Analysis Of Temperature Distribution Of Different Welded Joints In ShipBuilding**

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ABSTRACT:

Different materials are prone to distortion and cracks due to thermal stresses induced during welding .This project gives the information about the temperature induced in a joint due to welding in ship building . Simulation was carried out on a plate made of Aluminium and Cast-iron having dimensions 0.05×0.05×0.005 meters .The type of welding chosen is Gas tungsten arc(GTA) welding . Single pass welding was carried out . Simulation values calculated were taken as input for the analysis in ANSYS software.

A model was generated in ANSYS12(A general purpose FEA software) using SOLID Tet 10 node 87(3D solid element with temperature dof) . A refined mesh is made based on the convergence criteria and the analysis is performed to estimate the temperature distribution .Firstly a transient thermal analysis was carried out by giving heat flux as the time varying input to estimate the temperature variation .The non linear material properties are fed for the heat flow solution to get the thermal stress .The variation of the temperature with time , and thermal stress are obtained . The variation of these are reported and discussed.

The results of the present analysis is used in thermal stress analysis of the welded joints in ship building by using ANSYS parametric design language (APDL).

Keywords: *Gas tungsten arc(GTA) welding , Temperature field, Weld dimension, Finite element analysis, Thermal modeling.*

INTRODUCTION:

Welding is extensively used in the construction of shipbuilding, aerospace automotive, chemical, electronic, and power generation industries. In fusion welding, parts are joined by the melting and subsequent solidification of adjacent areas of two separate parts. Safety and reliability of the welded joints depend on the weld metal geometry, composition, and structure. Heat flow during welding is of great interest to welding engineers and metallurgists. It not only controls the size of the fusion, but also affects the properties of the resultant weld. The gas tungsten arc (GTA) welding is a process in which a coalescence of metals is produced by heating them with an arc between a tungsten electrode and the work piece. A good quality weld is characterized by material composition, joint condition, relative position of the welding arc to the joint and welding parameters such as arc current, arc voltage, and torch travel speed, etc.. Therefore, choosing an appropriate set of welding parameters becomes one of the most important tasks in GTA welding process.

The analytical solution to the steady state, two dimensional heat flow problem of thin-plate welding was first derived by Rosenthal. Due to some unrealistic assumptions, heat flow and solidification in the weld pool can not be predicated, and poor agreement exists between calculated and experimental results in the area immediately adjacent to the weld pool. Solving a transient three-dimensional heat conduction equation with convection boundary conditions at the surfaces of the weld element, Boo and Cho obtained the transient temperature distributions in a finite thickness plate during arc welding. A series of GTA welding experiments for various conditions is performed to verify their solutions. Oreper *et al.* and Oreper and Szekely formulated a mathematical model on the transient fluid flow and temperature fields in a liquid pool generated by a spatially distributed surface heat flux on an initially solid metal block. In the formulation, allowance was made for electromagnetic, buoyant and surface tension force, and the resultant equations were solved numerically. For GTA welding of pipes, Grill studied heat flow during girth welding by the finite difference method. A heat source was assigned to each grid point in the work piece, and the solution was obtained by using the alternating direction implicit scheme. Later, Kou and Le investigated the heat flow during the welding of pipes. Both steady state heat flow during seam welding and unsteady state heat flow during girth welding were theoretically calculated and experiment tally verified.

Considering arc parameters, radioactive and convective heat losses and the temperature dependent thermal properties, Sharir *et al.* employed the finite difference method to calculate the unsteady heat flow during the fusion welding of thin tantalum sheets. Based on the measured shape of the weld pool, Pavelic *et al.* calculated the temperature distribution in a thin plate of steel using the finite difference method. Neglecting heat conduction in the welding direction, Friedman used the finite element method to calculate the temperature and stress distribution in a thin plate being welded. Kou developed a model to describe the steady state, two-dimensional heat flow during the welding of thinplates. The heat of fusion, the size and distribution of the heat sources , the temperature depends of thermal properties , the heat conduction in the welding direction and the surface heat loss during welding were taken into account.

Gas Tungsten Arc Welding (GTA) Process Description:

Gas Tungsten Arc Welding (GTAW), also known as tungsten inert gas (TIG) welding is a process that produces an electric arc maintained between a non consumable tungsten electrode and the part to be welded. The heat-affected zone, the molten metal and the tungsten electrode are all shielded from atmospheric contamination by a blanket of inert gas fed through the GTAW torch. Inert gas (usually Argon) is inactive or deficient in active chemical properties. The shielding gas serves to blanket the weld and exclude the active properties in the surrounding air. Inert gases such as Argon and Helium do not chemically react or combine with other gases. They pose no odour and are transparent, permitting the welder maximum visibility of the arc. In some instances Hydrogen gas may be added to enhance travel speeds.

