

## International Journal of Innovative Research in Science, Engineering and Technology

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# Simulation and Experimental Study of Weld Induced Distortion of Butt Joint

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**ABSTRACT:** Welding is widely utilized as a main technique for manufacturing and amassing various metal items, for example, in shipbuilding, development, avionics and car ventures. One well known circular segment welding process, gas metal bend welding (GMAW), has been connected in a wide scope of plate thicknesses because of its ease and moderately high efficiency. Welding is considered as the most effective, trustworthy and affordable methods for creation to join metals for all time. So prediction of distortion before welding is of great importance for the setting techniques. The present project work can give the prediction of distortion. It has been found out the limit of angular distortion for three types of design for different thickness of plates i.e. 6 mm, 5 mm and 4 mm. with 1200, 900, and 600 Vee. These values of distortion will help the welder before welding to the present job and hence minimize distortion. But, still there is lack of information of this study.

**KEYWORDS:** Simulation, Butt joint, GMAW, Finite element method

### I. INTRODUCTION

#### 1.1 Introduction:

Welding is widely utilized as a main technique for manufacturing and amassing various metal items, for example, in shipbuilding, development, avionics and car ventures. One well known circular segment welding process, gas metal arc welding (GMAW), has been connected in a wide scope of plate thicknesses because of its ease and moderately high efficiency. Welding is considered as the most effective, trustworthy and affordable methods for creation to join metals for all time. In any case, mutilation is every now and again experienced because of the welding procedure that unfavourably influences the dimensional precision and aesthetical worth, which can prompt costly medicinal work and, in this manner, increment the manufacture costs. In Ref. [1], expectation of welding disfigurements in butt joint of slender plates was led utilizing thermo-versatile plastic limited component strategies, and contrasting the outcomes and the test and observational techniques.

**1.2 Structural Steel and Analysis:** Structural steel has a pivotal position in civil engineering. It is widely employed in the constructions of high-rise buildings, bridges, stadiums and offshore structures due to its high strength-to-weight ratio, easy prefabrication properties and attractive appearance. Currently, most of the existed steel structures are constructed by using normal strength steel with nominal yield strength up to 460 MPa. However, with higher requirements in architectural and structural design, normal strength steel is not always capable of delivering the most sustainable and economic solution in many applications in which the self-weight of the structure is critical [1].

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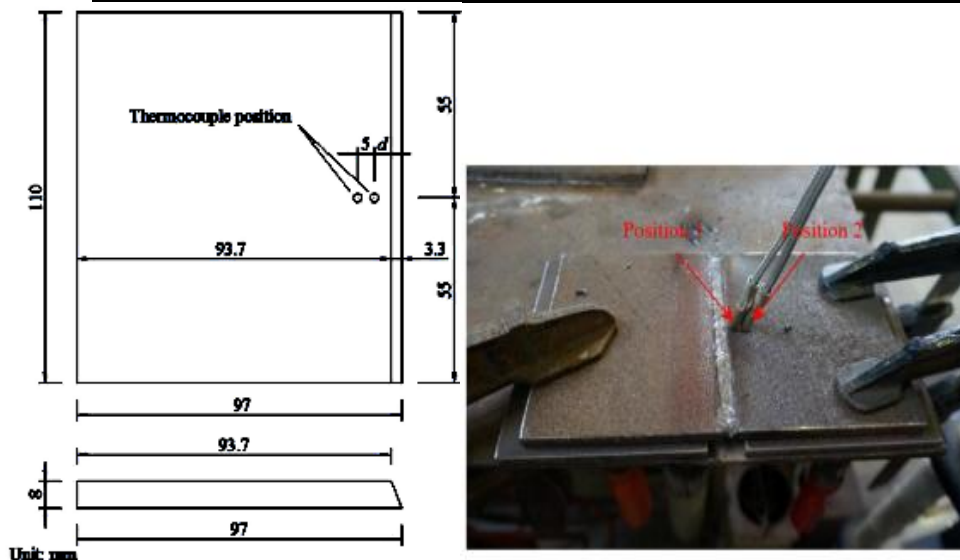
**1.3HAZ Tensile Strength:** Hochhauser and Rauch found that the width of soft layer ranged from 0.33 to 0.6 times of the specimen thickness, and the reduction of tensile strength of butt joint was 3% to 8% of its original strength. When conducting numerical simulation of the welding process, one of the most complicated modelling parameters is the material property of the HAZ. The size of the HAZ is estimated by using hardness

