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# Weld Design of Vehicle Bodies and Analysis of Welded Butt and T-joints Using Simufact

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**Abstract:** ***Nowaday's Weld design plays a more important role in the welding process has been used extensively in the fabrication of many structures including vehicle bodies, train, ships, buildings, air planes, bridges, pressure vessels, etc. The major focus in the weld design of vehicle bodies manufacturing industries is design of weld joints with more pay load capacity and possible less weight .It provides many advantages over other joining techniques. To mention only a few, it provides better mechanical properties and good joining efficiency .An important aspect of weld design of vehicle bodies and analysis is the stress distribution and fatigue life of prediction process. Fatigue is one of the most important parameters to consider when weld design of vehicle bodies. However, there are various problems such as residual stresses and shape distortion associated with the construction of welded structures. When a material is being welded, it experiences local heat due to the welding heat source. The temperature field inside the weld meant is not uniform and changes as the welding progresses. The welding heat cycle gives rise to a complex strain field in the weld metal and in the base metal regions near the weld. These strains, along with the plastic upsetting, create the residual stresses that remain after the welding is completed. In addition, shrinkage and distortion are also produced. Residual stresses and distortion are highly undesirable in welding technology. Thermal stresses during welding often cause cracking. Some of the above weld related problems can be solved by adhering to a preset weld design practice and employing appropriate weld process procedure in the welding tasks. In developing country there are limited numbers of vehicles body builders. Those body builders extensively use welding. In those local body builders there is lack of proper weld design practice in the fabrication of vehicle bodies. Moreover, there is no well developed welding process procedure they have adapted. As well as a FEM using simulating manufacturing /simufact / software has been performed in order to achieve a higher understand welding process and mechanical properties.***

**Keywords:** welding simulation, simufact, welding joints, Welding distortion, finite element method, temperature field.

## 1. Introduction

A weld can be defined broadly as a localized union accomplished by applying heat and/or pressure with or without extra material being added. & Also Welding is a dependable, efficient and economic method for permanently joining similar metals. [5] When the thing to be made is large, or when only a few copies are needed, it is usually more practical to join simple pieces by welding, bolting, or riveting than to create a single entity by casting or machining. Such welded assemblies are called weldments. Today's automobile body is a weldment, a single unit combining the functions of body and frame. Steel ships are also weldments. In both cases, the superior properties and economy of sheet metal are realized by using welding to produce a complex article. Welding has also become more economical for high-volume production with the use of robots, which can be programmed to produce a complex series of perfect welds. Welding is extensively used as a principal method of fabricating and assembling numerous metal products such as in shipbuilding, construction, aviation and automotive industries. One popular arc welding process, gas metal arc welding(GMAW), has been applied in a wide range of plate thicknesses due to its easiness and relatively high productivity. Welding is considered as the most efficient, dependable and economical means of fabrication to join metals permanently. However, distortion is frequently encountered as a result of the welding process that adversely affects the dimensional accuracy and aesthetical value, which can lead to expensive remedial work and thus increase the fabrication costs.

Distortion in a welded part occurs due to non-uniform expansion and contraction of the weld metal and adjacent parent metals, caused by complex temperature changes during the welding process. In addition, the distortion triggered from the welding process can induce residual stress as well, which significantly affects the performance of the welded structure. Many numerical methods and experimental studies have been performed to predict welding distortions. In Ref. [1], prediction of welding deformations in butt joint of thin plates was conducted using thermo-elastic-plastic finite element methods, and comparing the results with the experimental and empirical methods. From their observation, plate thickness and welding speed have been proven to have significant effects on welding distortions. It can be seen that the longitudinal and transverse shrinkages are increased when the welding speed is reduced. Considerable decreases of the transverse and longitudinal shrinkages can be observed when the plate thickness is increased. Research based on finite element analysis using linear elastic shrinkage volume and experimental methods was performed in Ref. [2] to study the welding distortions. It was found that when the included angle of single-vee butt preparation increases, the angular distortion is increased as well. For a large welded structure, the prediction of welding distortion was done by using elastic FEM based on inherent strain theory and thermal elastic-plastic FEM [3, 4].

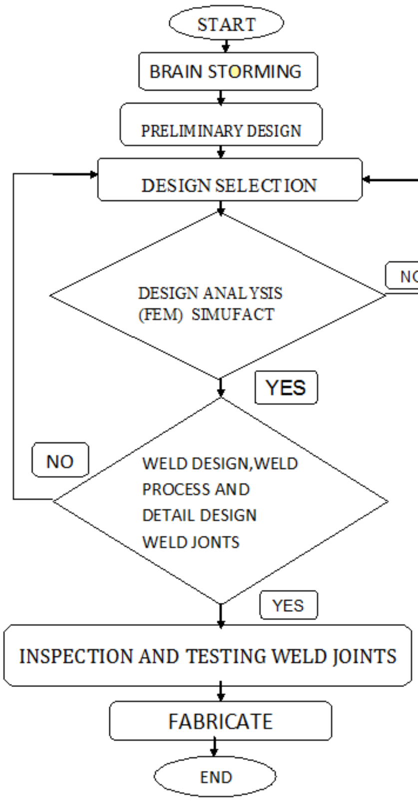


**Figure 1:** Problem Solution block diagram.

Three factors influence the length of fusion welds, namely, strength requirements, design of the parts, and distortion of the parts and possible resultant cracking of the weld. Depending upon these factors, welds may be either continuous, intermittent, or tack welds. Continuous welds are used whenever strength requirements are high, or where a liquid or gastight joint is required.

