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Research Paper

Analyzing the Uninterrupted Stresses in Welded Joints Under the Influence of Harmonic Vibrations using Finite Element Method

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ABSTRACT: *Numerous structures use welding. Welding produces localized heat, resulting in residual stress surrounding the bead. This study introduces an innovative method for mitigating residual stress post-welding by harmonic vibrational loading. We examine the welding of rolled steel for general construction at certain excitation frequencies. Specimens are welded on each side of the groove. The residual stress distribution of SS400 grade high-strength rolled steel weld joints was examined using ANSYS software and the finite element method (FEM). The welding procedure used gas shielded arc welding with a heat input of 750 J/mm. The finite element method analysis of the weld joint reveals a stress gradient around the fusion zone. The stress gradient is greatest in the fusion zone relative to adjacent areas. Cold cracks in the fusion zone of high-strength steel are ascribed to this cause. To avert welding fractures, mitigate thermal stress in the weld joint by regulating heat input. A finite element analysis of residual stresses in the butt welding of two similar plates is performed using ANSYS software. The research used a finite element model for simulating thermal and mechanical aspects of welding. This includes mobile heat sources, material deposits, temperature-dependent properties, metal plasticity and elasticity, transient heat transfer, and mechanical analysis. The welding simulation used sequential coupled thermo-mechanical analysis and the element birth and death method to model filler metal deposition. The distribution and amplitude of residual stress were quantified in the axial direction. A strong correlation exists between the finite element method and the experimental results.*
Keywords: *Welded Joint, Uninterrupted Stresse, FEM, Harmonic Vibration, ANSYS.*

I. INTRODUCTION

Residual stresses are those that remain within a structure even when no external pressures are applied. These residual stresses around the bead are a common result of welding. The use of metallurgical welding joints is widespread in various industrial products, including ships, offshore structures, and steel bridges. In the vicinity of the weld, however, brittle cracks, stress corrosion cracking, and fatigue may all happen. Pressure vessels are also present. Some advantages of such welded structures are low fabrication cost, air and water tightness, and high joint efficiency. Weld bead distortions and residual stresses may be caused by localized heating and rapid cooling that occurs during the welding process. If the base plate or other structural members contain residual stresses, the buckling strength of the system may be reduced. Reducing welding residual stresses is essential for their proper management in accordance with requirements. Past studies have explored many methods to reduce welding-induced residual stresses, including vibration stress alleviation, heat treatment, hammering, preheating, and weld sequencing. First, we consider the spectrum of stimulation frequencies and their potential effects on residual stress reduction. It is possible to weld the specimens on either side of the groove. To complete the welding process, one pass is required on each side. The specimen's general structure is made of rolled steel. Particular frequencies are selected in this case. The welding process is particularly destructive to high strength rolled steels because of (a) their excellent hardenability, (b) the hydrogen content, and (c) the stresses acting on the weld joint. A great deal of research and effort has gone into determining the critical residual tension that initiates fractures while welding. The study focused on SS400 steel weld joints, which are known for their high strength and wear resistance. The exact distribution of residual stresses is yet unknown. A wide variety of techniques have been used to quantify metal residual stresses, including diffraction, cracking, stress sensitive property approaches, and stress relaxation. Unfortunately, no matter how time-consuming, costly, or even dangerous these approaches are, they will not be able to spread the stress equally. Numerical analysis has been instrumental in the recent resolution of several complex engineering problems, including the evaluation of weld-induced residual stresses. The finite element method is the de facto standard for finding residual stresses. When two identical carbon steel plates are butt-welded, this study uses finite element analysis to model the welding process and forecast the residual stresses induced by the weld. Included in this research are mechanical analysis, transient heat transfer, temperature-dependent material properties, metal pliability and elasticity, and a fluctuating heat source.

