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Experimental and Computer Aided Study of Anisotropic Behavior of Material to Reduce the Metal Forming Defects

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ABSTRACT

This research work gives information about the behaviour of cold rolled steel IS 513_2008 CR2_D for reducing the metal forming defects. CR indicates Cold Rolled and D denotes Drawing grade. Wrinkles, dent, springback, thinning, insufficient stretching etc. are the problems identified while performing sheet metal forming operations. For cold rolled steel material, out of various defects the damage due to wrinkle formation was studied in this paper. In this paper, research is done for studying the behavior of cold rolled steel material used in deep drawing process. In this research work, wrinkling defect is studied experimentally and with the help of FE software.

***Keywords*— Deep drawing, Friction, FE software, Wrinkling**.

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I. INTRODUCTION

Sheet metal forming processes are one of the manufacturing processes which consist of several processes such as plastic deformation processes and cutting processes. In deep drawing which fails under the category of plastic deformation process, due to the force provided by punch, the metal blank is shaped into the die cavity.

Various types of defects like insufficient stretching, thinning, rupture etc. occurs in many manufacturing process and other defects such as wrinkling, tearing, cracks, thinning occurs particularly while carrying out deep drawing operations. Deep drawing process occurs like the raw material i.e. blank is shaped into the cavity of the die. For performing any deep draw operation mainly manual, hydraulic, pneumatic and mechanical presses are used. A series of work on wrinkle suppression have conducted by Yoshida et al. [1]. Hydraulic press of capacity 250 ton was used for the wrinkling analysis purpose. Lee et al. have studied the reason of wrinkles at the corner area [2].

In this research work the analysis of wrinkle of one of the auto component is done. While performing metal forming processes the defects like wrinkles, cracks were found several times in the component formed. After doing literature survey it can be understand that wrinkles and cracks can be minimized to large extent. Blank holding pressure, nose radius, geometry, draw depth, anisotropic properties of material, die design and shape of work piece, contact conditions etc. are the various parameters which mainly responsible for wrinkle formation. By considering all the factors it is difficult to analyze wrinkling initiation and growth. The main reason behind this is the effect of the each factor is very complex and for small deviations in factors wrinkling behavior study may be a wide scattering of data. In this research work, mainly in deep drawing process of the cylindrical cup, the phenomenon of wrinkling initiation and crack growth was studied. The work was carried out by performing experimentation on single stage hydraulic machine and the results were confirmed with Autoform software.

The strength found to be very weak while doing the assembly of the parts with the help of welding or any other joining operation due to the formation of wrinkles and wrinkles are also responsible for destroying the appearance of the component. Because of the above reasons wrinkling is not desirable. Because of the excessive compressive force acting on the sheet metal, wrinkle formation occurs. In case of multistage operations, high frequency wrinkles can damage the die.

II. CHEMICAL COMPOSITION of MATERIAL

The chemical composition of cold rolled steel tested on optical emission spectrometer.

TABLE I CHEMICAL COMPOSITION of MATERIAL

Si	**C**	**P**	**Mn**	**Bi**	**Ni**
%	%	%	%	%	%
0.0083	0.0425	0.004	0.2292	0.002	0.0138
Sn	**B**	**As**	**Zn**	**S**	**Ce**
%	%	%	%	%	%
0.0025	0.0004	0.002	0.002	0.002	0.003
Cr	**Al**	**Co**	**Cu**	**La**	**Pb**
%	%	%	%	%	%
0.158	0.0465	0.0062	0.0052	0.001	0.003
Ca	**Ti**	**Fe**	**Zr**	**Nb**	**Mo**
%	%	%	%	%	%
0.0002	0.001	99.6	0.002	0.003	0.002
W	**V**				
%	%				
0.001	0.001				

III. ANISOTROPIC PROPERTIES of COLD ROLLED STEEL

Anisotropic properties are the directional dependent properties means if rolling direction is changed there will be slight variation in mechanical properties. It can be calculated by uni-axial tension tests conducted in 0°, 45° and 90° with respect to rolling direction.

$$\text{Plastic Strain Ratio } (R_0) = \frac{\ln\left(\frac{\text{Width final}}{\text{Width initial}}\right)}{\ln\left(\frac{\text{Thickness final}}{\text{Thickness initial}}\right)}$$