They are costly because of the post welding straightening operation usually required to eliminate distortion caused by the heat of the welding operation. Intermittent welds are used on long joints where strength and rigidity requirements are not exacting enough to warrant the extra cost and weight of a continuous weld. There are five fundamental types of welded joints, namely butt, lap, corner, edge or flange and tee.

## 2. Sample of weld Strength Analysis

To indicate the weld strength analysis procedure for a trailer critically loaded component, external cross member, is taken. The detail of analysis is shown below:

### 2.1. Strength Analysis Assumptions

1) Loading Assuming that the load of the cargo is transmitted from the chequered plate to the cross member through the longitudinal beams and side beams. So R'1=959.39N and R'2=2689.4N are the loads due to the cargo distributed through side beam and longitudinal beam respectively. But there is additional weight of the side beam and the longitudinal side omega -(15 in number) which are to be loaded on the external cross member

$$R1 = 959.39 + 78.2 \times 9.81/15 = 1010.5N \quad (1)$$

$$R2 = 2689.4 + \frac{50 \times 9.81}{15} = 2722N \quad (2)$$

2) Support:-The cross member can be considered as a cantilever beam as shown in the figure below

For the above different points the result for direct shear force, induced bending stress, shear stress, maximum shear stress and factor of safety is as shown in the table below. The cross member is made of St-42 having yield strength of 255 *MPa*.

$$\Rightarrow \tau_y = 0.5\sigma_y = 0.5 \times 255MPa = 127.5MPa \quad \textbf{(3)}$$

**Table 1:** Parameters of the material

| Part | Option | Bending moment (N/m) | Induced bending stress (MPa) | Shear force (N) | Induced shear stress (MPa) | Combined Max. shear stress (MPa) | Shear yield stress (MPa) | Safety factor (static) |
|---|---|---|---|---|---|---|---|---|
| Front ext. cross member | 1 | 259.7 | 7.16 | 1010.5 | 0.86 | 3.68 | 127.5 | 34.63 |
| | 2 | 850.1 | 19.77 | 3732.5 | 3.02 | 10.33 | 127.5 | 12.34 |
| | 3 | 1846.7 | 36.90 | 3732.5 | 2.87 | 18.67 | 127.5 | 6.83 |
| Rear ext. cross member | 1 | 259.7 | 6.13 | 1010.5 | 0.82 | 3.17 | 127.5 | 40.17 |
| | 2 | 850.1 | 15.60 | 3732.5 | 2.78 | 8.28 | 127.5 | 15.40 |
| | 3 | 1846.7 | 26.94 | 3732.5 | 2.55 | 13.71 | 127.5 | 9.30 |

2.2 **Welding analysis:-**As can be seen from above the maximum bending moment and direct shear force are occurred at the end of the cross members and because those loads are totally carried by the welding, it is necessary to check the weld size. Case 1(front external cross member) Case 2 (rear external cross member) Case 1:-Let *h* be throat size of the weld and *a* weld size. Then, *h=0.707a* .It is known that failure of the weld occurs due to the shearing along the throat section when the weld is bending. Area of the weld group

$$A = 2 \times 0.108h + 3 \times 0.075h = 0.441h \quad (4)$$

Distance of center of gravity of the weld group at the top part is

For the L-shape

$$y = \frac{0.118 \times a \times 0.059}{0.080 \times a + 0.108 \times a} = 0.352m \quad (5)$$

For the C-shape y=0.059 m Totally for the group

$$y = \frac{0.258 \times a \mid 0.059 + 0.198 \times a \times 0.0352}{0.258 \times a + 0.198 \times a} = 0.04867m \quad (6)$$

And moment of inertia of the weld group is

$$I_{xx} = \left( \frac{\left(6.0 \times 0.075 + 0.108^3\right) \times 0.118^4}{12 \times \left(0.118 + 0.08\right)} h + \left(0.08 + 0.118\right) h \times 0.01347^2 \right)$$

$$= 908.71 \times 10^{-6}\, hm^4$$

So the bending stress at the extreme top is

$$\sigma = \frac{My}{I_{xx}} = \frac{1846.7 \times 0.04867}{908.71 \times 10^{-6} h} = \frac{0.0989}{h} MPa \quad (7)$$

