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Prediction of deformation in welding and Optimization of welding sequence for T section plate weld on a circular plate

Swati Jogibhai Patel[1*], Mayurkumar M. Makwana[2], Ankitkumar Chhaganlal Pambhar[3], Vimalkumar Dahyabhai Sonara[4], Hemenkumar H Thakar[5], Naishadhkumar P Patel[6]

[1*,2,3,4]Assistant Professor, Mechanical Engineering Department, L.D. College of Engineering, Ahmedabad, Gujarat, India,
[5]Assistant Professor, Metallurgy Engineering Department, Government Engineering College, Gandhinagar, Gujarat, India,
[6]Lecturer Metallurgy, Lukhdhirji Engineering College (Diploma), Morbi, Gujarat, India.

Email: [1*] swati2508@ldce.ac.in

ABSTRACT

Welding deformation is a common and crucial problem in industry. Distortion is an unavoidable problem in the assembly of the welded structures. Sequence of assembly or welding has a great but unpredictable influence on the distortion of the precision of the welded structures. Inherent strains are the residual plastic strains caused in welding process. They exist always in the welds and nearby where structures undergo a large thermal cycle, and are considered as a source causing the welding deformations. The aim of this study is to investigate the effect of the welding process and to optimize the welding sequence for welding of Filter Plates. SUS304 stainless steel is generally considered a good quality steel due to its excellent corrosion resistance, strength, and versatility. It's a widely used grade of austenitic stainless steel known for its balance of properties, making it suitable for various applications. FEA analysis with ANSYS can be used to predict the deformation in a filter plate. The results obtained are that End to End Transverse Zig Zag Welding Sequence has its advantage over other methods as the Total Deformation is less as compared to other methods.

Key words: Residual stress, Deformation, welding sequence, T-section plate, SMAW welding.

INTRODUCTION

Welding deformation is common and important problem in industry. Welding is widely used in shipbuilding, aerospace and automotive industries for assembling various products. However, welding distortion is one of inevitable problems during welding. Welding deformation has an adverse effect on fabrication precision, structure’s function, productivity and increase fabrication costs. Therefore, an analysis for the prediction of a welding deformation in a structure is essential.

In welding process, the structure undergoes a locally high temperature cycle. The thermal expansion of the welds and nearby areas are restricted by the constraints of surrounding metals where the temperature is rather low. The compressive plastic strains in the welds and nearby area will be caused and will remain at room temperature after welding. The causes of

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the welding stresses and deformations are the residual plastic strains, also named as inherent strain.

Finite element analysis technique has been used in the prediction of welding residual stress and distortion. Generally, the welding deformations are classified into four fundamental types, transverse shrinkage, longitudinal shrinkage, transverse bending and longitudinal bending. These four types of deformations can be regarded as fundamental components of the inherent deformations due to welding.

In this paper, Finite Element Analysis is used to predict the deformation due to welding of T-section Plates with circular plate. Welding deformation can be predicted by finite element analysis method.

PREDICTION OF DEFORMATION IN WELDING

Material joining is one of the major manufacturing processes used to assemble metallic and non-metallic parts for several applications. The industry is actively considering a number of alternate welding technologies that would enable the increased use of lightweight and high-performance materials. In the process of welding, the high temperature differences result in large temperature strains, which affect the distribution of the contact pressure between structural components. The safety requirements and the high costs of performing experiments to find different manufacturing routes is the motivation to increase the use of simulations in design of components as well as its manufacturing. It is then possible to optimize a chain of manufacturing processes as, for example, the welding residual stresses will affect the deformations during a subsequent heat treatment. The aim of the work presented in this thesis is to develop an efficient and reliable method for simulation of the welding process using the Finite Element Method Considering several welding sequences. A localized temperature at the pre modelled weld beads was applied to approximate the process. A welding sequence with the smallest residual stress distortion was investigated. The simulation was done in ANSYS environment.

The method may then be used when designing and planning the manufacturer of a component, so that introduction of new components can be made with as little disturbance as possible. In the same time the developed tool will be suitable for the task to perform an optimal design for manufacturing. While this development will also be valuable in predicting the components subsequent in-service behavior, the key target is to ensure that designs are created which are readily manufactured. If this understanding is captured and made available to designers, true design for manufacturer will result. This will lead to right first time product introduction and minimal ongoing manufacturing costs as process capability will be understood and designed into the component. When creating a numerical model, the aim is to implement the physical behavior of the process into the model A Three Dimensional geometry was created using ANSYS Design Modeler Tool which was imported into ANSYS Professional NLS. Depending upon welding sequence, the temperatures were applied as Boundary Conditions in a Structural Environment to let the displacements be calculated by means of the Co efficient of Thermal Expansion of the material.