Finite Element Model:

SOLID87 Element Description:

SOLID87 is well suited to model irregular meshes. The element has one degree of freedom, temperature, at each node. The element is applicable to a 3-D, steady-state or transient thermal analysis.

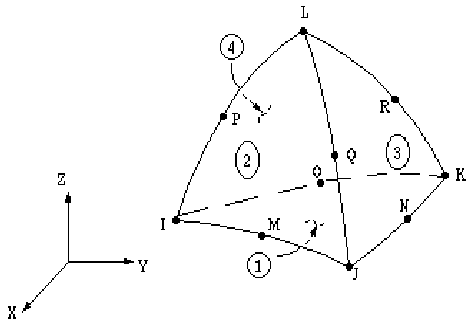

Fig.5. SOLID87 Element Geometry

2.3.Material Properties

1.Aluminium:

Thermal conductivity	= 155(W/m-k)
Specific Heat	= 915(J/kg-k)
Density	= 2750 (kg/m^3)

2. Cast Iron:

Thermal conductivity	= 12(W/m-k)
Specific Heat	= 461(J/kg-k)
Density	= 7900(kg/m^3)

Loading and Boundary Conditions:

A uniform temperature of 200^0 c is applied on the surface of the plates , and a heat flow of 2500W for the present analysis .The welding velocity of GTA is 3~7.24 mm/s. The time is calculated by knowing the distance between the nodes.

For brevity, it is assumed that the arc heat input area is far smaller than that of the plate and can be considered as a point heat source. No heat generates from the plate .Except during the initial and final transients of the welding process, the temperature distribution in a work piece of sufficient length is steady with respect to a coordinate system moving with heat source. Under such conditions the time dependent term in equation (1) vanishes and the process is reduced to a steady state (quasi-stationary state) heat flow problem [2, 3]. For this reason, a new group of variables is given as

$$x = x' - Ut \qquad y = y' \qquad z = z' \qquad \rightarrow 2$$

Substituting equation (2) into equation (1), the governing equation then becomes

$$\propto \left\{ \frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} \right\} + U \frac{\partial T}{\partial x} = 0 \qquad \rightarrow 3$$

where α, thermal diffusivity of the work piece, is equal to $k/(\rho c)$. The power input of the heat source Q describes the heat flux from the arc. It equals ŋ EI, where ŋ is efficiency of the arc, E is the arc voltage, and I is the welding current. According to Pavelic *et al.* [14] the heat flux from the arc can be expressed by

$$q = \frac{3Q}{\pi a^2} exp\left\{ -\frac{3r^2}{a^2} \right\} \qquad \rightarrow 4$$

where Q, r, and a are the power input, the distance from the center, and the radius of the heat source, respectively. To complete the mathematical description of theproblem, the boundary conditions are specified as follows:

$$-k\frac{\partial T}{\partial z} = \frac{3Q}{\pi a^2} exp\left\{ -\frac{3r^2}{a^2} \right\} + h(T - T_a) + \sigma\varepsilon(T^4 - T^4{}_a)$$

$$For \quad z = 0 \qquad \rightarrow 5$$

Table.The Minimum And Maximum Temperature Of Different Welded Joints In Various Materials

S.NO	Type Of Joints	Type Of Material	Min.Temp	Max.Temp
1	**Lap**	**Al**	**198.217**	**530.777**
		CI	**199.172**	**429.636**
2	**T-Joint**	**Al**	**199.208**	**506.423**
		CI	**199.866**	**419.831**
3	**Corner**	**Al**	**199.687**	**454.307**
		CI	**199.911**	**403.180**