II. LITERATURE SURVEY

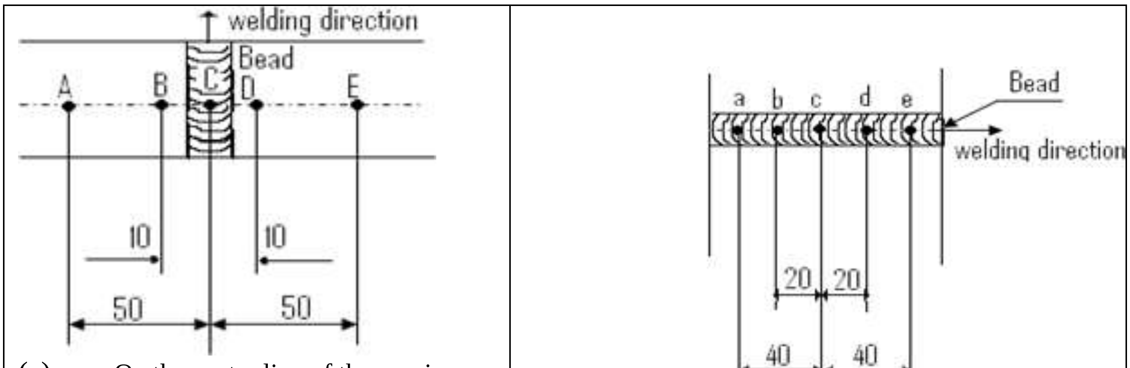
Among Tso-Liang Teng's notable endeavors were the creation of a workable welding sequence for a weld system and the exact prediction of residual stresses during welding. This is due to the fact that residual tension from welding is an inherent part of any structure that has been joined. Round patch welds, multi-pass butt-welded plates, and single-pass butt-welded plates subjected to varying welding sequences are studied for their thermomechanical behavior and residual stresses. This is achieved by the use of finite element techniques in thermal elastoplastic analysis. A welding sequence is also provided by this inquiry, which may be used to enhance the production process of welded structures. Dragi Stamenkovic and Ivana Vasov conducted research on hand metal arc welding using carbon steel plates. Utilizing ANSYS, a software application for finite element analysis of residual stresses, the process of butt welding two identical plates is examined. This study incorporates the finite element model, which is used for thermal and mechanical welding modeling. Additional components include mechanical analysis, a material deposit, metal elasticity and plasticity, and temperature-dependent material properties, as well as a temporary heat source. Thermomechanical studies including sequential coupling were used to mimic the welding process, while the element birth and death method was used to describe the deposition of filler metal. Along the axial axis, the magnitude and distribution of residual stress may be ascertained. A high degree of concordance is seen between the computational and experimental results. A number of structures rely on welded joints; the experiment was carried out by Shigeru Aoki and Tadashi Nishimura. Stress remains around the bead as a result of localized heat. When surface tensile residual stress is present, fatigue strength may be reduced. This study introduces a new method for reducing vibration stress in welding. We employ vibrational loads, random vibration, filtered white noise, and white noise. A butt joins the two narrow plates. A scintillation counter and a parallel beam X-ray diffractometer are used to measure the residual stress after the quenched scale has been chemically removed. According to our findings, the tensile residual stress around the bead is reduced when welding occurs due to random vibration. Using ANSYS, the authors Li Yajiang and Wangjuan investigated the distribution of residual stress in a weld joint of HQ130 grade high strength steel using a finite element method (FEM). The procedure of welding was carried out using gas shielded arc welding, which has a heat input of 16 kJ/cm. According to the weld joint's finite element model, there is a stress gradient in the region immediately surrounding the fusion zone. While it reaches 800-1000 MPa on the weld surface, the immediate residual stress is 500-600 MPa below the weld. The stress gradient is highest in the fusion zone as compared to the rest of the area. Many believe this is one of the reasons why cold fractures can develop in high strength steel close to the fusion zone. To avoid these types of fractures in the weld joint, it is crucial to lower the heat used during the weld.

III. PROBLEM DEFINITION

A review of the literature comparing the results obtained using the Finite Element approach to the residual stresses of welded joints.

Reducing residual tensions in welded connections made with mechanical vibration in mind is possible when the excitation frequency is equal to the natural frequency of the specimen. This leads to a considerable decrease in residual tensions.

Finding the residual stresses close to the weld bead in two directions (the longitudinal direction and the direction perpendicular to the bead) and finding these stresses in two directions while varying various frequencies.



(a) On the center line of the specimen

(b) On the bead

Fig 3.1 Measuring locations of residual stress (mm)

IV. IDEALIZATIONS

The welding process is modeled using the finite element method in this research. There are two primary parts to the calculation for welding: mechanical evaluations and thermal assessments. The temperature and phase evolution over time are first determined by the thermal analysis. Mechanical analysis determines stresses at integration sites and node displacements based on these results. The absence of inverse effects and the large influence of the temperature field on the stress field make sequentially linked analyses very successful. A perfect finite element (FE) study in three dimensions

