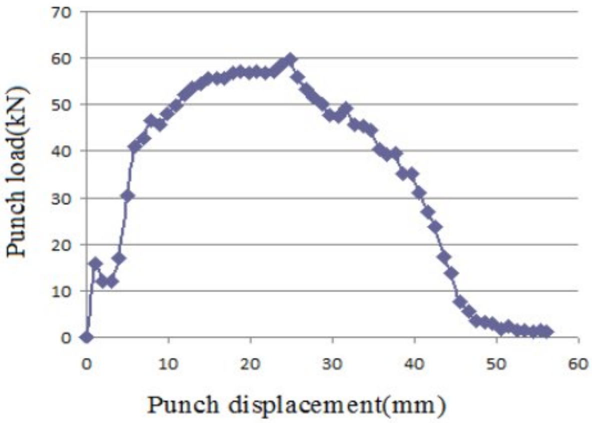

Fig 3: Punch load vs.punch displacement curve for 140 mm diameter

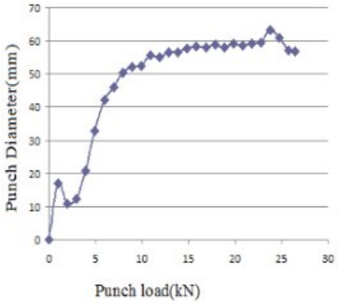

Fig 4: Punch load vs. punch displacement curve for 200 mm diameter

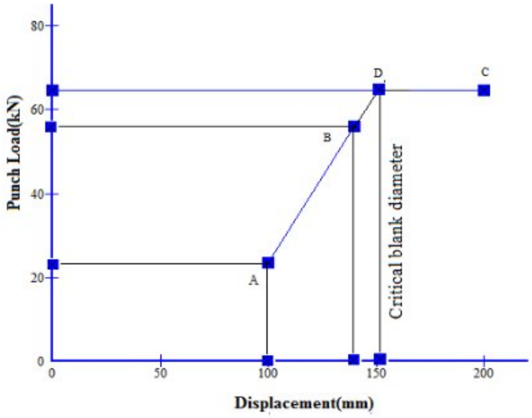

Figure 5: Critical blank diameter found from experiments

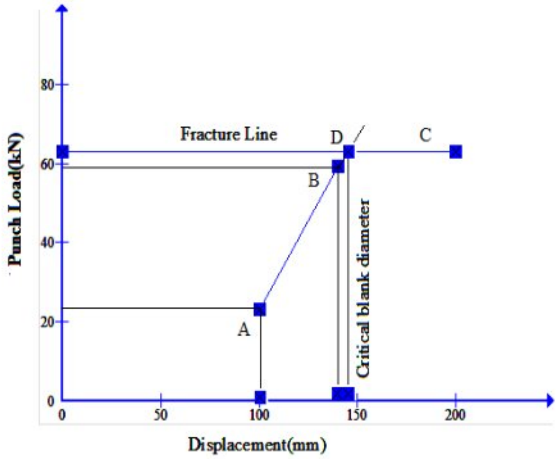

Fig 6: Critical blank diameter found from simulation

2.2. RESULTS AND DISCUSSION

The critical blank diameter found from simulation tests is 145.20 mm. The critical diameter found from experimental results is 140.05mm. The LDR for simulation is 1.85. The LDR for experiments is 1.75 with an acceptable error of 5.4%. This variation may be due to variation in friction conditions selected for simulation. It can be further concluded that the LDR may be studied for combination of different process and tool parameters to check the influence of these parameters on LDR

2.2. CONCLUSIONS

It had been found that the LDR found in experiments is in good agreement with FEM simulation results. The punch load is proportional to blank diameter both in experimental and simulation study. The proposed method is simple and saves time and money.

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