A STUDY ON WELD DISTORTIONS OF A BUS BODY SIDE FRAME

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Abstract—Welding is considered as the most efficient, dependable and economical means of fabrication to join metals permanently. Distortion is frequently encountered as a result of the welding process that adversely affects the dimensional accuracy of the part members. This paper presents the bus body side frame analysis for evaluating welding distortions. It includes the variation in the thermal deformations by varying the type of location and clamping supports

Keywords—Finite Element Simulation, Weld Deformation.

I. INTRODUCTION

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 tube frame welding the most usual deformation type occurring is angular deformations. The frame consists of several T joints, corner joints and cross joints. Clamping and location supports are mainly provided for arresting the degree of freedom of each joints. A non-uniform temperature field, applied during the welding process, produces deformation and residual stresses in welded structures. Distortion of a structure can be measured whilst in case of large complex structures it is expensive and also time consuming. Numerical analysis is then performed using finite element mechanical behaviour of welding, the computational expense is large and simplification linear finite element method has to be used.

Due to the nature of welding process involving localized heat generation from moving heat sources rapid heating in the welded structures, and subsequent rapid cooling, problems such as residual stresses and distortions occurs on welded structures. The single-side weld sequence causes more distortion than double-side weld sequence in the T-joint weld. Welding along the same direction of the previous weld will induce the maximum vertical deflection in both single- and double-side welding procedures [1]. The transient longitudinal stress in the adjacent region of the fusion zone varied from compressive stress in heating stage to tensile stress during cooling stage. Later, the longitudinal residual stress is kept as a constant value. The vertical displacement keeps increasing during heating and cooling stage and then it keeps as a constant value. But, the vertical displacement has been stabilized earlier than the longitudinal stress during the welding process [2]. Thermal analysis results show that the temperature distribution in the longitudinal direction (along the welding line) does not vary considerably since the constant temperature is applied at the weld joint during analysis, but the temperature varies significantly in the transverse direction. These changes of transient temperature will significantly affect the forming and developing of the residual stresses [3]. The angular distortion first increases to its maximum value at the threshold of heat input, then decreases with the further increasing of heat input, while the transverse shrinkage increases with the increasing of heat input continuously [4].

II. DESIGN AND ANALYSIS

2.1. Modeling using CATIA

The three dimensional model is modeled using CATIA V5R19. In a structure the lengthiest members will possess maximum amount of deflection. By taking the concept in consideration, the members having maximum length has taken into consideration. All the other members are joined after placing the main frame members.

Figure 1. 3D frame elements modeled using CATIA

2.2. Finite element modeling

The problem is formulated as a sequentially coupled Thermal stress analysis. First, a non-linear thermal analysis is performed to calculate the temperature history of the whole domain. Then, the results of the thermal analysis are applied as a thermal body load in
a non-linear structural analysis to determine distortions. The FE models for both thermal and structural analyses are the same. The general purposed FE program ANSYS WORKBENCH [14] is used for the analyses.

In order to facilitate data mapping between thermal and structural analysis, the same FE model is used with respective element types. For thermal analysis, the element type is SOLID70, which has a single degree of freedom, temperature, on each node. For structural analysis, the element type is SOLID187 with three translational degrees of freedom at each node. Due to anticipated high temperature and stress gradients near the weld, a relatively fine mesh is used there. Element sizes increase progressively with distance from the weld centre line.

III. RESULTS AND DISCUSSION

The FE model was run with all activated weld conditions and the fixed supports at the free ends of the member. The results which studied from the simulation were likely to give the maximum attention for the T joints and corner joints in which maximum deformation is observed.

Initially the weld deformations were studied for each part without having any kind of supports. Thus the main attention is given to the top rail, which is having more length and T joints. The part deformations due to weld parameters are mainly affected by the type of location and clamping supports used.

Results were observed for each weld members by activating them on different load conditions. Due to insufficient support, the deformation results were having more variation than the desired values.

The next sequences of experiments were carried out by assigning the fixed support to the top rail member. The maximum deformation was observed on the end weld members and minimum was on the weld members which are placed in the middle.

Results were observed by fixing the all end members and also by providing the location supports. The deformations thus given were greatly improved and also with a negligible amount of variation between each weld members.

CONCLUSION

Based on the FE analysis of the bus body side frame with different location and clamping supports are studied. The results obtained from the analysis shows
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the importance of supports used in the time of welding. With the use of proper supports the deformations can be reduced to an acceptable range. The study of fixture design has got more priority while designing a welded frame structure.

![Graph 1. Graphical representation of weld deformation with different supports](image)

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