- To analyze the effect of exerted pressure, the component outer ring is kept fixed per the picture.

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- The applied pressure on the plate is 1.5 x 1500 psi = 2250 psi to account for a Factor of Safety of 1.5
- 1500 psi pressure is given in the form of pressure drop across the plate.
- Bottom Face of Circular Plate is kept Fixed
- Weld Beads applied Temperatures as different sequences

In welding process, the structure undergoes a locally high temperature cycle. The thermal expansions of the welds and nearby areas are restricted by the constraint of surrounding metals where the temperature is rather low. The compressive plastic strains in the welds and nearby area will be caused and remained at room temperature after welding. The residual plastic strain, also named inherent strain, is considered as a source causing the welding stressed and deformations. are; circular Plate diameter, plate thickness, I-Beam section dimensions. Material for the circular plate and I-Beam section is SUS304. Different parameters and sequence are considered for the analysis.

Different parameter is required to be considered for the welding and modeling. The welding process adopted for this investigation is shielded metal arc welding process using the filler metal as E309MO-16 and the electrode diameter is of 2.50mm., Current to be taken is 50~80 Ampere, Voltage 20~26 and the electrode travelling speed is 40mm/min.

Welding Method: Shielded metal arc welding SMAW is the method used for welding. Temperature considered during Welding is from 22°C to 5000°C. Sequence of Welding is optimized welding “T” shaped plates with the Circular plate. In this the I Beam sections are created by means of welding the “T-Plate” section to the circular plate.

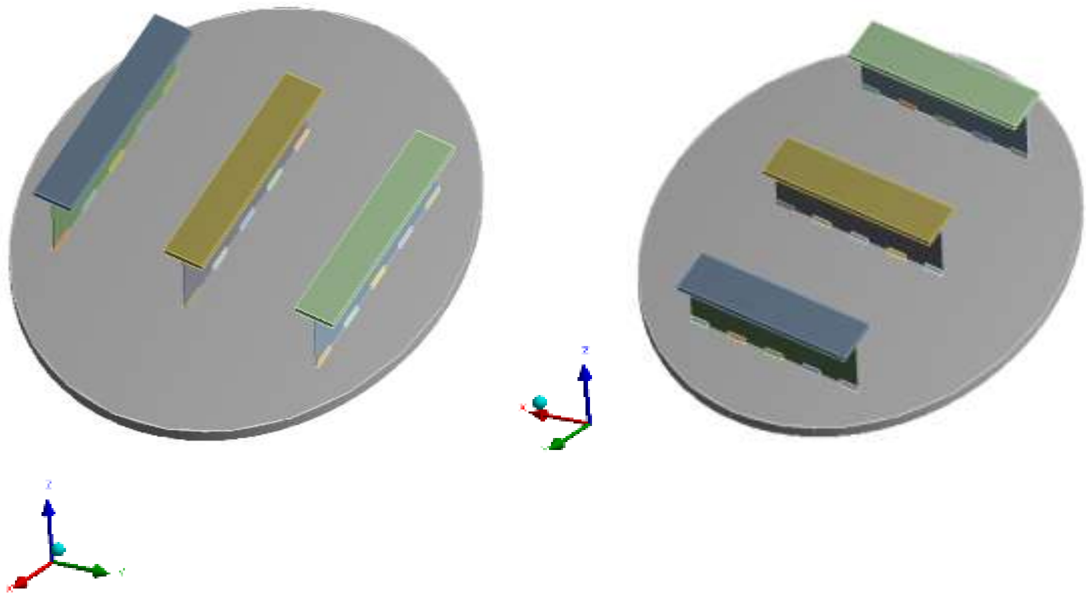

Figure 1.1 Plate welding shielded metal arc welding process circular plate.

