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Effect of Heat Treatment and Sheet Thickness on Deep Drawing Formability: A Comparative Study

M. Venkat Reddy[1*], P. Venkateshwar Reddy[2], R. Ramanjaneyulu[3]

[1] *Department of Mechanical Engineering, TKR College of Engineering and Technology, Hyderabad, Telangana -500097, India.*

[2] *Research Scholar, Department of Mechanical Engineering, JNTU Ananthapuramu (GPREC Research Centre – Kurnool), Andhra Pradesh-515002, India.*

[3] *Research Scholar, Department of Mechanical Engineering, JNTU Ananthapuramu (KSRM Research Centre – Kadapa), Andhra Pradesh -515002, India.*

Abstract

Deep drawing process is a sheet metal forming operations in which most complex shapes can be prepared without defects and with less wastage of material. Proper selection of process parameters is required to get a defect free product. The main aim of the present work is to compare the formability of two different sheets by heat treatment and also varying the sheet thickness on angular die deep drawing process. For which both SS 304 and Brass each of 0.8 mm and 1 mm is considered in the present work. The experiments were performed by designing the deep drawing tools such as die, blank holder, and punch. Punch forces and thickness variations are evaluated for all the experimental test settings. From this work, the effect of heat treatment and sheet thickness on the formability of two different sheets metal is observed on angular deep drawing tests.

Keywords: Sheet Metal; Deep Drawing; Formability; Angular; Punch Force

INTRODUCTION

Deep drawing process is a sheet metal forming operations in which most complex shapes can be prepared without defects and with minimum wastage of material. Deep drawing is a special sheet metal forming process by which a large amount of body parts are formed in aerospace, automobile and cooking utensil manufacturing industries. During the process, a lot of defects are going to occur, if the process parameters are not properly selected. Therefore, it is important to reduce the defects and to improve the formability of the sheet metals. Reddy *et al.* [1] investigated on the angular deep drawing process by considering different die/blank holder angles and concluded the best die/blank holder angle which improves the formability by improving the drawability and uniform thickness distribution. In another work by same author investigated on the different process parametric effect like sheet material and lubricant and concluded the best combination for attaining higher formability [2]. Pranavi *et al.* [3] investigated on the material properties effect the sheet metal formability for producing cylindrical cups using numerical simulations. Chen and Lin [4] investigated on the rectangular cups formation of SS 304 sheets using both numerical and experimental trials and suggested the best parameters combination for the improvement of formability. Cebeli and Bal [5] investigated on the effect of die and punch radii along with angular geometries for the improvement of draw ratio with different die/blank holder angles. Same author have also developed a mathematical model for the optimization of the above mentioned process parameters to improve the drawability and punch force along with thickness distribution for square cup formation [6]. Othmen *et al.* [7] investigated on the several constitutive laws by implementing in numerical simulations for the accurate prediction of experimental data in cylindrical cup formation. Reddy *et al.* [8] investigated on the square cup deep drawing process using both experimental and numerical simulations for the improvement of formability on different anisotropic materials. Lim *et al*. [9] investigated on the vinyl coated sheet by performing bending and nakazima tests to predict the forming limit diagram. The works leads to the development of damage model for the accurate prediction of the fractures in the sheet metal. Ulibarri *et al.* [10] investigated on the influence of heat treatment in sheet metal forming considering the responses like springback and formability of inconnel 718 sheet specimens. Kesharwani *et al.* [11] studied and compared the tailored welded blanks formability with parent metal sheets by performing limit draw tests and concluded that the optimized friction stir welded sheet attained higher formability.

Only few of the researchers have focused on heat treatment of blanks. Heat treatment of the blank material improves the formability by improving limit draw ratio since it affects the ductility of the sheet metal. The main aim of the present work is to analyze the effect of thickness and heat treatment of the blanks to improve the formability of the sheet metal in deep drawing process.