And the bending stress at the extreme bottom is

$$\sigma = \frac{My}{I_{xx}} = \frac{1846.7\times(0.118-0.04867)}{908.71\times10^{-6}h} = \frac{0.14089}{h}MPa \tag{8}$$

And direct shearing stress due the distributed load is

$$F_{sh} = 1010.5N + 2722N = 3732.5N$$

$$\tau = \frac{F_{sh}}{A} = \frac{3732.5}{0.441h} = \frac{0.008464}{h}MPa \tag{9}$$

Therefore, according to maximum shear stress theory, taking the maximum bending stress in to consideration

$$\tau = \sqrt{\tau_{ind}{}^2 + \left(\frac{\sigma_{ind}}{2}\right)^2} = \frac{0.07095}{h}MPa \tag{10}$$

Assuming factor of safety to be 5, the allowable shear stress becomes, note in this case property of the welding wire for EN440 G3Si-1 is $\sigma_y = 475MPa$
(Reference: ESAB welding handbook)

$$\tau_{all} = \frac{\tau_y}{F.S} = \frac{0.5\times475MPa}{5} = \frac{0.07095}{h}MPa \tag{11}$$

Therefore,

since
$$\tau_{\max} \le \tau_{all} \Rightarrow \frac{0.07095}{h} \le 47.5 \Rightarrow h \ge 0.001494m$$

and the welding size will be

$$a = \frac{h}{0.707} = \frac{0.001494}{0.707} = 0.002113m \tag{12}$$

Assuming the welding efficiency to be 50%, the actual welding size becomes

$$a_{acual} = \frac{a}{0.5} = \frac{0.002113}{0.5} = 0.004226m \Rightarrow a_{acual} = 5mm$$

<u>Case 2</u> For this case

$$A = 0.15h + 0.14h + 2\times0.075h + 0.08h = 0.52h \tag{13}$$

Distance of center of gravity of the weld group of the horizontal fillet

For the L-shape

$$y = 0.150 - \frac{0.150^2}{2(0.08+0.150)} = 0.101m \tag{14}$$

For the C-shape

$$y = 0.075m \tag{15}$$

Totally for the group

$$y = \frac{0.29\times a\times0.075 + 0.23\times a\times0.1011}{0.29\times a + 0.23\times a} = 0.08654m$$

And the moment of inertia of the weld group is

$$I_{xx} = \left(\frac{(6.0\times0.075+0.14)\times0.14^2}{12}h + (2\times0.075+0.14)h\times0.01154^2\right) + \left(\frac{4\times0.08\times0.15^3+0.15^4}{12\times(0.15+0.08)}h + (0.08+0.15)h\times0.01456^2\right) \tag{16}$$

So the bending stress at the extreme top

$$\sigma = \frac{My}{I_{xx}} = \frac{1846.7\times0.08654}{1.626\times10^{-3}h} = \frac{0.0983}{h}MPa \tag{17}$$

And direct shearing stress due the distributed loads is

$$F_{sh} = 1010.5 + 2722 = 3732.5N$$

$$\tau = \frac{F_{sh}}{A} = \frac{3732.5}{0.52h} = \frac{0.007177}{h}MPa \tag{18}$$

Therefore according to maximum shear stress theory

$$\tau_{\max} = \sqrt{\tau_{ind}{}^2 + \left(\frac{\sigma_{ind}}{2}\right)^2} = \frac{0.04967}{h}MPa \tag{19}$$

Assuming factor of safety 5, the allowable shear stress becomes

$$\tau_{all} = \frac{\tau_y}{F.S} = \frac{0.5\times475MPa}{5} = 47.5MPa \tag{20}$$

Therefore, since

$$\tau_{\max} \le \tau_{all} \Rightarrow \frac{0.04967}{h} \le 47.5 \Rightarrow h \ge 0.0010457m$$

And the welding size will be

$$a = \frac{h}{0.707} = \frac{0.0010457}{0.707} = 0.001479m \tag{20}$$

Assuming the welding efficiency to be 50%, the actual welding size becomes

$$a_{acual} = \frac{a}{0.5} = \frac{0.001479}{0.5} = 0.002958m \Rightarrow a_{acual} = 3mm \tag{21}$$

## 3. Analysis of welded T- joint& butt- Joint Using Simulating Manufacturing /Simufact / Software

In welded joints, two components may be under the direct control of the designer, the weld type and the joint type. There are several different techniques for joining two pieces of material. Examples of these techniques are butt joints, lap joints, corner joints, edge joint and tee joints. In accordance with the joining type designed, the weld will have different properties. Butt Joints and Welds:-Butt-welding is an economical and reliable way of jointing without using additional components requiring only butt-welding equipment. Butt Joints have several advantages over other types of joints. Butt joints are used where high strength is required. They are reliable and can withstand stress better than any other type of weld joint. To achieve full stress value, the weld must have 100 percent penetration through the joint. This can be done by welding completely through from one side. The alternative is working from both sides, with the welds joining in the center

