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Formability of Tig Welded Sheet Metal Butt Joints

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ABSTRACT: As the demand for different types of sheet metal welded blanks is increasing, the effects of difference in material properties, mechanical properties, forming characteristics, weld properties and its orientation on blank formability become important in various forming processes. Sheet metal welds consists of two sheet metals which are TIG welded together prior to forming. These welded blanks reduces the manufacturing costs and weight and also improves the quality of the components. In this paper experimentation of forming characteristics such as of sheet metal welded blanks of two different materials such as Austenitic Stainless Steel 304 (ASS 304) and mild steel with same thickness are found out. The specimens of sheet metal welded blanks of mild Steel, austenitic stainless Steel 304 (ASS 304) with reference to roll direction 0° and 45°and also 90^0 is prepared and welded using Tungsten Inert Gas welding. In this process the welded sheet metal blank with dimensions is clamped between die surface and blank holder (retaining ring) drawn to cup until the fracture is occurred at dome of cup by the application of force and through continuous movement of hemispherical punch into blank material. The hemispherical punch moves continuously into sheet metal welded blank until the fracture occurs at dome of cup, corresponding cup height at fracture is measured. The cup height at the fracture is taken as measure of formability index. Formability index is expressed as cup height at fracture. The cup height at fracture in millimeters is measured as Erichsen number. It is measure of the capability of the sheet material to be stretched before fracture.

KEY WORDS: Sheet metal welds, Erichsen number, stretchability

I. INTRODUCTION

Research and development in sheet metal forming processes requires lengthy and expensive prototype testing and experimentation in arriving at a competitive product. The overall quality and performance of the object formed depends on the distribution of strains in the sheet material. In selecting material for particular application, a compromise usually must be made between the functional properties required in the part and the forming properties of the available materials. Material properties, geometry parameters, machine parameters and process parameters affect the accurate response of the sheet material to mechanical forming of the component. Sheet metal welds with similar or dissimilar metals maintained major role in the sheet metal forming process. Erichsen number will represent good sign for material usage for producing components. The formability characteristics can be evaluated through different formability tests. The tests are intrinsic tests and simulative tests. In the category of simulative tests such as bending tests, drawing tests, stretching tests and combined mode of tests. The formability characteristics of different sheet metals such as Erichsen number and peak load can be studied from Erichsen cupping tests. This test is under the category of stretching operation [1-3]. In this process the blank is generally pulled over the draw punch into the die; the blank holder prevents to move the flange. There is great interest in the process because there is a continuous demand on the industry to produce light weight and high strength components. Design in sheet metal forming, even after many years of practice, still remains more an art than science. This is due to the large number of parameters involved in stretching and their interdependence. These are material properties, machine parameters such as tool and die geometry, work piece geometry and working conditions. [4-8]. The effect of material properties on formability as the properties of sheet metals varies considerably, depending on the base metal (steel, aluminium, copper, and so on), alloying elements present, processing, heat treatment, gage, and level of cold work. Some processes can be successfully operated using work material that has a wide range of properties. In general, consistency in the forming properties of the work material is an important factor in producing a high output of dimensionally accurate parts.

For optimal formability in a wide range of applications, the work materials should: distribute strain uniformly, reach high strain without fracturing, with stand in plane compressive stresses without wrinkling, with stand in-plane shear stresses without fracturing, retain part shape upon removal from the die, retain a smooth surface and resist surface damage. Some

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production processes can be successfully operated only when the forming properties of the work material are within a narrow range[9-12]. More frequently, the process can be adjusted to accommodate shifts in work material properties from one range to another, although sometimes at the cost of lower production and higher material waste.

II. EXPERIMENT DETAILS

Formability of TIG welded sheet metal butt joints evaluated from Erichsen test. Erichsen cupping test consists of hemi spherical punch, blank holder, die with blank supporting plates. Erichsen cupping test line diagram is shown in fig.2.1. Erichsen number is the one of the forming characteristics of sheet metals under forming operation. This number is evaluated through Erichsen cupping test.

