Evaluation of Mechanical Properties of Tailor Welded Sheet Metal Blanks

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Abstract. A tailor welded blank consists of two or more sheet metals which are welded together prior to forming. The sheets which are welded together may be different in size, shape and even in thickness also. The blanks may be also differing in sense of coating and material grade also. This different blanks are welded together to form into one continuous blank. In industries since last long years the materials which are used for preparing tailor welded blanks in general are combinations of mild steel to stainless steel with different grades. Also the common materials which are used for making tailor welded blanks are generally aluminium alloys with different grades or it may be combination of aluminium and steel alloy sheets. Most tailor welded blanks today embody a multiple thickness design in order to eliminate the use of extra reinforcing components. The advantages of using tailor welded blanks are numerous, they ensure that the components are light, stronger, and provide required functionality at lower cost than parts made from monolithic pressed sheets, as well as improving structural integrity, safety and corrosion resistance in specific areas. In an automotive application, Tailor welded blanks eliminate the need for reinforcement, resulting in an overall reduction in vehicle body weight. The use of different strength or thickness in a single part can simplify the whole structure of a vehicle. Low car weight means improved fuel economy that is very important to today’s energy consumption. Decrease of automobile parts number. This paper presents the tailor welded blanks of steel alloys tensile specimens are prepared and tested through uniaxial tensile test. Determined mechanical properties of tailor welded sheet metal blanks and also studies done on those properties.

Keywords: Tailor welded blanks, Mechanical properties, TIG welding.

1. Introduction

The material selection criteria depends on the results of tensile tests for applications of engineering. The specifications of materials are included in tensile properties for ensure the quality of products. The study of behavior of material under varying loads apart from uni-axial tension(1-5). The primary concern of material is generally strength of materials. The strength is measured in terms of stress, it is caused to plastic deformation of material. The ductility also another important parameter, which is study of material
deforms before it fracture. Stress, strain, ductility and toughness are maintained major role in engineering design of material(6-10). The tensile specimen is gripped at its shoulders in tensile testing machine for study the mechanical properties. Deformation is considered in gauge length and cross sectional area of gauge section within tensile specimen. The failure is generated in gauge section such as neck deformation and fracture. Gauge length, thickness, width and cross sectional area of specimen is measured after its fracture. Material flow will be depends on stress and strains are generated in it. It is studied with the help of true stress and true strain curves. The strengthening of doors is requires of reinforcements, this is obtained from general workshop. The elimination of these reinforcement in doors, presently introduced with tailor welded blanks, which are in the form of large, thin, thick sections. This will improves in functional performance of components and sections(11-13). Structural rigidity and corrosion resistance are improved in steels due to using of tailor welded blanks. These tailor welded blanks are prepared from two or more materials sheets are welded together prior to forming. These blanks are with different size, thickness and also in different welding processes(14-15). The characteristics of tailor welded blanks are influenced by various welding processes.

2. Experimental Methodology
In Mechanical properties and forming characteristics curves of tailor welded blanks (TWBs) are evaluated through calibrated uniaxial tensile testing machine. The tensile specimens of Tailor Welded Blanks are prepared as per ASTM standard. The tensile specimens made of Stainless steel 304 and Mild Steel. Joining of these two material blanks through TIG welding process. These two material pieces were selected and cut into rectangular shape required dimensions. These two rectangular pieces were welded through TIG welding process. From these joined pieces, prepared Tensile specimens of TWB. One of these tensile specimen with the weld is perpendicular direction of tensile loading that is called horizontal weld and second tensile specimen the weld is parallel(along) to the direction of tensile loading that is called vertical weld. These Tailor Welded Blanks of both combination of these materials are subjected to uniaxial tensile test, through which various mechanical properties such as yield strength, ultimate tensile strength, percentage elongation, peak load, and forming characteristics curves are obtained and studied. In this methodology the number of samples are prepared for testing is two, this is based on weld orientation such as horizontal weld and vertical weld.

2.1. Material selection
There are two alloys of materials used. The details and the composition are:
(a) Stainless steel 304 - Composition : chromium -18% , nickel-8% and carbon 0.08%.
   This alloy also called chromium nickel austenitic alloy.
(b) Mild steel - Composition : carbon -0.16 % -0.18%, manganese -0.75 - 0.9%, silicon -0.4%,
    sulphur -0.04%, phosphorous -0.04%.
Tailor Welded Blank is the combination of both steel alloys of stainless steel 304 and mild steel.

2.2. Tailor welded blank (Horizontal weld )
It is combination of both Mild steel and Stainless steel 304 and the weld is perpendicular to the gauge length of tensile specimen. The weld is perpendicular to direction of Tensile loading. The tensile specimen of Tailor Welded Blank is prepared according to ASTM standard as shown in fig.1 before uniaxial tensile test.
The test performed on this tensile specimen of tailor welded blanks (TWBs) through uniaxial tensile testing machine. The Stainless steel 304 is in fixed position and Mild Steel is in movable position. The tensile specimen after performing uniaxial tensile test as shown in fig.2. The failure is occurred in mild steel region, because it is weakest zone compared to steel zone. The mechanical properties are determined and also obtained forming characteristics curves. The studies done on these parameters.