In this research work the different parameters that are required to be considered for the welding and modeling are; circular Plate diameter, plate thickness, I-Beam section dimensions. Material for the circular plate and I-Beam section is SUS304. The welding process adopted for

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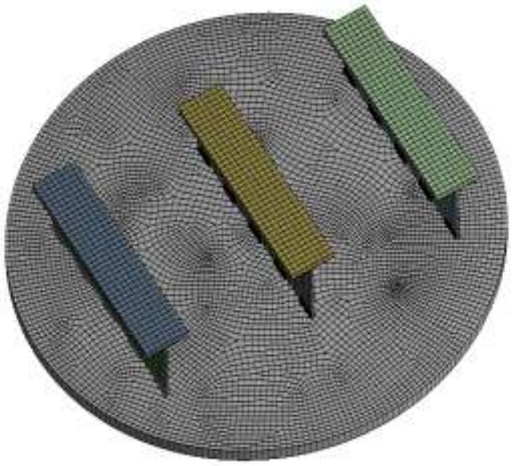
this investigation is shielded metal arc welding process using the filler metal as E309MO-16 and the electrode diameter is of 2.50 mm., Current to be taken is 50~80 Ampere, Voltage 20 ~ 26 and the electrode travelling speed is 40mm/min.



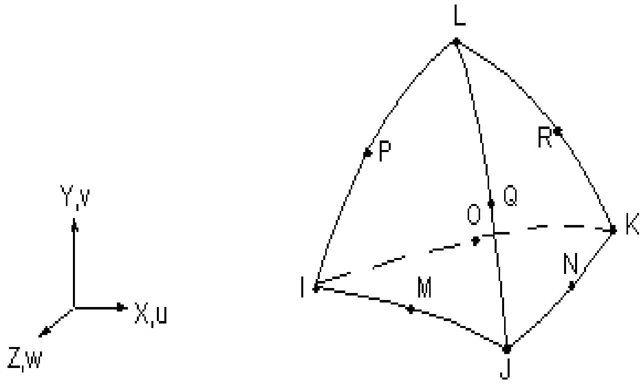
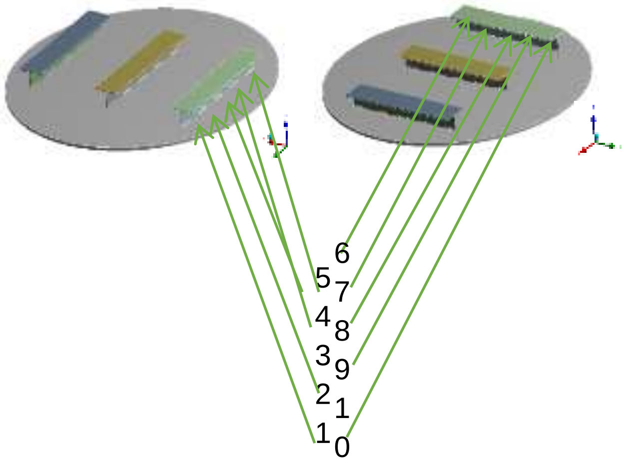


Figure 1.2 3D Structural Solid

I,J,K,L,M,N,O,P and Q are Nodes



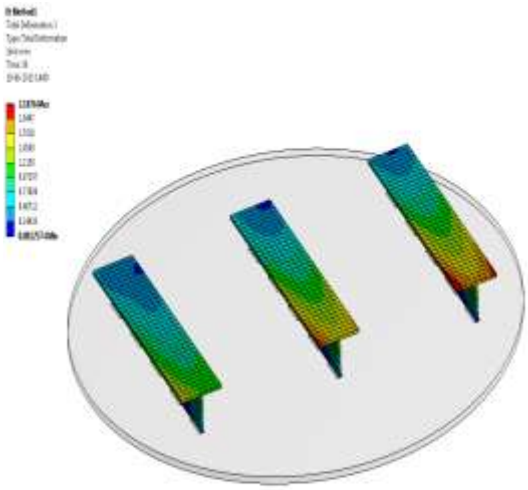


Figure 1.3 Linear Zig-Zag Welding sequence(WS-1)

Figure 1.4 Total Deformation Linear Zig-Zag Welding sequence (WS-1)

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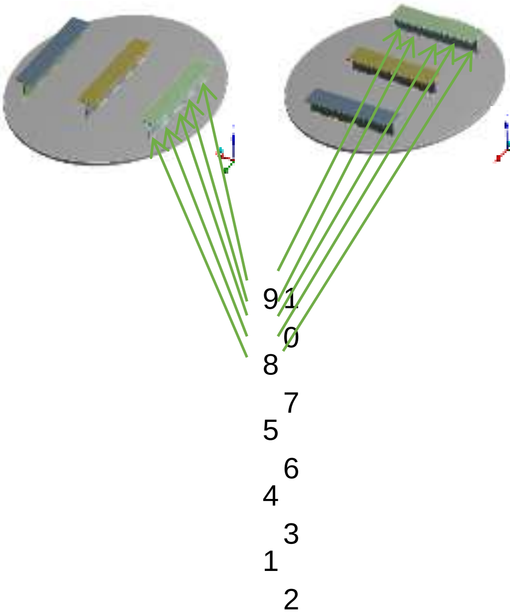