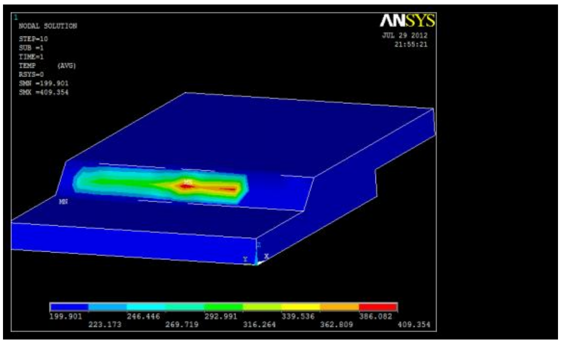

Fig. Shows The Nodal Temperature Range Of Lap Joint Of Aluminum Material

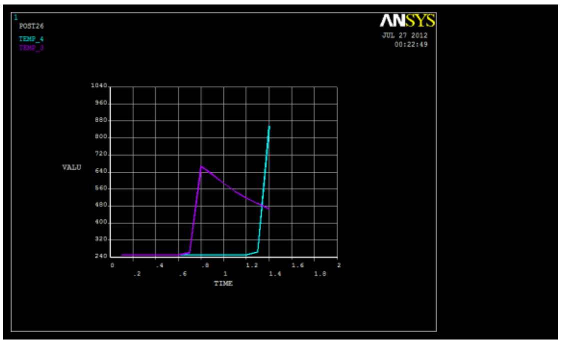

Fig.Variation Of Temperature W.r.t Time Of Lap Joint Of Aluminum Material

Variation of First Node Temperature with respect to Time:

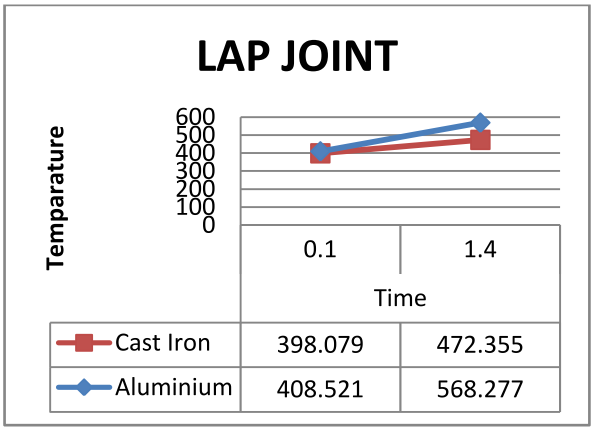

Fig.21.Variation of Temp. W.r.t Time in Lap Joint at First Node(328)

The Graph.1.. depicts the variation of first node(328) temperature with respect to time .The temperature value increases gradually from time 0.1 to 1.4. It can be observed from the figure in lap welded joint , the material of cast iron temperature is low with respect to time compared to aluminium at first node.

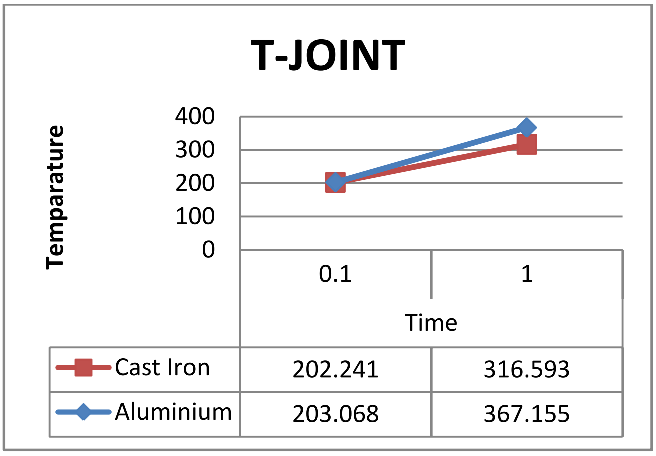

Fig.22.Variation of Temp. W.r.t Time in T-Joint At First Node

The Graph.2. depicts the variation of first node temperature with respect to time .The temperature value increases gradually from time 0.1 to 1.0. It can be observed from the figure in T- welded joint , the material of cast iron temperature is low with respect to time compared to aluminium at first node.

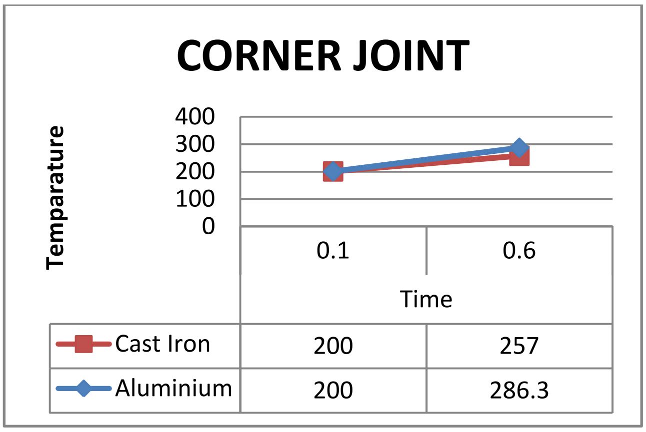

Fig.23.Variation of Temp. W.r.t Time in Corner Joint at First Node

The Graph.2. depicts the variation of first node temperature with respect to time .The temperature value increases gradually from time 0.1 to 0.6. It can be observed from the figure in corner welded joint , the material of cast iron temperature is low with respect to time compared to aluminium at first node.