![M.S S.S 304](image)

**Figure 2**: Tailor welded blank with horizontal weld after tensile test

### 2.3. Tailor welded blank (Vertical weld)

It is combination of both Mild steel and Stainless steel 304 and the weld is parallel to the gauge length of tensile specimen. The weld is parallel to direction of Tensile loading. The tensile specimen of Tailor Welded Blank is prepared according to ASTM standard as shown in fig.3 before uniaxial tensile test. The test performed on this tensile specimen of tailor welded blanks (TWBs) through uniaxial tensile testing machine. The Stainless steel 304 is in fixed position and Mild Steel is in movable position.

![M.S S.S 304](image)

**Figure 3** Tailor welded blank with vertical weld before tensile test

The tensile specimen after performing uniaxial tensile test as shown in fig.4. The failure is approximately in the centre of the sample. The mechanical properties are determined and also obtained forming characteristics curves. The studies done on these parameters.

![M.S S.S 304](image)

**Figure 4** Tailor welded blank with vertical weld after tensile test
3. Results and Discussion
The evaluation of mechanical properties and forming characteristics curves of Tailor welded blank (TWB) through computerized tensile testing machine.

Tailor welded blank: Horizontal weld and vertical weld

The input parameters considered for the test are as follows.

| Specimen shape | Flat |
| Material Type  | Stainless steel 304+ Mild Steel |
| Sample Name    | Stainless steel 304+ Mild Steel |

**Table.1.** Input parameters for test on tensile specimen of tailor welded blank

| Type of weld  | Width (mm) | Thickness (mm) | Gauge Length (mm) | Pre-Load Value (kN) | Max. Load (kN) | Max. Elongation (mm) | Cross Section Area (mm²) |
|---------------|------------|----------------|-------------------|---------------------|----------------|---------------------|------------------------|
| Horizontal    | 12.52      | 0.91           | 50                | 0                   | 200            | 200                 | 11.39                  |
| Vertical      | 12.55      | 1.77           | 50                | 0                   | 200            | 200                 | 22.21                  |

The Uni-axial tensile test of Tailor Welded Blank, the observations are made from test and also the following parameters are evaluated.

**Table.2.** Observations are made from test

| Type of weld  | Load at Yield (kN) | Yield Stress (N/mm²) | Load at Peak (kN) | Tensile strength (N/mm²) | Final Gauge Length (mm) | Elongation (%) |
|---------------|--------------------|----------------------|-------------------|--------------------------|--------------------------|---------------|
| Horizontal    | 2.93               | 257.171              | 4.43              | 388.82                   | 59.58                    | 19.16         |
| Vertical      | 4.64               | 208.882              | 7.710             | 347.086                  | 55.88                    | 11.76         |

The stress strain curve for the tailor welded blank horizontal weld material as shown in fig.5. From Fig.5 the strain increases with increase in stress up to ultimate tensile strength. After this point the tailor welded blank horizontal weld gets into failure (neck formed), then stress decreases with increase in strain and finally fracture is obtained in the metal.
Figure 5: Stress - strain curve for tailor welded blank with horizontal weld.

The Load and Displacement curve as shown in Fig. 6. From Fig. 6 it is observed that the load increases with increase in displacement of the material up to neck formation (failure) and after that load gradually decreases with increase in displacement till fracture is generated in the material.

Figure 6: Relation between load and displacement (CHT - Cross Head Travel) for tailor welded blank with horizontal weld.
The stress strain curve for tailor welded blank vertical weld material as shown in fig.7. From Fig.7 The strain increases with increase in stress initially up to ultimate tensile strength. After this point the Tailor Welded Blank with vertical weld gets into failure (neck formed) , then stress sharply decreases with increase in strain and finally fracture is obtained in the metal.

Figure 7: Stress - strain curve for tailor welded blank with vertical weld.

The Load and Displacement curve as shown in fig.8. From Fig.8 it is observed that the load increases with increase in displacement of the material up to neck formation (failure) and after that load sharply decreases with increase in displacement till fracture is generated in the material.

Figure 8: Relation between load and displacement (CHT - Cross Head Travel) for tailor welded blank with vertical weld.
4. Conclusions
The uniaxial tensile test performed on combination of tailor welded blank of mild steel and stainless steel 304 with different weld line orientation. The tensile specimens made of different material. The materials are selected are stainless steel 304, mild steel and combination of these two materials as tailor welded blanks with TIG welding. The experimental investigations on mechanical properties such as yield strength, ultimate tensile strength, peak load, percentage elongation and ductility are evaluated and also forming characteristics curves are obtained.

The conclusions of present research work as follows.

Mechanical Properties:
- Yield stress is higher in horizontal weld (Horizontal weld means the weld line is perpendicular to gauge length) compared to vertical weld (Vertical weld means the weld line is parallel to gauge length).
- Horizontal weld shows a higher tensile strength value than vertical weld.
- Ductility is measured in percentage of elongation
- Ductility shows a higher value for horizontal weld than vertical weld.
- Peak load is lesser in horizontal weld compared to vertical weld

In the analysis, it is obtained that better in acceptable mechanical properties in the horizontal weld i.e., the weld line which is perpendicular to the gauge length of the tensile specimen than with the vertical weld i.e., the weld line is along the gauge length.

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