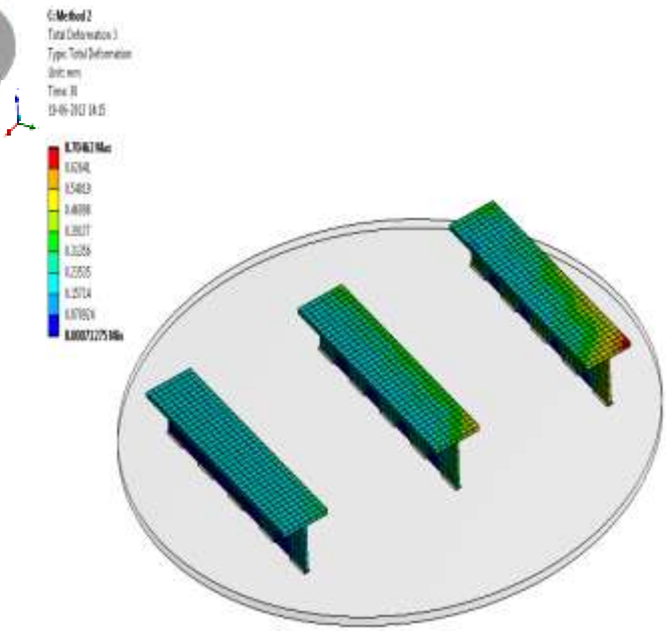

Figure 1.5 Transverse zig-zag welding sequence (WS-2)

Figure 1.6 Total Deformation Transverse zig-zag welding sequence(WS-2)

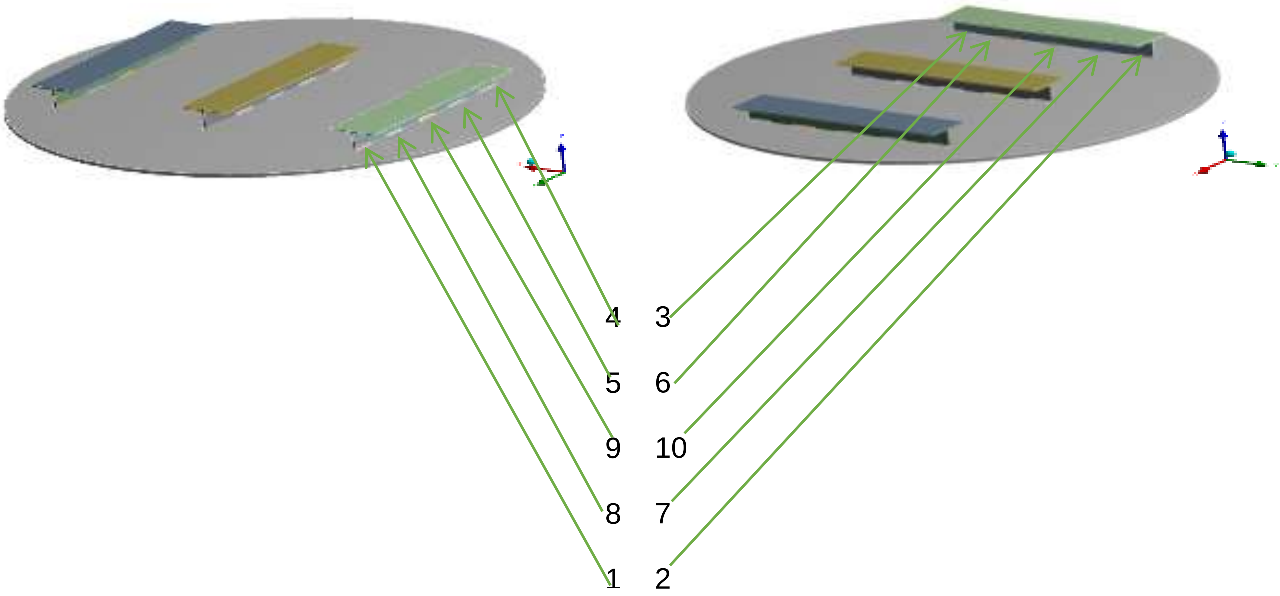

Figure 1.7 End to End transverse zig-zag welding (WS-3)