**Table 1: Mechanical Properties of S690 HSS and Weld Metal**

Material	Elastic modulus (GPa)	Yield strength (MPa)	Ultimate tensile strength (MPa)	Elongation (%)
S690Q HSS	209	745	838	14.5
LB 80 L	210	767	848	22.0

**Table 2: Chemical Composition of S690 HSS and Weld Metal**

Elements	C	Si	Mn	P	S	Ni	Mo	CE
S690Q HSS	0.14	0.40	1.35	0.012	0.003	0.01	0.12	0.40
LB 80 L	0.05	0.56	1.37	0.009	0.005	2.77	0.76	0.33



**Fig.1: Plate configuration and thermocouple position**

He welds material LB-80 L was utilized as filler for welding and it satisfies the AWS A5.5 E11018-G filler metal determination. The mechanical properties of the S690Q HSS and filler weld metal are listed. The comparing substance structure and carbon equivalent (CE) are recorded. It very well may be seen that the quality of weld metal matches with that of S690Q HSS. Two distinct cathodes with width of 3.2 mm and 5.0 mm were used to accomplish diverse welding

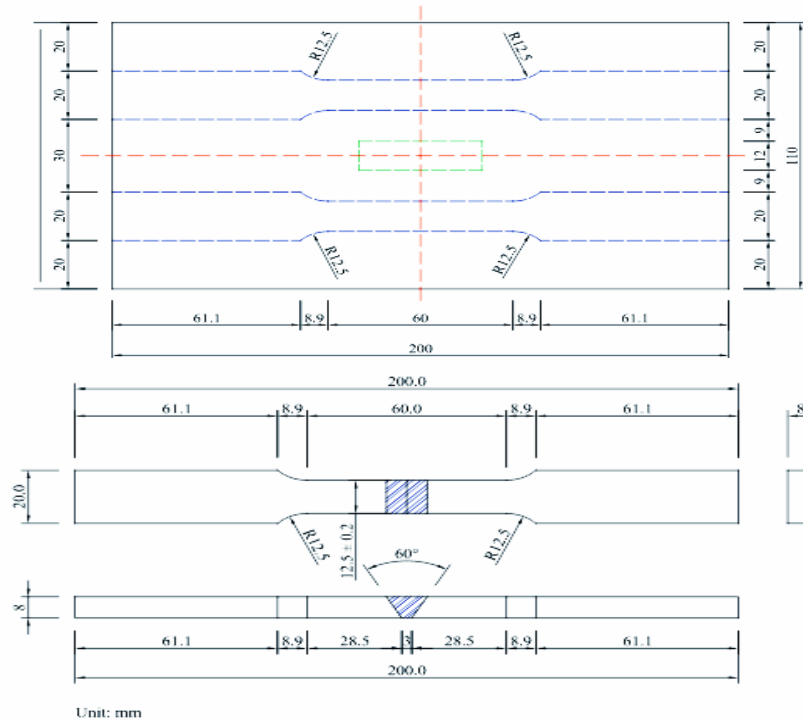
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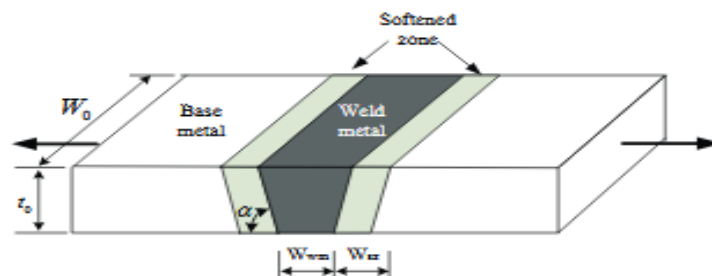
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heat inputs. The two butt joint examples were individually named as BJ-3.2 and BJ-5.0 for 3.2 mm and 5.0 mm terminals welding. The temperature history close to the weld was recorded by two thermocouples.



**Fig.2:**Dimension of coupons and cut out block for hardness, micro-hardness and tensile test



**Fig 3:**Welded joint with a softened zone and explanation for denotations

**1.3Effect of Distortion:** It is noticed that warmth doesn't happen consistently on a work piece while welding procedure is continued. Therefore, a nearby leftover pressure (warm pressure) has been created on that work piece because of shrinkage of weld contortion. Subsequently twisting is an eventual outcome of combination welding and it results change fit as a fiddle of collected parts contrasted with what these were before welding. So obviously the estimation of any activity was to the structure determination before welding isn't same a while later.