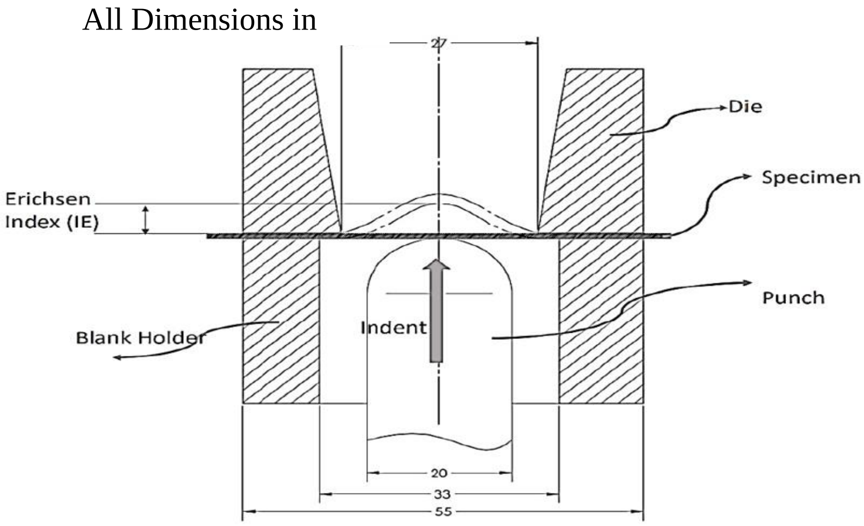


Fig.2.1. Erichsen Cupping Test

This test belongs to stretching operation. In this test the blank (specimen) with dimensions is clamped between die surface and blank holder and drawn to cup until fracture is generated or appears on the dome of the cup by the force applied through continuous penetration of hemispherical punch into the blank material.

The Erichsen cupping test machine is used to evaluate Erichsen number for the sheet metal welded specimens of ASS 304 and Mild steel of dimensions 90 mm x 90 mm and with thickness of specimens of 2 mm. The preparation of specimens of sheet metal welds, which are TIG welded. The sheet metal welded blanks of Mild steel and ASS 304 of the following dimensions 90 mm x 45 mm, three numbers are cut from the sheets with respect to roll direction 0^0,45^0 and 90^0 combined to form a sheet metal welded blank of 90 mm x 90 mm. Fig.2.2 indicates the Mild steel specimen in 0^0 sheet roll direction, Mild steel specimen in 45^0 sheet roll direction, and Mild steel specimen in 90^0 sheet roll direction.

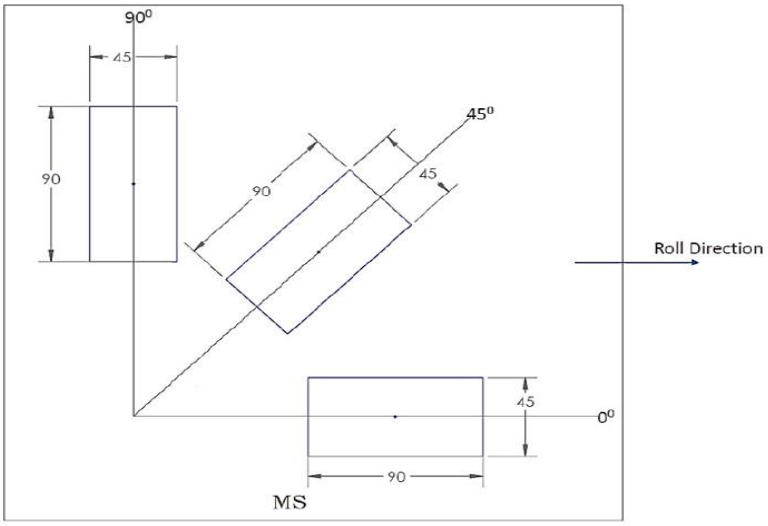


Fig.2.2 Specimens of Mild steel in different sheet roll directions

The same procedure considered for preparation of ASS 304 specimens in same roll directions. After that three specimens are prepared for testing with respect to roll directions through TIG welding is shown in Fig.2.2.