**T-Joints and Welds**: - Various T-joint designs are used to join parts at an angle to each other. Depending on the intended use of the weldment, the joint may be made with a single fillet, double fillet, or a groove and fillet weld combination. Fillet welds are made to specific sizes that are determined by the allowable design load. They are measured where design loads are not known; a "rule of thumb" may be used for determining the fillet size. In these cases, the fillet weld leg lengths must equal the thickness of the thinner material. The main problem in making fillet welds is lack of penetration at the joint intersection. To prevent this condition, always make stringer beads at the intersection. Weave beads do not provide the desired penetration on fillet welds.

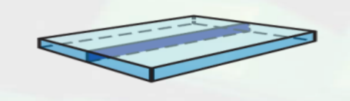


**Figure 1:** Butt joint

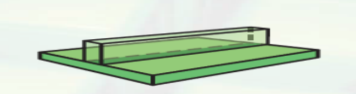


**Figure 2:** T- joint

### 3.1. Experimental Set Up and Procedure

For verification purpose, a series of experiments were carried out using robotic welding ABB IRB 2400/16 with GMAW power source KEMMPI Pro Evolution Pro MIG 540 MXE Nowadays, robotic welding is recognized as a mature production method which has a flexible movement pattern using six axes. The advantage of a robotic welding system is that one single point remote robot control unit can be used to perform all welding parameters.

**Table 2:** Welding parameters used for experimental method

| *Welding parameters* | *Butt joint* | *T- joint* |
|---|---|---|
| Current, I (A) | 160 | 160 |
| Voltage, V (V) | 20 | 20 |
| Travel speed, v (mm/s) | 4 | 4 |
| Wire feed speed, wfs (m/min) | 4 | 4 |
| Shielding gases (Ar / CO2) | 80%/20% | 80%/20% |
| Velocity: | 10.0 mm/s | 10.0 mm/s |
| Efficiency: | 0.85 | 0.85 |
| Energy per length - gross: | 3200.0 J/cm | 3200.0 J/cm |
| Front Length: | 3.0 mm | 3.0 mm |
| Width | 5.0 mm | 5.0 mm |
| Depth | 6.0 mm | 6.0 mm |
| Heat front scaling factor: | 0.75 | 0.666667 |
| Weaving type | Zigzag | zigzag |

**Table 3:** Time summary For butt joint and For T-joint

| *Trajectory* | *For butt joint Trajectory* | *For T-joint Trajectory1* | *For T-joint Trajectory2* |
|---|---|---|---|
| Length | 200 | 200 | 200.0 mm |
| Start welding | 0.0 s | 0.0 s | 20.0 s |
| End welding | 20.0 s | 20.0 s | 40.0 s |
| Welding time | 20.0 s | 20.0 s | 20.0 s |
| End time | 20.0 s | 20.0 s | 40.0 s |
| Welding filler | Trajectory-fillet | Trajectory-fillet | Trajectory-2-fillet |

## 4. Results and Discussions

3.2 Welding simulation method *Geometrical modeling of butt and T-joints* A schematic illustration of FE models of butt and T-joints is displayed in Fig. 1and Fig. 2 FE mesh of butt joint has two symmetrical plates with plate size of 50 mm x 200mm. A weld bead for the butt joint is also modeled on which the welding trajectory is located. T-joint consists of two plates, which are base plate with 100 mm x 200mm and stiffener with 50 mm x 200 mm. Similar to butt joint, a weld bead on T-joint is also modeled and the welding trajectory is located on the bead as well. During the simulation, both butt and T-joints have different clamping conditions.

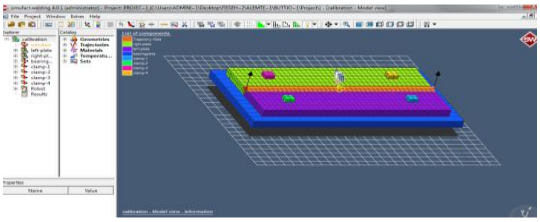


**Figure 3:** Models /simufact /butt. Joint

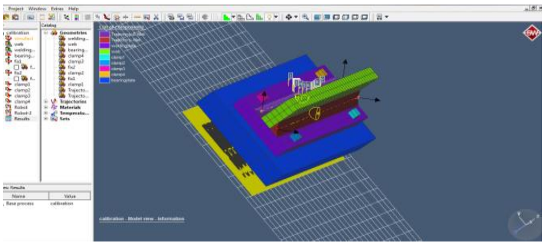


**Figure 4:** Models /simufact /T-joint

Material modeling
In this simulation, Materials: S235-SPM-sw general steel material has been used to predict the welding distortion. This type of structural steel has been widely used in many applications, combining good welding properties with guaranteed strength.