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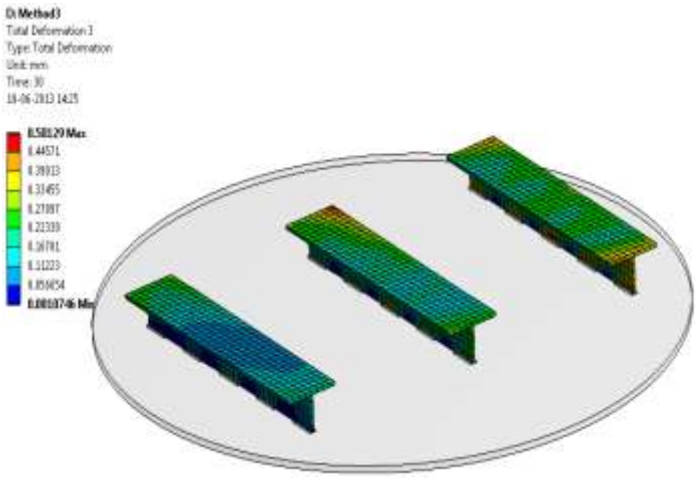

Fig 1.8 Total Deformation End to End transverse zig-zag welding (WS-3)

Table 1 Maximum temperature range for welding

Time	1	2	3	4	5	6	7	8	9	10
Temperature	22	193.66	365.31	536.97	708.62	880.28	1051.9	1051.9	1223.6	1395.2
Time	11	12	13	14	15	16	17	18	19	20
Temperature	1738.6	1910.2	2081.9	2253.5	2425.2	2596.8	2768.5	2940.1	3111.8	3283.4
Time	21	22	23	24	25	26	27	28	29	30
Temperature	3455.1	3626.8	3798.4	3970.1	4141.7	4313.4	4485	4656.7	4828.3	5000

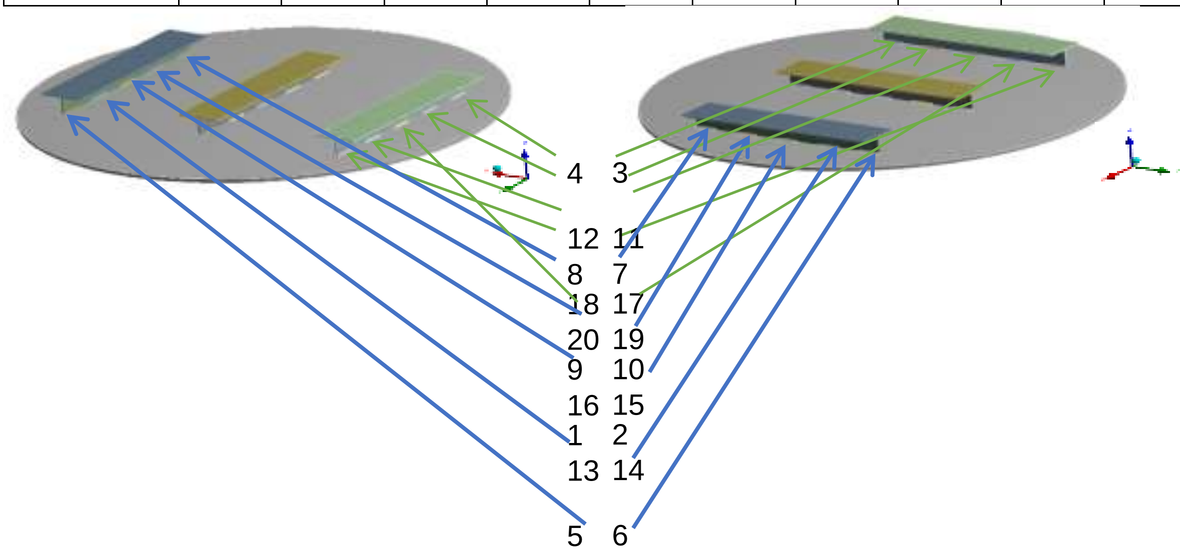

Figure 1.9 End to End plates transverse zig-zag welding sequence(WS-4)