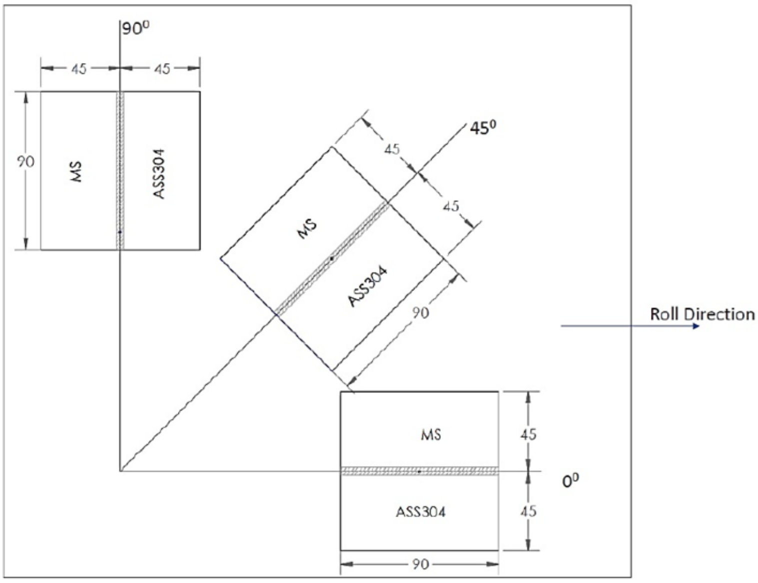
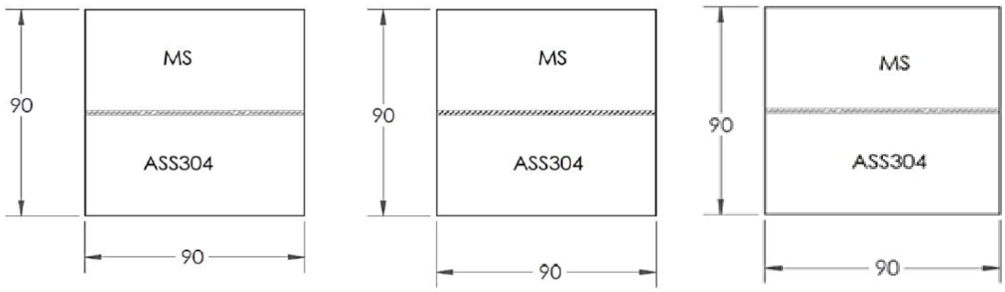


Fig.2.3. Specimens of sheet metal welds of Mild steel & ASS 304 in different sheet roll directions

Fig.2.3 indicates the Mild steel and ASS 304 specimen in 0˚ sheet roll direction, Mild steel and ASS 304 specimen in 45˚ sheet roll direction, and Mild steel and ASS 304 specimen in 90˚ sheet roll direction.



(a) 0° Sheet metal welded blank (b) 45° Sheet metal welded blank (c) 90° Sheet metal welded blank

Fig.2.4 Specimens of 0°, 45° and 90^0 Sheet metal welded blanks for Erichsen Cup test

Fig.2.4 indicates the 0°, 45° and 90^0 Sheet metal welded blanks used in Erichsen Cup test to determine Erichsen Number. The final dimension of Sheet metal welded blanks made of Mild steel and ASS304 is 90 mm x 90 mm in two specimens with thickness 2mm, which are TIG welded. Each specimen of sheet metal welded blanks is 90 x 90 mm is tested through Erichsen cupping test. In this process the hemispherical punch moves continuously onto the sheet metal welded blank and cup height is measured at point of fracture on the dome of the cup. The fracture occurred in deformed cup at near and around weld region. The height of the cup at the fracture is taken as measure of formability. Erichsen number is indicated by the height of the cup at the fracture, measured in millimeters. Height of the cup at the fracture gives the formability index.

III. RESULTS AND DISCUSSION

Erichsen Number is determined for 0°, 45°and 90^0 sheet metal TIG welds specimens. Erichsen number is denoted by k, Erichsen number is used for measuring the formability of sheet metal welds. Stretchability of sheet metal welds specimens is known through the height of the deformed cup at fracture. The summarized results are shown in Table 1

Table 1. Summarized Results - Erichsen test

Sheet roll direction of sheet metal welds	Formation of cup until fracture (Cup height at fracture)(mm)	Erichsen Number (mm)
0^0	10.23	10.23
45^0	13.56	13.56
90^0	14.89	14.89

Erichsen number for 0° is 10.23 mm, 45° is 13.56 mm and for 90^0 is 14.89. The variation of Erichsen number for these specimens shows that $k_0 < k_{45}$, $k_0 < k_{90}$. The variation of Erichsen number is obtained for sheet metal welds with different roll directions.