METHODOLOGY

In the present research work the tools are fabricated using CNC machine operations and the dimensions are tabulated in Table 1. Two different sheet metals (SS304 and Brass) of 0.8mm and 1mm brass are considered in the work. The total fabricated deep drawing setup is coupled to universal testing machine to record the punch force while performing the experiments. The schematic illustration of the angular deep drawing test setup is shown in Fig.1 and its fabricated test setup is shown in Fig.2.

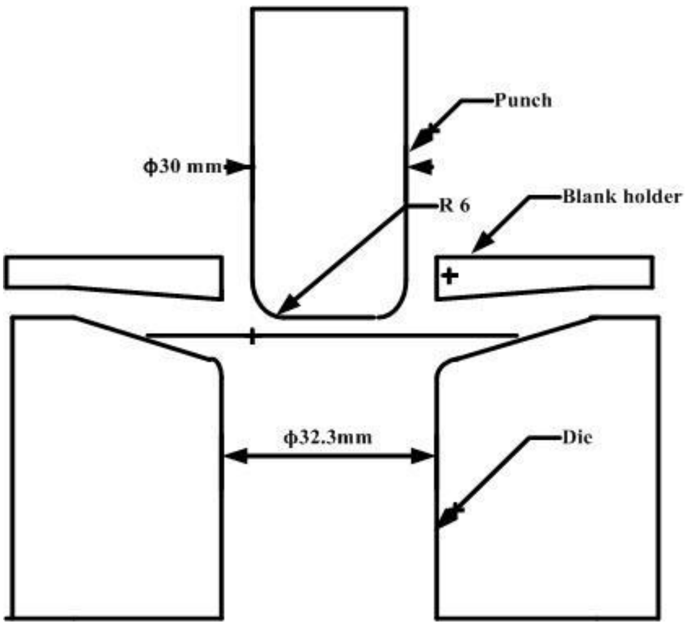

Fig. 1 Schematic illustration of the Angular Deep Drawing test setup

Table 1 Angular deep drawing considered tool dimensions

Punch	Diameter Nose radius	30mm 6mm
Deep Drawing Die	Die diameter Die profile radius	32.3mm 5mm
Blank	Thickness Diameter	0.8mm and 1mm 60mm
Process parameters	Blank holder/Die angle	12.5º

Fig.2 Experimental Setup of Angular deep drawing

Heat Treatment of the sheet metals

Both the sheet metal samples were heat treated after the preparation of the blanks from the stock in an electrical furnace which has a capacity of 1500ºC. A total of 8 Samples each sheet metals of two (0.8mm and 1mm) was heated upto 900^0 C in the furnace. When the temperature reaches the 900^0 C, the electric supply turned off automatically. The sheet metals were left inside the furnace for cooling up to 2.5 hrs.