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## 1.4 Thermal Properties:

### a. Coefficient of Expansion

Higher coefficient of thermal expansion means higher amount of expansion, when heated and greater subsequent contraction when cooled. High coefficient of thermal expansion tends to increase the shrinkage of the weld metal and the metal adjacent to the weld.

### b. Thermal Conductivity

Thermal conductivity is a measure of heat flow, lower the thermal conductivity steeper the temperature gradient. Hence increases distortion.

### c. Yield Point of the Material

Higher the yield strength of material in the weld territory, more prominent will be the leftover pressure that can demonstrate to twist the weld get together. Then again, bring down the yield point, less serious the conceivable mutilation. Additionally, stress strain relationship at the raised temperatures digressed significantly from the glorified flexible plastic relationship at room temperature. The coefficient of straight extension diminishes to focus in the range between 1200-1500°F and afterward expands again to the high esteem.

## Classification of distortion and its analysis

Welding Distortion can be classified into following group:

1. Longitudinal shrinkage
2. Transverse shrinkage
3. Angular distortion
4. Bowing

## II. EXPERIMENTAL WORK

Experimental were designed for measuring the following distortion of butt weld joints having different types of weld details and different thickness(e.g. 6 mm, 5 mm & 4 mm) of the plates.

1. Angular shrinkage
2. Longitudinal shrinkage
3. Transverse shrinkage
4. Bowing

The magnitude of above distortion was obtained by measuring the distance of the points which is punched on the plates, from three rectangular axis, X, Y and Z, before and after welding.

### 2.1 Test Plate Preparation

Thirty-six quantities of 6mm thickness test plates were cut by power hacksaw from a moved Indian standard plate, ISP 16, having material particular gentle steel (IS 226) and EN-31. At long last each plate of each side was machined in shaper machine to a size of 120 mm x 60 mm x 6 mm according to checking. Six plates of M.S. also, EN-31 of thickness 6mm is diminished to 5mm through pounding. Thus, six plates of M.S. also, EN-31 of thickness 6mm is diminished to 4mm through crushing. The jobs were numbered from- W1, W2, W3, W4, W5, W6, W7, W8, W9, W10, W11, W12, W13, W14, W15, W16, W17 & W18. The horizontal lines are marked on the job as AA, BB, CC, DD and EE from the top and the vertical lines are marked as 1-1,2-2,3-3,4-4,5-5,6-6,7-7 and 8-8 from left to right of the job.

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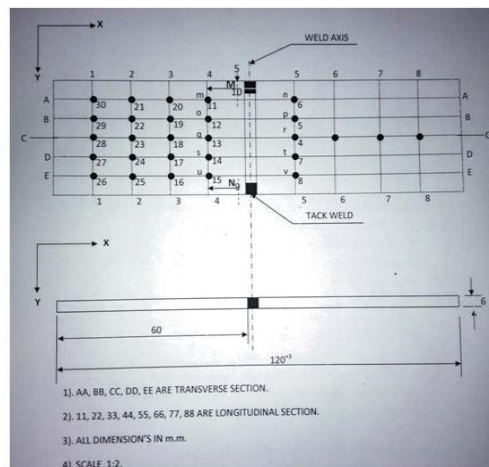


Fig. 4. Figure of Layout of gauge points

### 2.2 Apparatus Used

To measure the several types of distortions discussed earlier following apparatus and accessories were used.

- Dial indicator with universal stand. (Least count 0.001 mm.)
- Vernier caliper. (Least count 0.02 mm.)
- Lens (focus 100 mm.)
- Punch (made by carbon steel material)
- Try square (least count 1 mm.)
- Spirit level (made by cast iron)
- Knife-edge (made by carbon steel material)
- Steel-scale (least count 0.5 mm.)
- Height-gauge (made by stainless steel material)
- Ground angle plate (made by cast iron)

### 2.3 Machine Used

For preparation the work piece following machines are used.

1. Power Hacksaw: Model No.-HS 30

#### Specifications:

- Stock length for blade 325\*38\*2 mm. made by high speed steel.
- 3 phase power supply
- Heavy duty machine
- Cutting pressure- 1 to 10 kg/cm<sup>2</sup>

2. Shaper Machine: Modal No. CSM-63

#### Specifications:

- Max. Length of stroke – 630 mm.
- Max. Horizontal travel of table – 650 mm.
- Max. Travel of table – 370 mm.
- Minimum travel of tool – 105 mm.