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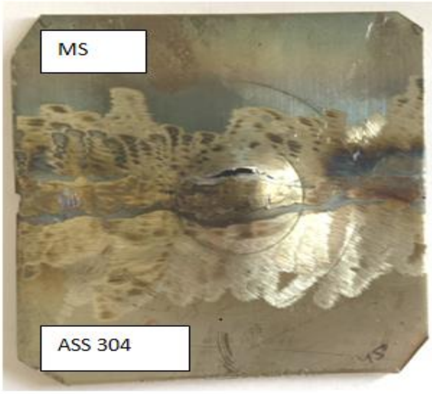

Fig.3.1 Deformed sheet metal butt weld specimen from Erichsen cupping test

The sample of deformed specimen (45^0) of sheet metal welded butt joint obtained from Erichsen test is shown in fig.3.1.

IV. CONCLUSIONS

- Erichsen number is found to increase with increase in angle of roll direction of sheet.
- Erichsen Number has been determined for Sheet metal welded blanks of MS and ASS 304 with respect to roll directions 0° and 45° and also 90^0.
- Erichsen number obtained for zero degree is 10.23 mm and forty five degree is 13.56 mm of sheet metal welds.
- Formability Index obtained for 90 degree sheet weld is 14.89 mm.
- Higher Erichsen number is obtained in 45 degree sheet metal welds is comparison with. 0 degree sheet metal welds. It is higher by 32.55% compared to 0 degree sheet metal welds.
- Erichsen number represents formability of sheet metals
- The higher value of Erichsen number in the Specimen with 90° Sheet metal welded blanks among three sheet roll directions, it shows greater formability.
- Lesser formability is noticed in 0° Sheet metal welded blanks as it has lowest Erichsen number of 10.23 mm.

REFERENCES

[1]. Thomas Mennecart, Deepet al, "Drawing and stretching of High-Strength Tailored Blanks by Using Tailored Tools, Materials (Basel)", 2016.
[2]. D. Anand, Forming Behaviour of Tailor (Laser) Welded Blanks Of Automotive Steel Sheet, The Canadian Journal of Metallurgy and Materials Science, pp 189-198, 2013
[3]. OM Rodrigues, Formability of steel and aluminium tailor welded blanks, Welding in the World, 2007.
[4]. M.Habibi, Experimental investigation of mechanical properties, formability and forming limit diagrams for tailor-welded blanks produced by friction stir welding, Journal of Manufacturing Processes, Pages 310-323, 2018
[5]. Brad Kinsey, Forming of Aluminum Tailor Welded Blanks, SAE Technical Paper 2001
[6]. Behrouz Bagheri, Comparison of different welding methods on mechanical properties and formability behaviors of tailor welded blanks (TWB) made from AA6061 alloys, Journal of Mechanical Engineering Science, 2020.
[7]. Abou Bakr Elshalakany, An experimental investigation of the formability of low carbon steel tailor-welded blanks of different thickness ratios, The International Journal of Advanced Manufacturing Technology, volume 88, pp.1459 –1473, 2017
[8]. Aminzadeh A, Safari A, Parvizi A, Experimental Study of Weld Line Displacement and Drawing Depth in TWBs Steel Sheets Manufactured by Laser and Friction Stir Welding Modares Mechanical Engineering. **Volume 19, Issue 9, 2019.**
[9]. Dey, Ronit, Formability of tailor welded blanks produced by friction stir welding - a study on the effect of tool pin profile and eccentricity, Journal of Mechanical engineering, Vol 10, issue10, pp.78-85, 2006
[10]. Marco Parent, A study on the formability of aluminum tailor welded blanks produced by friction stir welding, The International Journal of Advanced Manufacturing Technology, Vol. 10, issue 11, pp.65-72, 2016.
[11]. A. Karpagaraj, N. Siva Shanmugam and K. Sankaranarayanasamy, Studies on mechanical behavior and microstructural analysis of tailor welded blanks of Ti–6Al–4V titanium alloy sheet, Journal of Materials Research, pp.112-117, 2016
[12]. Hareshkumar O. Dabhi: Experimental and Numerical Investigation of Tailor Welded Blanks [TWBs], International Journal of Advanced Mechanical Engineering, pp. 589-599, 2014