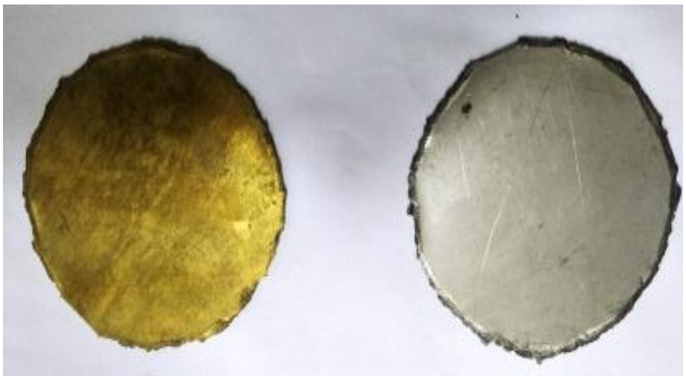

Fig.3 Blanks after heat treatment

Experimental Procedure for Deep Drawing

Before conducting the experiments, the tools are cleaned. The complete setup of the angular deep drawing was placed in between the base plate and centre table of Universal Testing Machine (UTM). For conducting the experiments the blank is placed in between the blankholder and die, after that the blankholder nuts are tightened with wrench to impart blank holding force on the blank. Both SS 304 and brass sheets each of 0.8 mm and 1 mm with a diameter of 55 mm were utilized in the present study by maintaining a constant clearance between punch and die as shown in Fig 1. Later, the punch was positioned in between the die by maintaining proper clearance. The load was applied continuously by the hydraulic press till the blank deforms into the required shape without failure. Once the blank completely entered into the die machine was stopped and test was terminated. Punch force obtained through DAQ system of UTM is noted for all different conditioned tests and also the thickness variations along the deep drawn cup is measures by slicing it into two equal parts.

RESULTS AND DISCUSSION

This section discusses the results of all the experimental investigations. Once the tests are completed, the specimens are used for testing the thickness variations along the cup surface using vernier calipers. Deep drawn cups of heat treated and without heat treated for both the SS 304 and brass sheet metals are shown in Fig 4 & 5 respectively.

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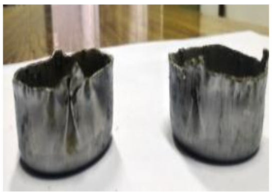
a



b

Fig. 4 Deep drawn cups of SS304
a) with heat treatment b) without heat treatment

a

b

Fig. 5 Deep drawn cups of brass sheets
a) with heat treatment b) without heat treatment

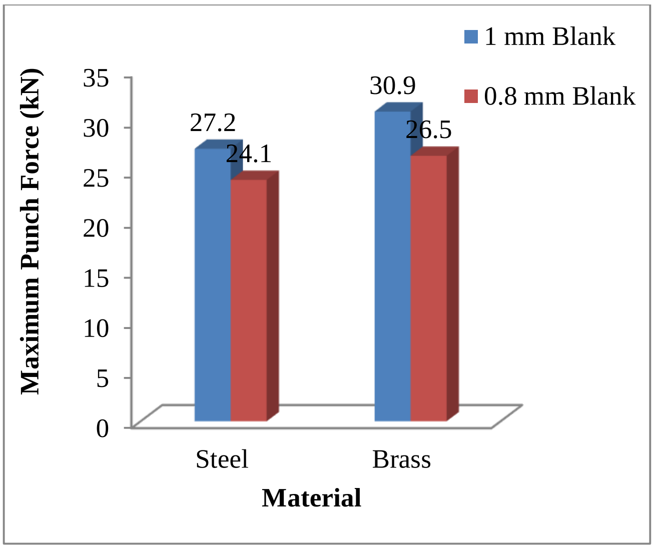


Fig. 7 Effect of sheet thickness on punch force without heat treatment

From Fig 4 & 5 represents the deep drawn components of both SS 304 and brass sheet metal respectively. It was observed that the wrinkle formation is reduced for the heat treated samples for both the sheet metals. As the heat treatment improves the ductility of the sheet metals, the wrinkles formation is reduced such that a defect free product can be obtained by the heat treatment of the samples.

Punch Force evaluation

Punch force of each test is noted directly from the Universal Testing Machine (UTM). The results of the punch force for both sheet metals with varying thickness and with heat treatment are shown in Fig 6. Without heat treated blanks are also tested to check the formability of the specimens and the results are noted in the similar manner and are shown in Fig 7. From Fig 6, it was observed that the punch force increases with increase in sheet thickness. Moreover force required to draw is more for brass sheet when compared to SS 304 sheet.