### 3.2 Simulation method and procedures using simulating manufacturing /simufact /

The principal relationship between heat input and weld induced distortion has already been observed by many researchers [1-5, 7-9]. For linear elastic FE analysis, each step of the welding process is not simulated, whereas only steady state thermal mechanical analysis is involved. Furthermore, metallurgical structure analysis is omitted. The total strain computed in this method is solely dependent on elastic strain in which the modulus of elasticity and Poisson’s ratio are calculated at ambient temperature while neglecting the temperature- dependent material properties. Therefore, by using this approach, prediction can be made in a short analysis time. The **simufact** uses a simplified modeling approach with appropriate assumptions introduced as equivalent loading which should be in proportion to the induced distortion.

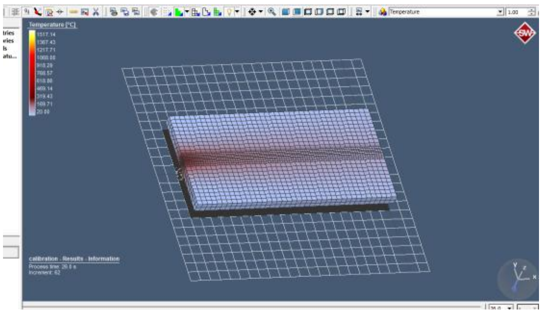


**Figure 5:** Temperature butt- joint weld

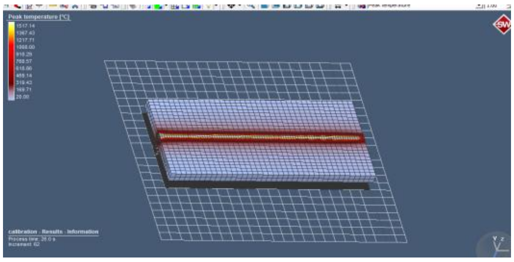


**Figure 6:** Peak Temperature butt- joint weld

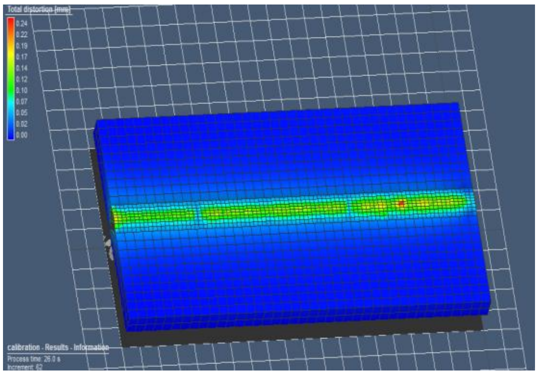


**Figure 7:** Total distortion/mm/ butt- joint

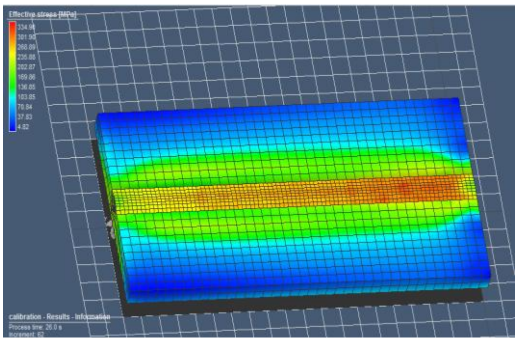


**Figure 8:** Effective stress butt- joint weld

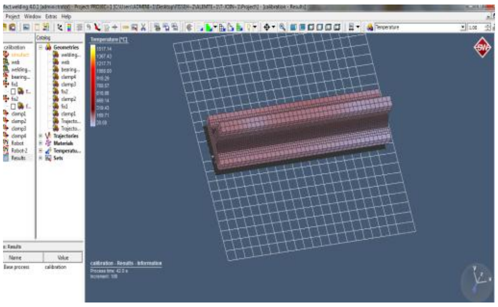


**Figure 9:** Temperature T- joint weld

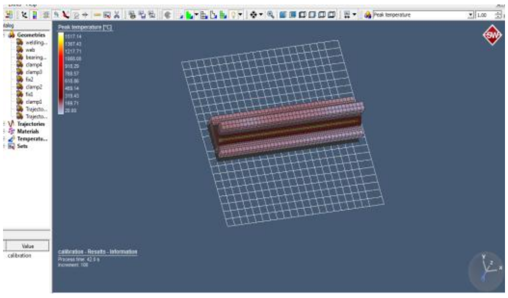


**Figure 10:** Peak Temperature T- joint weld

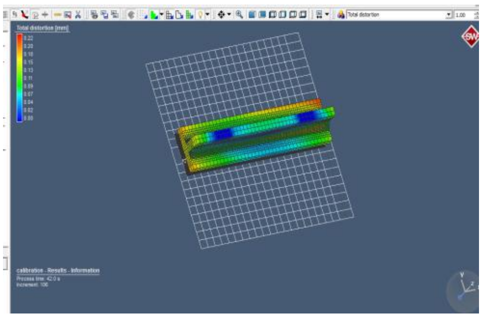


**Figure 11:** Total distortion/mm/ T- joint weld

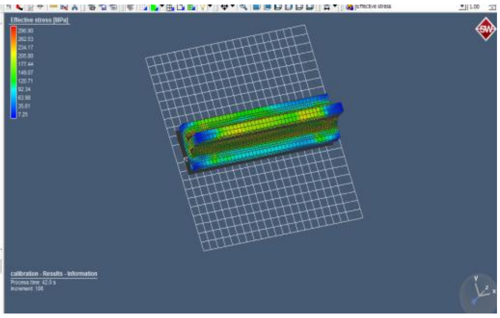


**Figure 12:** Effective stress T- joint weld

Welding processes involve the melting of the faying surfaces and the filler metal, if any, followed by solidification of the molten weld metal. Melting and solidification steps of welding are associated with the flow of heat and are affected by rate of heat transfer in and around the weld metal. Metallurgical structure of metal in weld and region close to the weld metal is mainly determined by the extent of rise in temperature and then cooling rate experienced by the metal at particular location of HAZ and weld. Further, differential heating and cooling experienced of different zones of weld joint cause not only metallurgical heterogeneity but also non-uniform volumetric change which in turn produces the residual stresses.