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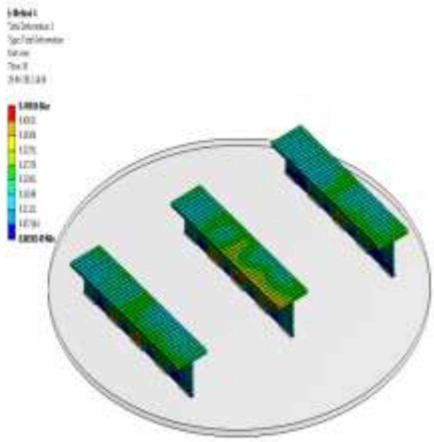

Figure 1.10 Total Deformation End to End plates transverse zig-zag welding sequence(WS-4)

RESULTS AND DISCUSSION

Several welding sequences (WS) were considered in this study and the numerical investigation of the resulted temperature distribution, distortions due to the welding sequences was then carried out on a filter plate. Four welding sequences considered were the Linear Zig-Zag Welding sequence(WS-1), transverse zig-zag welding sequence (WS-2), End to End transverse zig-zag welding sequence(WS-3), and End to End plates transverse zig-zag welding (WS-4), which are illustrated in Table 2.

Table 2 Methods and welding sequence

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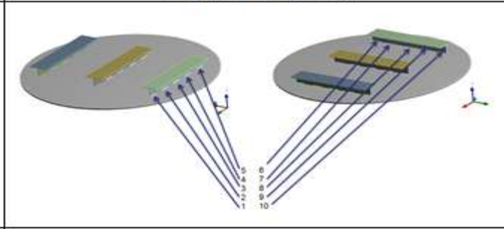
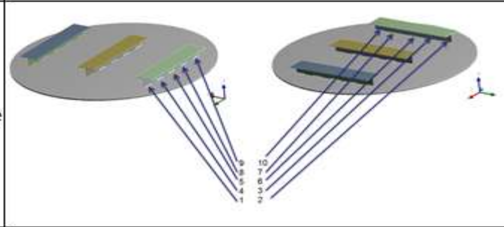
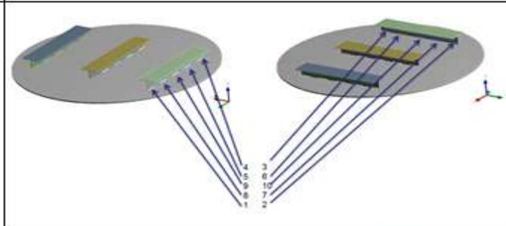
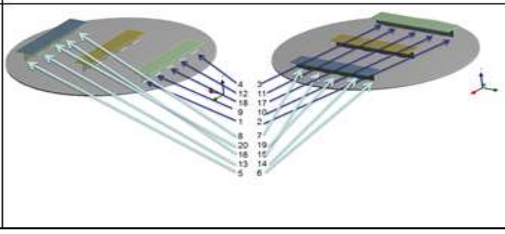
Sr	Method Name	Welding Sequence	Maximum Deformation(mm)
1	Linear Zig Zag Welding Sequence		2.1876
2	Transverse Zig Zag Welding Sequence		0.96863
3	End to End Transverse Zig Zag Welding Sequence		0.9273
4	End to End Plate Transverse Zig Zag Welding Sequence		0.92886

As presented in the Table 2. Linear Zig-Zag Welding sequence(WS-1) the temperature loads are applied on each bead. In linear zig-zag welding sequence the total deformation obtained is 2.1876mm. Transverse zig-zag welding sequence (WS-2). In transverse zig-zag welding sequence the total deformation obtained is 0.96863mm. End to End transverse zig-zag welding sequence(WS-3). End to End transverse zig-zag welding sequence the total deformation obtained is 0.9273 mm. End to End plates transverse zig-zag welding sequence(WS-4). As presented in Table 5.1 the temperature loads applied on each bead of the filter plate. The temperature loads for each bead is provided in the Excel sheet Appendix-I

From the results End to End transverse zig-zag welding sequence(WS-3). The total deformation obtained is 0.9273mm. By performing End to End Transverse zig-zag welding sequence the minimum deformation is obtained. Thus it is recommended to use the End to End Transverse zig-zag welding sequence.

CONCLUSION

From the results and discussion, it can be concluded that End to End Transverse Zig-Zag Welding Sequence has its advantage over other methods as the Total Deformation is less compared to other methods. The total deformation obtained is 0.9273mm. By performing End to End Transverse zig-zag welding sequence minimum deformation is obtained. It is recommended to use End to End Transverse Zig-Zag Welding Sequence over other methods.

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