The first step, thermal analysis, involves figuring out the welding thermal cycle using the distributions of temperatures. Consequently, the welding process is modeled in this study using a sequentially connected 3-dimensional thermomechanical FE formulation based on ANSYS. In both mechanical and thermal investigations, the temperature-dependent thermo-physical and mechanical properties of the materials are taken into account. Welding simulations are made easier and resource consumption is reduced by separating mechanical and thermal research. It is believed that the thermal state is unaffected by changes to the mechanical state. Nonetheless, changes in temperature have an effect on the mechanical state. To set up the mechanical model for residual stress analysis, we first utilize the temperature field that was calculated during welding and cooling as a body force. This endeavor includes the use of finite element models (FEMs) for the purpose of simulating mechanical and thermal welding. Appropriate numerical models for welding must take into account the process parameter, geometry constraints, material nonlinearities, and other physical phenomena. Speed of welding, number of passes, order of passes, amount of filler material supplied, and other characteristics fall under this category. Because of how hard it is to account for everything at once, most models include some approximations. In this research, we take a look at the thermal model and the assumptions that go into it:

Welding displacements have no effect on the component temperature distribution. II. All material characteristics are described up to the metal's liquid phase. IIII. The effects of air and radiation are considered. IV. Birth and death processes are used. Additionally, data is preserved after every load step. To separate the thermal and mechanical studies, it is assumed that the structural results obtained in the past as per point (i) do not rely on the thermal calculation at a certain instant.

V. FINITE ELEMENT MODELING OF THE SPECIMENS

Two SS400 rolled steel plates were butt-welded together in Figure 1 using a simulation of the welding process. In order to account for the large temperature and stress gradients close to the weld, the finite element model uses a very thick mesh on either side of the core line. The model's mesh is constructed using brick components with eight nodes and linear form functions. Reproducing a moving heat source requires precise representation of the heat source at each time step. Assuming the welding arc stays at a fixed element with a constant heat production rate per unit volume and advances to the next element at the end of the load step after welding is finished simplifies the movable heat source in this research. The SOLID70 element type, which has one degree of freedom, was employed in the thermal investigation. The SOLID45 element type, with three translational degrees of freedom at each node, was employed in the structural analysis. After the heat-affected zone (HEZ) has achieved equilibrium, it is shown in Figure 3.