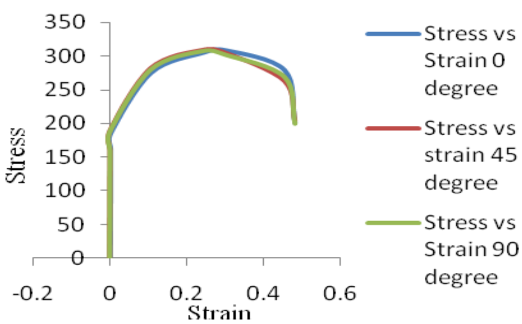


Fig1 Stress strain cure observed in different rolling direction

In above fig.1, the nature of stress strain curve in different rolling direction is shown. The stress strain curve behavior is almost same in different rolling direction. Calculation of normal 'R' value is taken to be average 'r' value:

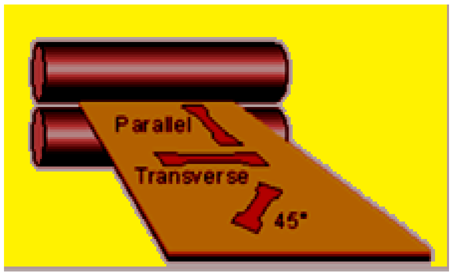


Fig 2. Specimen with different rolling direction

$$\text{Lankford coefficient } (R) = \frac{R_0 + 2R_{45} + R_{90}}{4}$$

Normal R value of the material strongly depends on the strain.

Calculation of planar anisotropy coefficient value R_p

$$R_p = \frac{R_0 - 2R_{45} + R_{90}}{2}$$

For Isotropic material

The material has same property in all directions.

For Planar anisotropy

The R values vary at different directions to the rolling direction: R_0 not equal to R_{45} not equal to R_{90}. This can lead to 'earing' in deep drawing.

For Normal anisotropy

$R_0 = R_{45} = R_{90}$ but not equal to 1.

The value R determines the limiting drawing ratio, and R_p is in correlation with the extent of earring. A combination of high R and low R_p provides optimal drawability. The results obtained after doing uni-axial tensile testing is tabulated as follows:

TABLE II MATERIAL PROPERTIES of COLD ROLLED STEEL

Parameters	Values
Yielding stress, σs (MPa)	217.78
Ultimate tensile stress, σ_{ut} (MPa)	307.83
Total elongation, δl (%)	40
Strain hardening exponent, *n*	0.2136
Hardening coefficient, *k* (MPa)	502.73
R_0	1.914
R_{45}	1.1615
R_{90}	1.77
$R_{avg.}$ Lankford Coefficient	1.50175

IV. EXPERIMENTATION

A. A. Experimental Setup

As shown if figure 3 hydraulic press of capacity 250 Tons was used for final component. Deep drawing is a process in which final component is in cup shape and produced from Sheet metal. In this case single stage draw is done and finally inverted cup was obtained. J. Cao et al. have studied the concept of flange wrinkling [3].

Fig 3 Punch and die setup

Fig 4. Effect of varying Blank holding pressure & Draw depth

Fig 5. Location of cup in automobiles

For prevention of wrinkling, blank-holder was used because it can apply sufficient pressure on the blank studied in [4]. Therefore, larger radial tension is created on the flange and higher tensile stress is needed on the cup wall, while drawing cups at larger draw ratios. By varying the parameters like blank holding pressure and draw depth, the component which is obtained is shown in fig. 4.

Liao et al. have studied the wrinkling of stamping of a motor cycle oil tank. In automobile, the actual location of cup is shown in figure 5.

B. Observation Table

By varying the parameters like draw depth and blank holding pressure, the observations were taken. From table 3, it can be seen that the optimum values were obtained at draw depth 29 mm and blank holding pressure 60 kg/cm^2.

TABLE III EFFECT of VARYING BLANK HOLDING PRESSURE and DRAW DEPTH

Sr. No.	Punch force (Kg/cm^2)	Blank Holding Pressure (Kg/cm^2)	Major Wrinkle Waves	Punch Speed (mm/s)	Dra-w depth-h (mm)	Conclus-ion
1	100	30	17	8.6	26	Large wave count
2	100	35	15	8.6	26	Decreas-ed wave count
3	100	40	12	8.6	26	Decreas-ed wave count
4	100	45	4	8.6	26	Decreas-ed wave count
5	100	60	Absent	8.6	26	Negligib-le waviness
6	100	65	Crack	9.3	24	Thinnin-g & Crack
7	100	60	Absent	7.5	30	Wavine ss visible
8	100	60	Absent	7.9	29	No wrinkles

c. Effect of Various Friction Material

As shown in Table 4, 5 and 6, for lubrication purpose there were different friction material used as a lubricant. By using Plastic paper and palm oil, the most effective result was obtained. In forming process when palm oil used as a lubricant for cup formation, there was one drawback found that is cleaning of cup is necessary after forming.