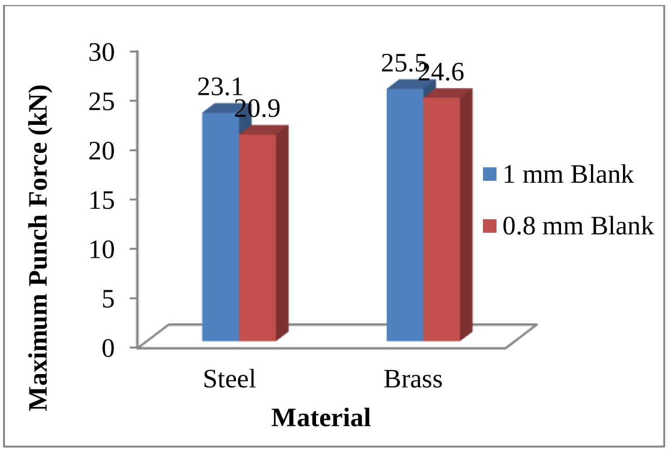


Fig. 6 Effect of sheet thickness on punch force with heat treatment

The impact of heat treatment can be clearly observed from Fig 6 & 7. Heat treated samples possessed less drawing force when compared to non heat treated samples. The reason for low drawing force is that, heat treatment makes the sheets more ductile such that the force is decreased for both the sheet metals.

Thickness measurement of the deformed cups

After the completion of each test, the deep drawn components are tested for the thickness variations. Initially the cups are sliced in the rolling direction into two equal halves. The thickness of the deep drawn cups is measured using vernier calipers. The effect of sheet thickness on thickness variations are shown in Fig 8 for 1 mm thickness and for 0.8 mm thickness is shown in Fig 9 for both with heat treatment and without heat treatment.

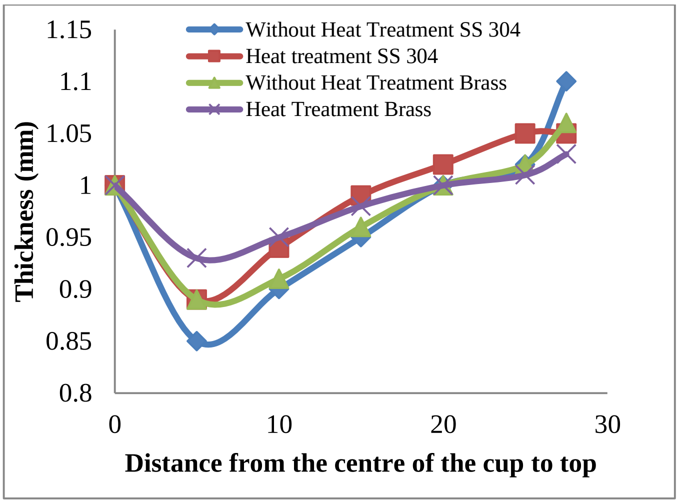


Fig. 8 Thickness distribution comparison of 1mm thickness sheet

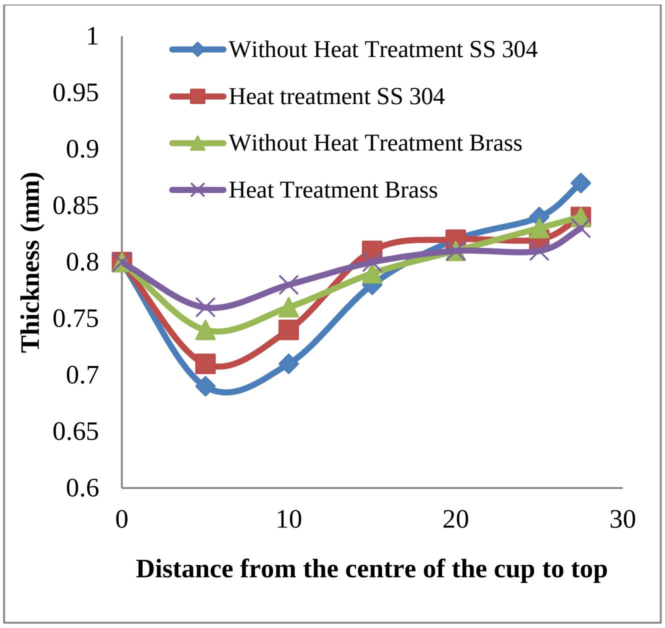


Fig. 9 Thickness distribution comparison of 0.8 mm thickness sheet

From Fig 8 & 9, it was observed that heat treated samples posses' uniform thickness distribution when compared to non heat treated samples. This is because the heat treatment improves the ductility of the samples, thereby uniform thickness is attained. Moreover, brass samples have a uniform thickness variation than the steel samples.