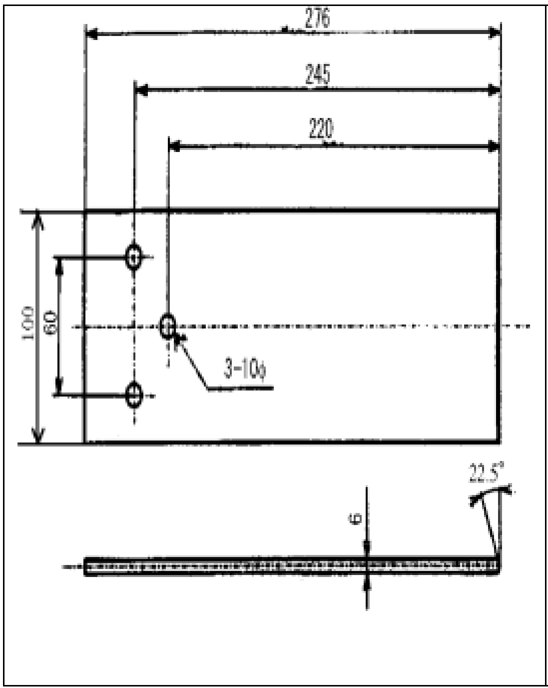


Fig. 5.1Geometry of the model used in the Analysis

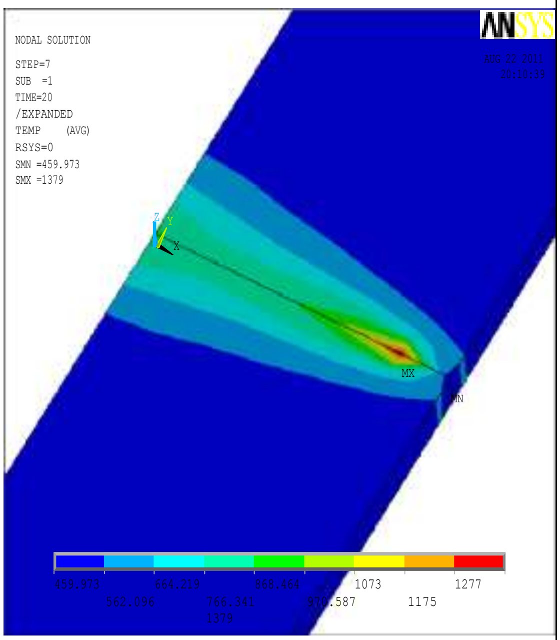


Fig. 5.2 Temperature Distribution after welding

VI. RESULTS AND DISCUSSIONS

The Results of the work done is as follows

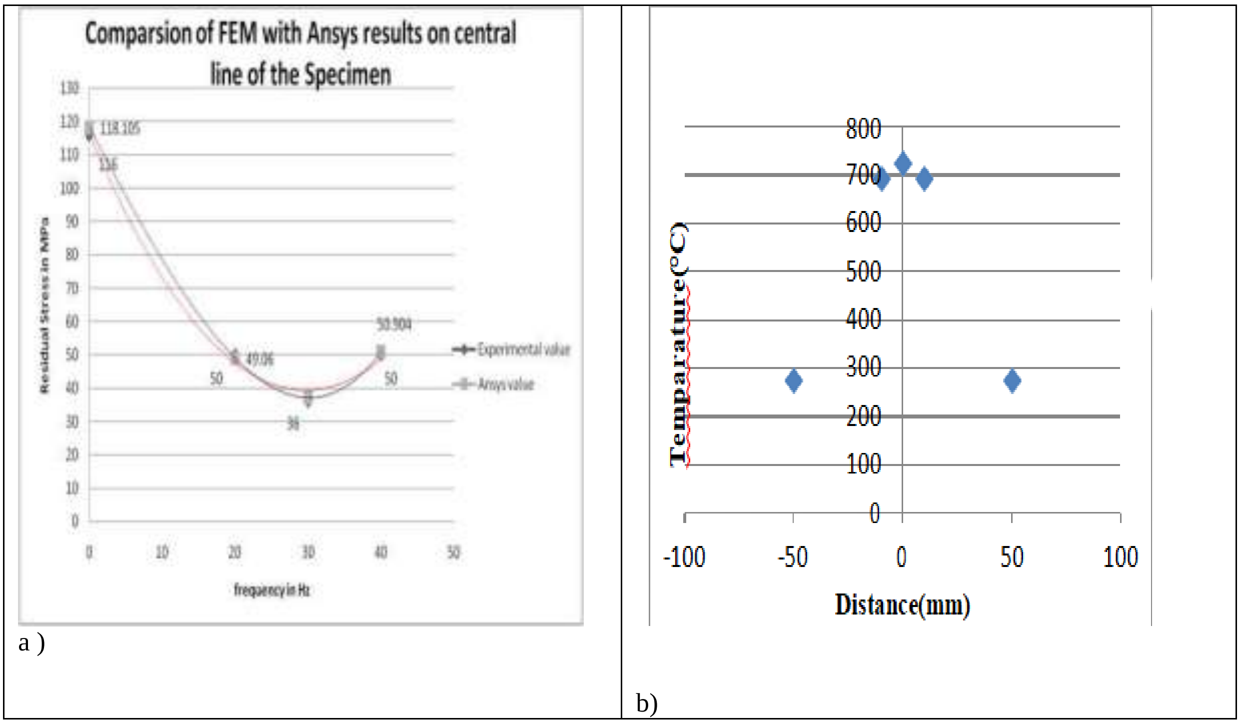


Fig 6.1 a) Comparison of FEM with Ansys results on central line of the Specimen, b) Temperature acting on the centre line of the specimen