Fig 6. Use of plastic paper as a lubricant

TABLE IV EFFECT of PLASTIC PAPER 100MICRON-0.1MM as a FRICTION MATERIAL

Sr. No.	Punch force	Blank holding presssure	Punch Speed	Draw depth	Conclusion
1	100	50	7.7	29	Less wave count
2	100	55	7.7	29	Decreased wave count
3	100	60	7.7	29	No wrinkles
4	100	65	9.7	23	Wrinkles observed

TABLE V EFFECT of PALM OIL as a FRICTION MATERIAL

Sr. No.	Punch force	Blank holding presssure	Punch Speed	Punch Stroke	Conclusion
1	100	50	9.7	23	Wrinkles observed
2	100	55	7.7	29	Less wave count
3	100	60	7.7	29	No wrinkles
4	100	65	7.7	29	Thinning

TABLE VI EFFECT of HYDRAULIC OIL GRADE 68 as a FRICTION MATERIAL

Sr. No.	Punch force	Blank holding presssure	Punch Speed	Punch Stroke	Conclusion
1	100	50	9.7	23	Wrinkles observed
2	100	55	9.7	23	Wrinkles observed
3	100	60	8.6	26	Minute waviness
4	100	60	7.5	30	Waviness visible

V. SIMULATION

A. *A. Creation of Model*

By using CATIA, the numerical model of forming of deep drawing process was built up. By using CATIA V5 R17, the sample model created which is shown in fig.7 and by using Autoform software it was analyzed further.

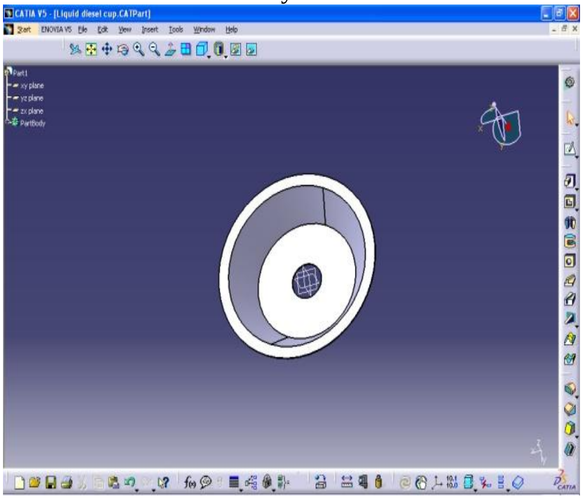
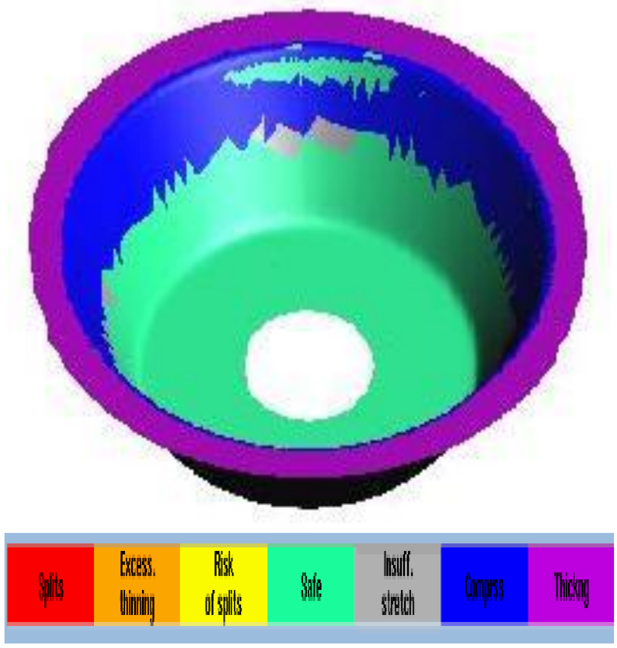


Fig 7. Component 3 d model created in CATIA V5 R17

B. Analysis of Model

By using Autoform software, the numerical model was analyzed. For approaching towards the optimum value, all the observed values were analyzed. It was observed that at blank holding pressure 60kg/cm^2 and the draw depth 30mm safe region was decreased and for same blank holding pressure and 29mm draw depth, increased safer region was observed.