These residual stresses adversely affect the mechanical performance of the weld joint besides distortion in the welded components if proper care is not taken. Since heating, soaking and cooling cycle affect the metallurgical & mechanical properties, development of residual stresses and distortion of the weld joints therefore it is pertinent to study various aspects related with heat flow in welding such as weld thermal cycle, cooling rate and solidification time, peak temperature, width of heat affected zone. Further, mechanisms of development of residual stresses and common methods relieving residual stresses apart from the distortion and their remedy will be discussed in this chapter on heat flow in welding Weld thermal cycle shows variation in temperature of a particular location (in and around the weld) during the welding as a function of welding time. As the heat source (welding arc or flame) approaches close to the location of interest first temperature increases heating regime followed by gradual decrease in temperature cooling regime. In general, an increase in distance of point of interest away from the weld centre-line: decreases the peak temperature, decreases the rate of heating and cooling, increases time to attain peak temperature, decreases rate of cooling with increase in time Therefore, the heat source model was validated with respect to the weld macrograph of experimental weld cross-sections and a fairly good agreement was achieved in terms of weld pool boundary shape and size as shown in Fig.9 and. Fig.10 There zone indicates that temperature of the portion is above the melting point. After validating the heat source, the simulation predicted out- of-plane distortion was compared with the experimental results . The finite element method (FEM) is a numerical method used for finding approximate solutions of partial differential equations. This method is very useful to predict and simulate future failures in the material; therefore the use of FEM modeling produces a save in time and money with regard to classical methods. Developing of computers with higher calculus power has brought an increase in the capability to design models each time more similar to real systems, hence the Accuracy of FEM modeling is improving very fast. The software used to this simulation was simufact. Results and Discussions of Tracking points butt joint wend and T-joint are shown below