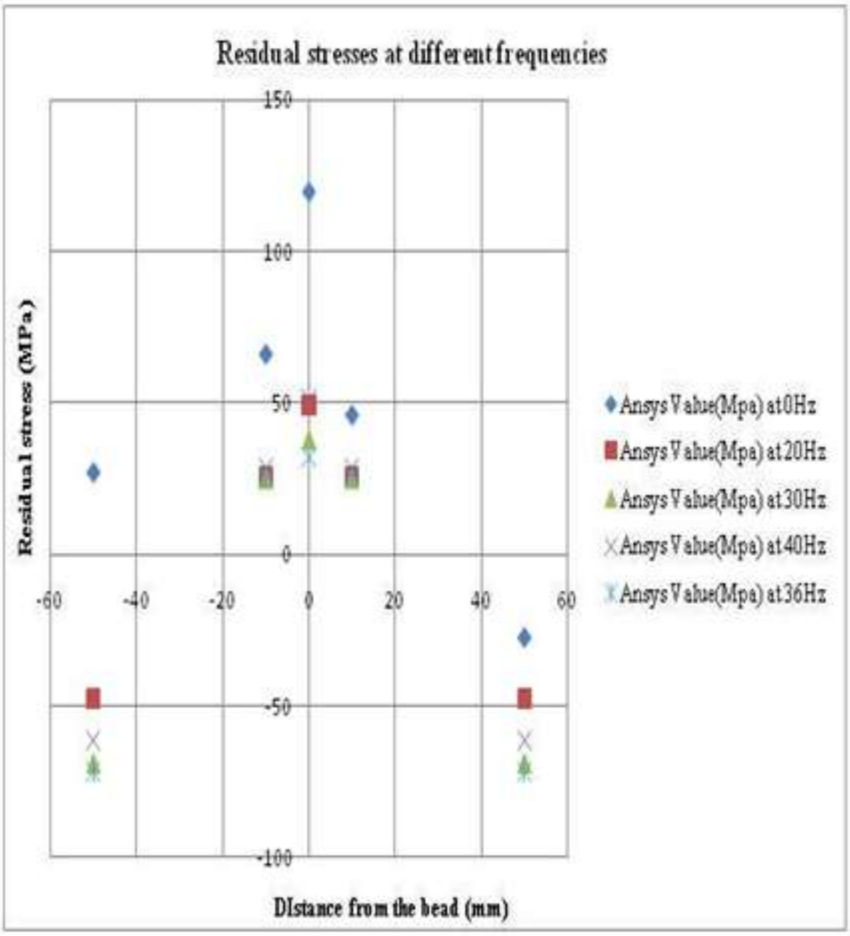


Fig 6.2 a) Residual stresses at different frequencies

Graph 1 shows that residual stresses are significantly reduced when the stimulation frequency is in sync with the material's inherent frequency.

Temperatures are much higher in the center of the specimen and relatively lower at its extremities, as shown in graph 2.

Graph 3 shows the frequency dependence of residual stresses at 10, 20, 30, 40, and 36 Hz.

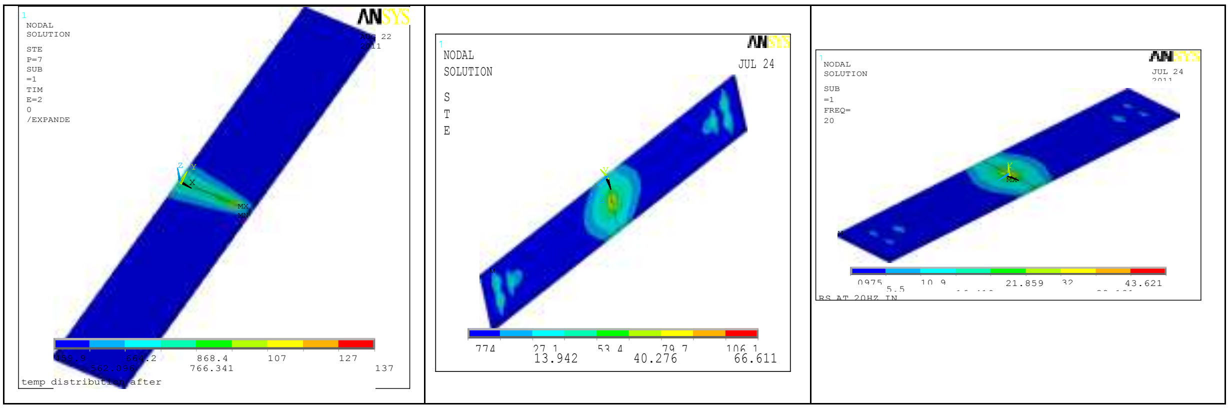


Fig 6.2 b) Residual stresses at different frequencies Anasys

VII. CONCLUSIONS

The purpose of this research was to use the Finite Element Method (FEM) to examine the welding process's effect on the thermal and structural characteristics of SS400 rolled steel. Finding out how much stress remains after welding was the primary goal. Finite Element analysis showed that the SS400 rolled steel has residual stresses of 119 MPa.

Model analysis was used to establish the natural frequency for 20, 30, 36, and 40 Hz. At the natural frequency of 36 Hz, a coupled thermo-mechanical research showed a considerable decrease in residual stress.

A little rise in residual stress from 119MPa to 123MPa was the consequence of a second-side welding procedure. following welding, the typical residual stress dropped to 29.23 MPa following a series of measurements taken at intervals of up to 30 minutes.

Thus, it is recommended to raise the welding speed and make sure the forced vibration frequency is near the specimen's natural frequency in order to drastically reduce residual stress.

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