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Deep Drawing Investigations of IS 513 CR 4 Sheets

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Abstract - This study focuses on the deep drawing process of IS 513 CR 4 sheets, both experimentally and through finite element analysis. IS 513 CR 4 sheets are widely used in industries like automotive and appliances due to their smooth surface, good strength, and excellent formability. In this experiment, 1.2 mm thick IS 513 CR 4 sheets were used, with circular blanks of 105 mm, 107 mm and 109 mm, in diameter. The deep drawing process was carried out at room temperature using a 30-ton hydraulic deep drawing machine. Force-displacement curves for each blank were recorded using integrated software. Formability was assessed using the Limiting Drawing Ratio (LDR), which is the ratio of the maximum blank diameter to the punch diameter. A higher LDR indicates better formability. Additionally, 3D finite element models were developed to simulate the deep drawing process. The experimental and simulation results showed good agreement, confirming the accuracy of the analysis.

Keywords :- Drawability IS 513 CR 4 Sheet, deep drawing and limiting drawing ratio.

I. INTRODUCTION

IS 513 CR 4 sheets are widely used in deep drawing applications due to their excellent formability, good strength, and smooth surface finish. These properties make them suitable for industries such as automotive, appliances, and general manufacturing, where components like car body panels, enclosures, and structural parts are commonly produced.

The advantages of using IS 513 CR 4 sheets include superior surface quality, consistent mechanical properties, and the ability to achieve complex shapes without defects like cracks or wrinkles. During deep drawing, IS 513 CR 4 sheets undergo significant deformation while maintaining structural integrity. Their ductility and work-hardening behavior allow smooth forming, while uniform thickness contributes to dimensional accuracy. The material's heat dissipation capacity also ensures stable forming conditions.

A key parameter in evaluating the formability of sheet metals is the Limiting Drawing Ratio (LDR). Materials with higher LDR values have better drawability. Bal et al. [1] investigated the influence of varying die/blank holder angles and punch radii, concluding that increasing the punch radius (R) and die/blank holder angle (α) leads to an increased LDR. Similarly, Behrens et al. [2] studied the effect of tool geometries and observed that LDR improved with a larger die radius.

Finite element simulations were carried out to determine the LDR using [3]. In the present study, experimental deep drawing of IS 513 CR 4 sheets was performed, and the results were compared with finite element simulations to assess formability. The effects of tool geometry—particularly punch radius and die/blank holder angle—on LDR were analyzed.

II .METHODOLOGY

The experiments were carried out on Deep drawing hydraulic machine which is specially designed for deep drawing operations. IS 513 CR 4blanks of 1mm thickness were cut into circular shape using Hydraulic punch and deep drawing was carried out on blank diameters ranging from 105 to 109 mm of IS 513 CR 4blanks. Hydraulic press of 30 Tons capacity was used for deep drawing on IS 513 CR 4 blanks. Since there is tendency in the material to change dimensions at higher temperatures, An Induction heater is used in designing and manufacturing the die, blank holder and punch. The lubricant is applied to reduce the friction between the punch and die. Blank is fixed rigidly between the upper and lower dies. Punch is then rammed down deep draw the blank into a cup. The formingload 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, wallthinning is prominent and results in an uneven part wall thickness. The maximum stressthat 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 symmetric blanks). LDR is then determined.

Deep drawing experiments:

The Limiting Drawing Ratio (LDR) is experimentally evaluated for IS 513 CR 4 sheets during deep drawing process. The significance of the LDR lies in its role in selecting materials that can successfully form cups during deep drawing operations. LDR is defined as the ratio of the maximum blank diameter (Dmax) that results in a successful cup formation to the diameter of the punch (d).

LDR is represented by

LDR = Dmax⁄d   eq. (1)

Were,

Dmax = Maximum diameter of blank, and

d = Diameter of punch

A higher Limiting Drawing Ratio (LDR) indicates greater formability, while a lower LDR signifies reduced formability of metals.

