

Formability of Sheet Metal Blanks by Erichsen Cup Test

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Abstract— Sheet metal blanks are used in almost all the Automotive, Aircraft, Ship and Navy applications to create complex geometric shaped components and to meet the present trends. So that sheet metal blank should be formed into the desired shaped component. This can be achieved by various sheet metal operations. Before forming the sheet metal blank into the desired shaped component it is necessary to know its formability.

Erichsen cup test is one of the currently used formability tests, which is carried out to evaluate the ability of sheet metal to be formed into useful components successfully. In this operation the test piece is pressed into the die by means of a penetrator having a spherical head, until the fracture is obtained. The depth of penetration there by obtained is measured as Erichsen number. This Erichsen number indicates formability index of the sheet metal.

Keywords— Sheet Metal Blank, Erichsen Test, Stretching, Forming, Formability and its Index.

I. INTRODUCTION

Rolling is the process of plastically deforming the metal billet by passing it between the rolls as shown in fig.1. It is most widely used forming process, which provides very high production and close control of the final product.

Rolling processes are mainly divided into

- 1) Hot rolling and 2) Cold rolling.

Hot rolling is a mill process in which rolling of the metal at a high temperature (above the recrystallization temperature) is done. When the metal is above its recrystallization temperature, it can be shaped and formed easily with very less amount of forces compared to cold working. Hot rolled steel is cheaper than cold rolled steel because of the fact that it is often manufactured without any delays in the process, and therefore the reheating of the steel is not required (it is required in cold rolling). When the metal cools off it will shrink a little thus giving less control on the size and shape of the finished product compared with cold rolling[1]. Hot rolled steel is used where precise shapes and tolerances are not required. This method is used in Railway tracks, I-Beams etc.,

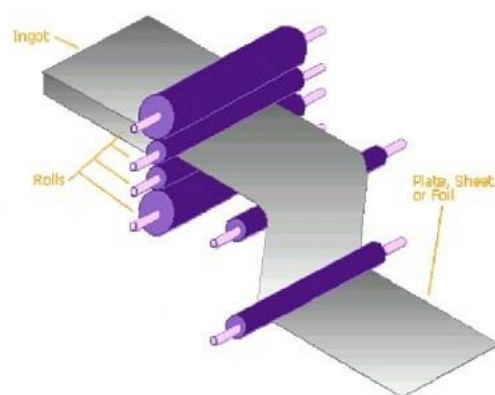


Fig. 1 Rolling Process

Cold rolled steel is much essentially hot rolled steel that has further more processing. The metal is processed further in cold reduction mills, in which the material is cooled to the room temperature, followed by annealing and/or tempers rolling [2]. This process will produce the metal with much closer dimensional tolerances and with a wide range of

surface finishes. This process results in higher yield points with better surface finishes. Any projects in which tolerances and surface conditions are the major factors are cold drawn. There is a continuous demand in the industry to produce light weight and high strength components [1-2].

Welding is the process of joining two or more metal pieces together so that bonding takes place at their original boundary surfaces. The welded joint is formed by applying heat or pressure or both with or without filler metal for the formation of sound joint. Metal pieces are heated to plastic state and then external pressure is applied to form the joint is said to be plastic welding or Pressure Welding. The metal pieces to be joined are placed side by side and heated to molten state and then allowed to solidify to have a permanent joint is said to be molten state welding or Fusion Welding. Though we have many types of welding techniques in our paper we selected TIG welding and Gas Welding Processes for our research work to weld hot rolled and cold rolled sheets together and then they are tested for their formability.

Formability can be defined as the ability of material by which it can be deformed without failure [8]. More the formability more will be the deformability before its failure. Formability of a sheet can be determined in many experimental methods.