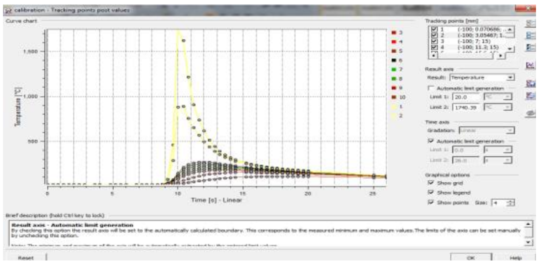


**Figure 13:** The temperature of T- joint

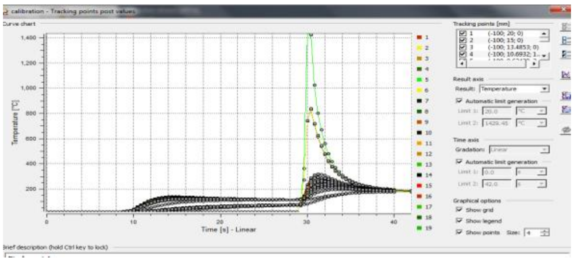


**Figure 14:** The temperature of butt joint

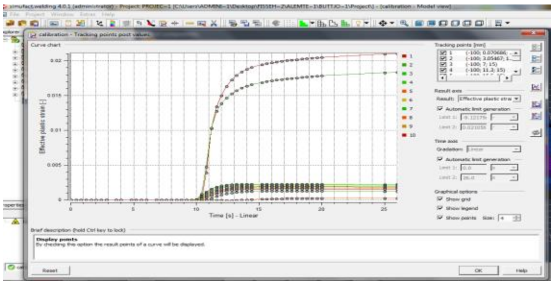


**Figure 15:** The Effective plastic strain of butt joint

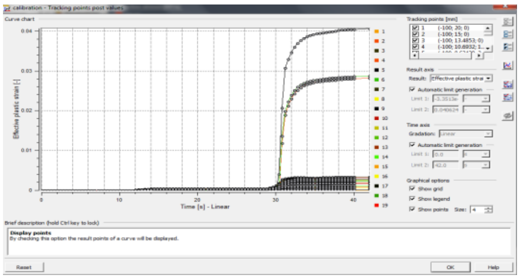


**Figure 16:** The Effective plastic strain of T- joint

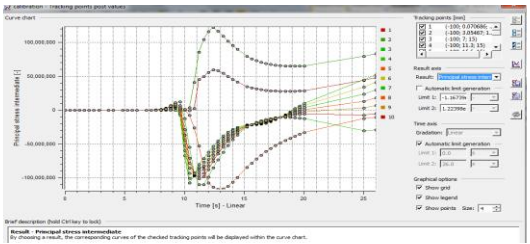


**Figure 17:** principal stress intermediate of butt joint

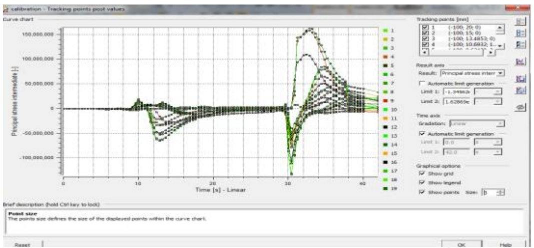


**Figure 18:** principal stress intermediate of T- joint

| Tracking points | | | Automatic Limit generation °C | Automatic Limit generation time(s) |
|---|---|---|---|---|
| The temperature | butt joint | Limit2 | 1740.39 °C | 26 seconds |
| | | Limit1 | 20°c | 0 |
| | T-joint | Limit2 | 1429.45 °C | 26 seconds |
| | | Limit1 | 20°c | 0 |
| Effective plastic strain | butt joint | Limit2 | 0.021056 | 26 second . |
| | | Limit1 | -9.12175e-05 | 0 |
| | T-joint | Limit2 | 0.040624 | 26 second . |
| | | Limit1 | -3.3513e-05 | 0 |
| principal stress intermediate | butt joint | Limit2 | 1.22398e+08 | 26 seconds, |
| | | Limit1 | -1.16739e+08 | 0 |
| | T-joint | Limit2 | 1.62869e+08 | 26 seconds, |
| | | Limit1 | -1.34562e+08 | 0 |
| Temperature rate | butt joint | Limit2 | 2311.32 | 26 seconds, |
| | | Limit1 | -793.12 | 0 |
| | T-joint | Limit2 | 2019.22 | 42. seconds, |
| | | Limit1 | -766.358 | 0 |
| Total distortion | butt joint | Limit2 | 0.109258 | 26 seconds, |
| | | Limit1 | 0 | 0 |
| | T-joint | Limit2 | 0.123395 | 42 seconds, |
| | | Limit1 | 0 | 0 |

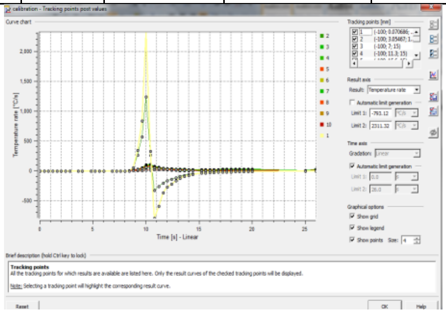


**Figure 19:** Temperature rate of butt- joint

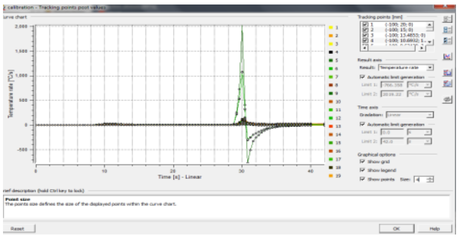


**Figure 20:** Temperature rate T- joint

Table 4 Results Tracking points of all butt and T-joint

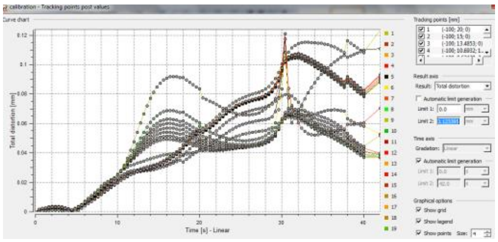


**Figure 21:** Total distortion of T-joint

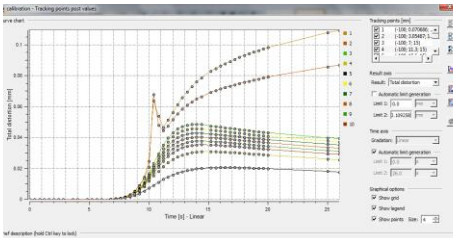


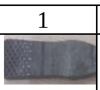
**Figure 22:** Total distortion of Butt joint