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- Floor space – 2200\*127 mm.
- Driving motor power – 2.2 KW.

### 2.4 Welding Condition

Welder's efficiency	:	More than 80%
Position	:	Flat (Horizontal)
Welding speed	:	0.06 m/min (normal speed)
Current	:	80-100 amps (AC)
Voltage	:	100 volts
Electrode size	:	3.15mm.
Process applied	:	Manual metal arc welding.

### Detail of Electrode-(SWG 10)

**SWG** – Standard wire gauge  
**Size** – 3.15mm.( $\phi$ ) x 450 mm.(L)  
(Flux coated for mild steel)

## III. RESULT AND DISCUSSION

3.1 There are nine photographs 4.4.6.1 of EN-31 Plate of dimension 120mmX60mmX6mm. The thickness of the plates has to be made as mentioned in the photographs. Vee grooves are also to cut on these plates as mentioned in the photographs. These pictures are taken after cutting the plates from the length of bar.



**Fig. 5.**Figure of EN-31 plate of dimension 120mmX60mmX6mm

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There are nine photographs in 4.4.6.2 of Mild Steel Plate of dimension 120mmX60mmX6mm. The thickness of the plates has to be made as mentioned in the photographs.



Fig. 6. Figure of M.S. plate of dimension 120mmX60mmX6mm



Fig. 7. Figure of M.S. plate of dimension 120mmX60mmX5mm



Fig. 8. Figure of M.S. plate of dimension 120mmX60mmX4mm

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Photographs from 4.4.6.7 to 4.4.6.12 of EN-31 Plate and Mild Steel Plates are taken after making notch marking, punching and tack welding of the plate.



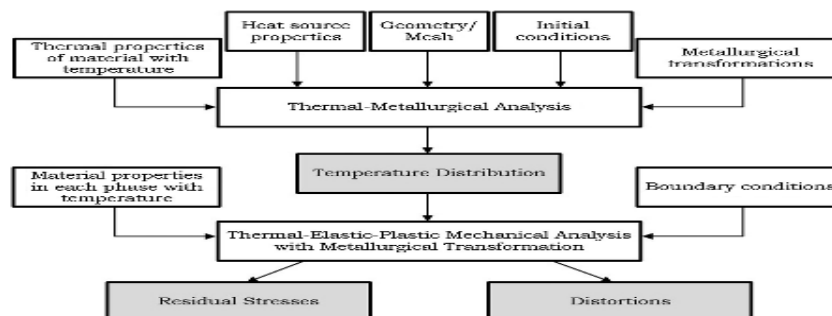
**Fig. 9.**Figure of EN-31 plate of dimension 120mmX60mmX6mm



**Fig. 10.**Figure of EN-31 plate of dimension 120mmX60mmX5mm

### 3.2 Finite Element Analysis

A 3D limited component model was created utilizing the commercial code SYSWELD. A consecutively coupled thermo-metallurgical-mechanical limited component count was connected to anticipate the welding actuated leftover pressure and welding mutilation for four different welding processes. Illustrates the flowchart where coupling between warm investigation and stage change computation is utilized as contribution for mechanical analysis. Temperature and stage subordinate material properties, for example, warm conductivity, explicit warmth, Young's Modulus, Poisson's proportion, and Yield strength were considered for warm and mechanical analysis.



**Fig 11:** Flowchart of the sequentially coupled thermo-metallurgical-mechanical FEM in SYSWELD



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## IV. CONCLUSION

Distortion is must when a plate is welded with another one. The amount of distortion can be controlled or minimize if pre-setting techniques are apply through welding fixtures. By controlling the distortion or fabricated works lot of manufacturing cost can be saved. So, prediction of distortion before welding is of great importance for the setting techniques. The present project work can give the prediction of distortion. It has been found out the limit of angular distortion for three types of design for different thickness of plates i.e. 6 mm, 5 mm and 4 mm. with 1200, 900, and 600 Vee. These values of distortion will help the welder before welding to the present job and hence minimize distortion. But, still there is lack of information of this study. It can't be suggested that what will happen if different types of weld cross section, different types of plate thickness, and different types of plate material are used in butt welding joints. Hence further study is necessary. Moreover it can't be said that what will happen if the other parameters of welding like speed of welding, voltage of welding, time of welding etc. which were kept constant in this study work.

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