Some of the tests are Bending Test, Erichsen Cup Test, Swift Cup Test, Fukui Cup Test, Hydraulic (Viscous Pressure) Bulge Test etc.,[9-10]. The formability characteristics of different sheet metals such as erichsen number and peak load can be studied from erichsen cupping tests[1-2]. This test is under the category of stretching and drawing test [2-3]. The overall quality and performance of the object formed depends on the distribution of strains in the sheet material. Material properties, geometry parameters, machine parameters and process parameters affect the accurate response of the sheet material to mechanical forming of the component [4-5].

The material properties affect the formability because of the fact that the properties of sheet metals varies considerably during the forming process. As well as depending on the base metal i.e steel or Aluminium or copper and on the alloying elements present, Processing method of metals, heat treatment and the level of cold work the forming behavior will be [6-7]. Though we have many types of formability tests in our paper we discussed formability of sheet metal by conducting Erichsen Cup Test.

II. METHODOLOGY

In this research the following four sheet metal specimens of 2 mm thick are considered. On these specimens Erichsen cup test is performed to determination of formability.

Hot Rolled Steel Sheet as show in Fig.2

Cold Rolled Steel Sheet as show in Fig.3

TIG Welded Sheet (Hot Rolled & Cold Rolled) as show in Fig.4

Gas Welded Sheet (Hot Rolled & Cold Rolled) as show in Fig.5

This experiment was performed on an Erichsen Sheet Metal Testing Machine of model: VET – 20, of the following specifications.

Machine Specifications:

Size of the sample is 70 × 70 mm

Thickness of Sample is 0.2 to 2 mm

Least count of micrometric device is 0.01/0.02 mm

One turn of hand wheel is 1.25 mm advance

Weight of appliance is 20 kgs

Overall measurement is 450×500×500 mm

Bottom plate is 245×225 mm

Screw holes in bottom plate is Ø12 mm

Distance of screw hole centres is 200×200 mm

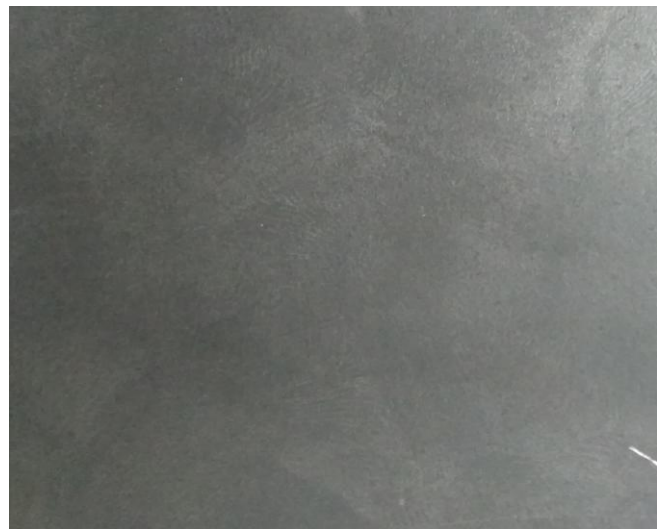


Fig.2 Hot Rolled Steel Sheet



Fig.3 Cold Rolled Steel Sheet



Fig.4 TIG Welded Sheet (Hot Rolled & Cold Rolled)



Fig.5 Gas Welded Sheet (Hot Rolled & Cold Rolled)

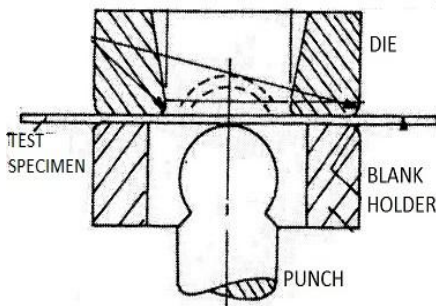


Fig.6 Principle of Erichsen Cup Test

Thickness of the sheet metal selected is 2 mm
Diameter of the spherical head penetrator is 20mm

The Erichsen cup test (Fig.6) is one of the formability tests, which is performed to evaluate the formability of metallic sheets and strips to undergo plastic deformation in stretch forming. The test consists of forming an indentation by pressing a punch with a spherical end against a test piece clamped between a blank holder and a die, until its failure (crack appears). Then the depth of the cup is measured. This is used to measure the formability.