III. RESULTS AND DISCUSSION

Limiting drawing ratio of IS 513 CR 4 sheets

The deep drawing process was conducted on IS 513 CR 4 circular blanks with diameters ranging from 105 to 109 mm in incremental steps. Each blank had a thickness of 1.2 mm. The failure of the IS 513 CR 4 cup occurred at a 109 mm blank diameter, and the largest diameter that successfully formed a cup without defects is termed the maximum blank diameter (Dmax) of 107 mm as shown in Fig 1.

In this study, the maximum blank diameter (Dmax) was found to be 107 mm, while the punch diameter (d) was 50 mm. The Limiting Drawing Ratio (LDR), which represents the material's formability, is calculated as:

LDR=Dmax/d=107/50= 2.14

Finite Element Simulations:

Numerical analysis of deep drawing involves using computational techniques to simulate and optimize the process. This approach allows engineers to predict material behavior, optimize process parameters, and enhance the quality of formed parts without costly and time-consuming trial-and-error experimentation.

Figure 1: Drawn cups at room temperature.

Finite Element Analysis (FEA) is commonly used for deep drawing simulations. In FEA, the sheet metal, die, and other components are divided into small elements, and mathematical equations governing their behavior are solved iteratively to simulate the entire forming process.

Various factors, such as material properties, friction conditions, blank holder force, and draw ratio, are incorporated into the simulation to accurately predict deformation, stresses, strains, and other key variables.

In this study, the deep drawing of IS 513 CR 4 sheets was analyzed using ABAQUS/Explicit FEA software.

The tooling geometries were designed in SolidWorks and converted into finite element models. The material properties of IS 513 CR 4 sheets used in the FEA analysis are presented in Table 1 below.

Table 1. Properties of IS 513 CR 4 used in Abaqus Software.

Parameter	**Value**
Material	IS 513 CR 4
Density	7.85×10^3 kg/m^3
Youngs modulus	210 GPa
Poisson ratio	0.3
Yield Strength	210MPa
Elongation	28%
Tensile Strength	270MPa

The simulations accurately predicted deformation patterns and verified the LDR from the physical experiments. As shown in Fig 2

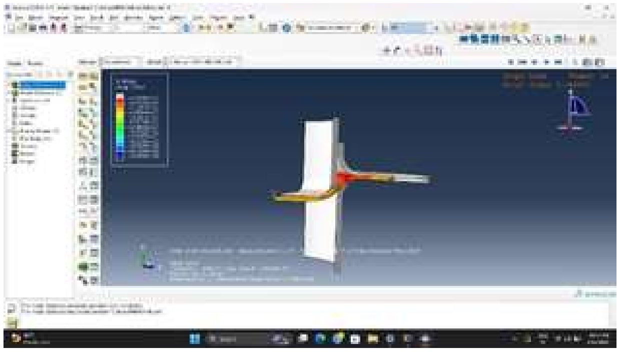

Figure 2: Simulation of Drawn cup at room temperature.

IV.CONCLUSION

• The highest Limiting Drawing Ratio (LDR) has been determined for IS 513 CR 4 sheets for 107mm blanks.
• The numerical value of highest LDR is 2.14.
• IS 513 CR 4 Sheets is highly suitable for industrial applications.

REFERENCES

[1] M. Bal, C. Özek, “The effect of die/blank holder and punch radii on limit drawing ratio in angular deep- drawing dies,” International Journal of Advanced Manufacturing Technology, vol. 40, pp. 1077–1083, 2008.

[2] G. Behrens, F. O. Trier, H. Tetzel, F. Vollertsen, “Influence of tool geometry variations on the limiting drawing ratio in micro deep drawing,” International Journal of Material Forming, vol. 9, no. 2, pp. 253–258, 2016.

[3] H. S. Sultan Aljibori, A. M. Hamouda, “Finite element analysis of sheet metal forming process,” European Journal of Scientific Research, vol. 33, no. 1, pp. 57–69, 2009.