Variation of Last Node Temperature with respect to Time:

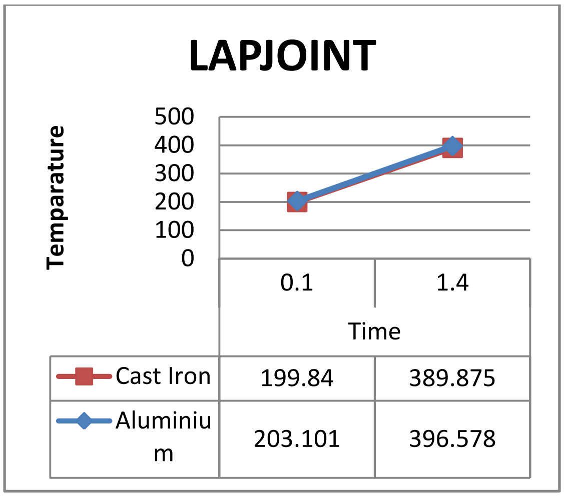

Fig.24.Variation of Temp. W.r t Time in Lap Joint at Last Node(337)

The Graph.4. depicts the variation of last node(337) temperature with respect to time .The temperature value increases gradually from time 0.1 to 1.4. It can be observed from the figure in lap welded joint , the material of cast iron temperature is low with respect to time compared to aluminium at last node.

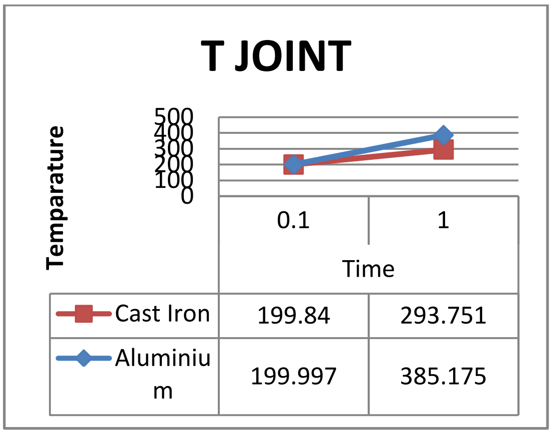

Fig.25.Variation of Temp. W.r.t Time in T-Joint at Second Node

The Graph.5. depicts the variation of last node temperature with respect to time .The temperature value increases gradually from time 0.1 to 1.0. It can be observed from the figure in T- welded joint , the material of cast iron temperature is low with respect to time compared to aluminium at last node.

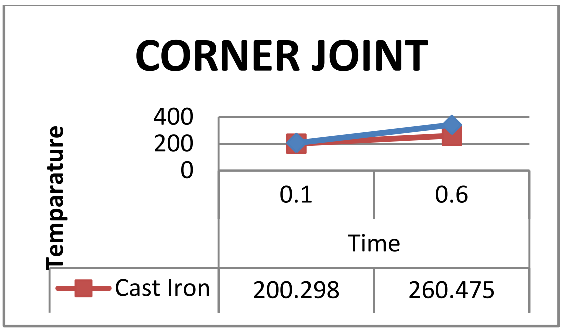

Fig.26.Variation of Temp. W.r.t Time in Corner Joint at Last Node

The Graph.6. depicts the variation of last node temperature with respect to time .The temperature value increases gradually from time 0.1 to 0.6. It can be observed from the figure in corner welded joint , the material of cast iron temperature is low with respect to time compared to aluminium at last node.

CONCLUSION:

1. The temperature distribution of aluminum and cast iron is uniform throughout the entire length of the weld.
2. The thermal flux distribution is uniform over the surface of aluminum and cast iron plates.
3. The thermal stresses and material properties of aluminum and cast iron does not change with time.
4. Thermal stresses developed during welding may be used for thermal analysis and structural analysis of shipbuilding.