All the Tracking points of the Butt joint and T-joint for which the result are listed on the graph and the results curves of the checked tracking points will be displayed As shown on table 4

**Real experimental tests of Butt** and T-joint welded

The T-joint and butt joint is made of steel plates of 3/8 of inch (9.5 mm) in thickness and 10 inches in length (200 mm). Analog data, welding experiment, get butt weld street corner weld By bending tensile test machine and subjected to a tensile testing machine bending test and experiment, Structural measurements were done. Tensile test data in Table 4, where $\sigma$ s (yield limit) average reaches 339.478MPa, $\sigma$ *b* ((tensile strength) average reaches 461.518MPa, elongation Elongation average reaches 36.62%, all indicators over the base metal.

**Table 4:** Tensile Test of butt joint welded

| Plate | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| |  |  |  |  |  |
| Ao(mm2) | 179.27 | 182.16 | 184 | 182.8 | 180.82 |
| Fs(KN) | 61.5 | 61.5 | 62 | 63 | 60.5 |
| Fb(KN) | 83.5 | 84.5 | 84.5 | 84.9 | 82.5 |
| L(mm) | 49.28 | 55.78 | 56.24 | 58.2 | 53.74 |
| $\sigma$ s(Mpa) | 343.58 | 337.62 | 336.96 | 344.64 | 334.59 |
| $\sigma$ b(Mpa) | 469.27 | 458.39 | 459.24 | 464.44 | 456.25 |
| Elongation (%) | 23.2% | 39.45% | 40.6% | 45.5% | 34.3% |
| Lo/original length | 40 | 40 | 40 | 40 | 40 |

Using bending test machine for T-joint Welded was bending experiments using three-point bending, welding bent $60^0$ degrees, remain intact, or will not crack proven and reliable welding quality. Weldment bent shown in Figure 23. Welded experimental simulation parameters, access to a good quality of welding, indicating reliable simulation parameters, and simulation calculations are correct

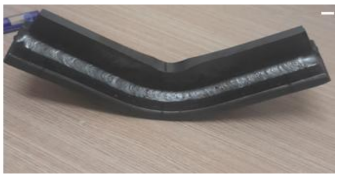


**Figure 23:** T-joint welded

## 5. Conclusion

### 1. Welding design issues raised

From the analysis and the result of the soft ware on the weld design and process in this paper the following conclusions could be made **1.** Proper engineering weld design should be performed specially on critically loaded components, like chassis central lateral & cross frame weld joint. For this purpose weld design manual has to be developed. **2.** It is high time to establish welders qualifying and certifying institute in national level as there is no one yet. **3.** It is highly recommendable to the local body builders to establish quality control section that corresponds to their fabrication capacity. **4.** In national level Weld Codes, Standards and Specifications are to be adapted by responsible professional of Mechanical Engineers. Simufact software is a powerful tool to achieve assessments close to the real behavior of the welding. But it is necessary keep developing this method to achieve a higher accuracy.

### 2. Analog calculation method, good results were obtained

Due to increasing requirements for improved performance of welded structures, it has become essential to take into account process variability during the design phase of a welding process. Traditional experiment based welding process variable optimization is quite expensive and is not always guaranteed to provide the optimum parameter combination. Furthermore, such approach cannot also effectively control several critical parameters such as welding direction. In this study, the modeling of a T-joint welding presenting a V preparation was done. The simulated model was done using simufact software with the “birth and death” method to simulate the filler metal deposition, also it uses the double ellipsoid model to simulate the heat in the weld pool. For the simulation, the temperature dependent thermo-physical material properties are taken in consideration. A new formula has been presented for the evaluation of the combined heat loss coefficient. Then the FE model is compared with an experimental test in the welding laboratory. Both models contain two parts: thermal part and structural part. Through simufact software and experimental study, the results from both methods revealed a reasonable agreement. A principal advantage of using this prediction method is that only a short computational time is required for the simulation analysis.

The accuracy of this method is crucially dependent on the geometrical model of weld bead. Hence, the size of weld bead should be wisely determined according to the actual weld bead in order to obtain accurate and reliable results. Conversely, the deviating results in this study might arise from other factors such as physical properties and chemical composition of materials, geometry and thickness as well. Besides, the significant contribution from this research is that the distortion which is inevitable can be predicted; thus the control of distortion can be possibly planned in advance prior to the commencement of the actual welding process.

Therefore, this software possesses a great potential for identifying distortion in more complex welded joints. The welding simulation is conducted using the built-in MSC Marc solver of simufact. Welding. Thermal analysis is performed separately from mechanical analysis with the assumption of weakly coupled analysis, that is, temperature history is not affected by stress and strain.

**3. Parameters using simulation experiments, to obtain reliable welds.**

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