CONCLUSION

Angular deep drawing experiments were performed by designing the deep drawing tools such as angular die and blank holder and punch. Punch forces and thickness variations are evaluated for all the experimental trails. The impacts of the sheet thickness and heat treatment are observed on the aforementioned responses. The following conclusions were drawn from the work.

- Sheet thickness increased the drawing force required for deep drawing of the cups in angular deep drawing process.
- Heat treatment of the samples before forming reduced the wrinkles formation on the deep drawn cups.
- Heat treatment of the samples also reduced the drawing force required to form the cups.
- Uniform thickness distribution is obtained for the heat treated samples when compared to the non heat treated samples.

REFERENCES

[1]. Venkateshwar Reddy, P., Hari Prasad, S., Ramulu, P. J., Battacharya, S., & Guptha, D. S. (2015). Effect of Geometries of Die/Blank Holder and Punch Radii in Angular Deep-Drawing Dies on DP Steel Formability. In *Applied Mechanics and Materials* (Vol. 813, pp. 269-273). Trans Tech Publications.

[2]. Reddy, P. V., Ramulu, P. J., Madhuri, G. S., Govardhan, D., & Prasad, P. R. (2016, September). Design and Analysis of Deep Drawing Process on angular Deep Drawing Dies for Different Anisotropic Materials. In *IOP Conference Series: Materials Science and Engineering* (Vol. 149, No. 1, p. 012142). IOP Publishing.

[3]. Pranavi, U., Reddy, P. V., Lavanya, K., Charyulu, N. N., & Ramulu, P. J. (2014). Effect of Mechanical Properties on Deep Drawing Formability Prediction. *Int. J. of Curr. Engg and Techl*, *3*, 302-305.

[4]. Chen, F. K., & Lin, S. Y. (2007). A formability index for the deep drawing of stainless steel rectangular cups. *The International Journal of Advanced Manufacturing Technology*, *34*(9-10), 878.

[5]. Özek, C., & Bal, M. (2009). The effect of die/blank holder and punch radiuses on limit drawing ratio in angular deep-drawing dies. *The International Journal of Advanced Manufacturing Technology*, *40*(11-12), 1077-1083.

[6]. Özek, C., & Ünal, E. (2011). Optimization and modeling of angular deep drawing process for square cups. *Materials and Manufacturing Processes*, *26*(9), 1117-1125.

[7]. Ben Othmen, K., Sai, K., Manach, P. Y., & Elleuch, K. (2017). Reverse deep drawing process: Material anisotropy and work-hardening effects. *Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications*, 1464420717701950.

[8]. Reddy, P. V., Ramesha, J., Rao, P. S., & Ramulu, P. J. (2018). Experimental and numerical analysis on deep drawing rectangular cups made of different anisotropic materials. *Materials Today: Proceedings*, *5*(13), 27171-27177.

[9]. Lim, Y., An, T., Ko, S., & Kim, N. (2016). Formability of coated vinyl on sheet metal during deep drawing process. *Journal of Materials Processing Technology*, *227*, 178-189.

[10]. Ulibarri, U., Gil, I., Mendiguren, J., Galdos, L., & De Argandoña, E. S. (2016). Influence of heat treatments on springback and formability of Inconel 718 alloy in multi-stage deep drawing processes at room temperature. IDDRG.

[11]. Kesharwani, R. K., Panda, S. K., & Pal, S. K. (2015). Experimental investigations on formability of aluminum tailor friction stir welded blanks in deep drawing process. *Journal of Materials Engineering and Performance*, *24*(2), 1038-1049.