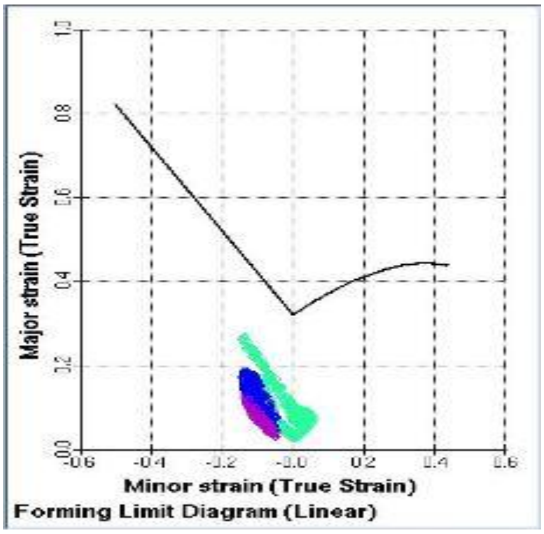


Fig. 8 Component formability and FLD curve for Blank holding pressure 60kg/cm^2 and draw depth 29mm

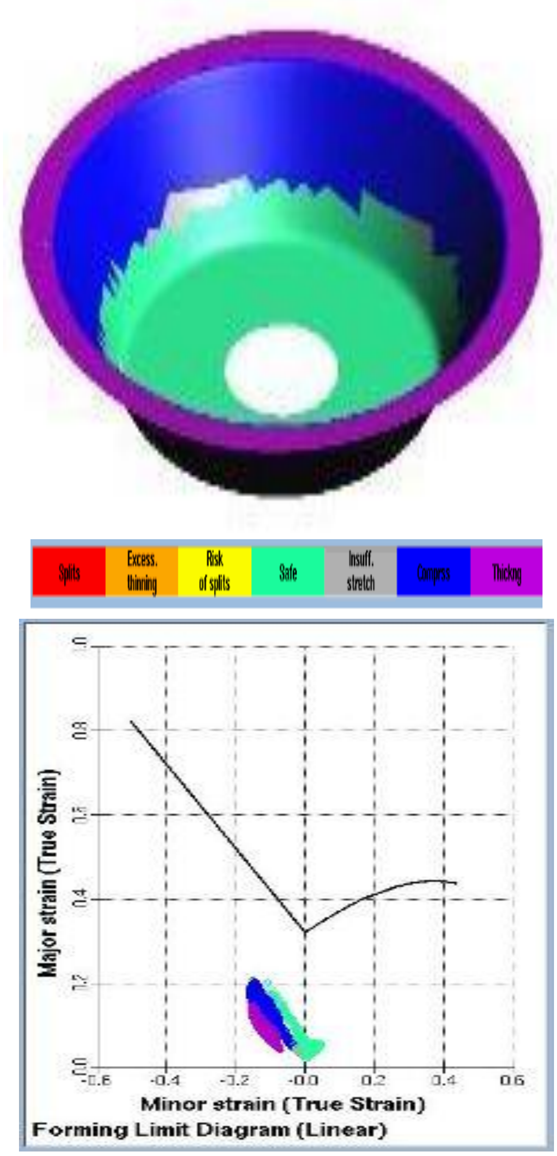


Fig. 9 Component formability and FLD curve for Blank holding pressure 60kg/cm^2 and draw depth 30 mm

VI. CONCLUSION

1) If the draw depth is increased, then decreased wave count was observed and also more compression region was formed which is highly undesirable.
2) From table 3, it can be seen that if blank holding pressure is increased then wrinkle formation was decreased.
3) At blank holding pressure 60 kg/cm^2 and draws depth 29mm, the optimum value was observed as shown in Table 3, 4 and figure 8 and figure 9 shows optimum values.
4) By using Plastic paper and palm oil as a lubricant, the most effective result was obtained.
5) Experimental and simulation results were found to be nearly same.

REFERENCES

[1] K. Yoshida, H. Hayashi, K. Miyauchi, Y. Yamamoto, k. Abe, M. Usuda, R. Ishida, Y. Oike, The effect of mechanical properties of sheet metals on the growth and removing of buckles due to non uniform stretching, Sci. Pap. Inst. Phys. Chem. Res. 68 (1974) 85-93.

[2] J.H. Lee, B. S. Chun, Investigation on the variation of deep drawability of STS304 using FEM simulations.

[3] X. Wang, J. Cao, An analytical prediction of flange wrinkling in sheet metal forming, J. Manuf. Processes 2 (2) (2000) 100 – 107.

[4] T. Yagami, K. Manabe, Y. Yamauchi, Effect of alternating blank holder motion of drawing and wrinkle elimination on deep–drawability. Journals of materials processing Tech. 187-188(2007) 187-191.

[5] Fuh-Kuo Chen, and Yeu-Ching Liao, Analysis of draw-wall wrinkling in the stamping of a motor cycle oil tank. Journals of materials processing Tech. 192-193 (2007) 200-203.