III. RESULTS AND DISCUSSIONS

The Erichsen Cupping Test experiment was performed on various sheet metal blanks individually and the blanks made by TIG (both hot rolled and cold rolled) and Gas welding (both hot rolled and cold rolled). The deformed cups of the 4 specimens of Hot Rolled Sheet (Fig.7), Cold Rolled Sheet (Fig.8), TIG welded both hot and cold rolled sheet (Fig.9) and Gas Welded both cold and hot rolled sheet (Fig.10) are follows.



Fig.7 Hot Rolled Steel Sheet after deformation



Fig.8 Cold Rolled Steel Sheet after deformation



Fig.9 TIG welded sheet (both hot rolled and cold rolled) after deformation



Fig.10 Gas welded sheet (both hot rolled and cold rolled) after deformation

Ericksen No. for Hot Rolled Steel Sheet =13.90 mm
 Ericksen No. for Cold Rolled Steel Sheet= 12.03 mm
 Ericksen No. for TIG Welded Sheet (Hot Rolled & Cold Rolled) = 9.24 mm
 Ericksen No. for Gas Welded Sheet (Hot Rolled & Cold Rolled) = 4.90 mm

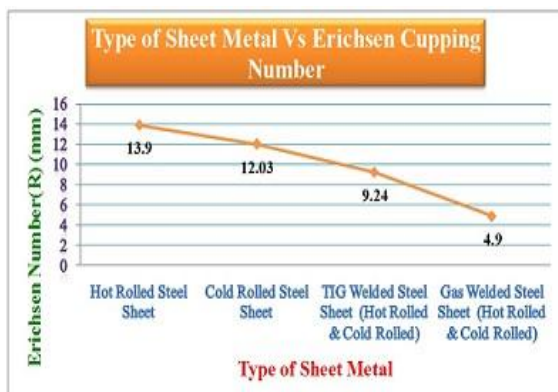


Fig. 11 Comparison of Formability of Sheets

In the Erichsen cupping test four sheet metals tested and the Comparative results are shown in Fig.11

For the same thickness of 2mm Hot Rolled and Cold Rolled steel sheets the Erichsen Number (R) was found out to be higher for the Hot Rolled steel sheet than that of a Cold Rolled steel sheet.

On the other hand for the same thickness of 2mm TIG welded sheet (Hot Rolled & Cold Rolled) and Gas welded sheet (Hot Rolled & Cold Rolled) the Erichsen Number (R) was found out to be higher for the TIG welded sheet (Hot Rolled & Cold Rolled) than that of a Gas welded sheet (Hot Rolled & Cold Rolled).

From the results it is confirmed that Erichsen Number (R) decreases gradually from Hot Rolled steel sheet to Cold Rolled steel sheet and followed by TIG welded sheet (Hot Rolled & Cold Rolled) to Gas welded sheet (Hot Rolled & Cold Rolled) which indicates the decrease in formability i.e., bad stretching formability.

IV. CONCLUSIONS

When choosing a material for forming it into the desired shape, it is important to know the formability. Formability can be obtained by conducting Erichsen Cup Test. Following are the few factors of steel that are been evaluated and concluded through Erichsen Formability Test.

In the Erichsen cupping test, the cup height at the fractures is measured. Cup height at the fracture in mm is measured as Erichsen number. This is used as a measure of formability index.

The Erichsen number obtained for Hot Rolled steel sheet is more than Cold Rolled steel sheet metal. Higher in the Erichsen number is higher formability index. Hence better formability is obtained in Hot Rolled steel sheet metals.

The Erichsen number obtained for TIG welded sheets are more than Gas welded sheet metals. Higher in the Erichsen number is higher formability index. Hence better formability is obtained in TIG welded sheet metals.

Comparing the values of Erichsen number for four specimens, the Erichsen number is high in Hot Rolled steel sheet metals. So this Hot Rolled steel sheet metal has better formability nature.

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