MECHANICAL AND THERMAL PROPERTIES BY TIG WELDING & SIMULATION PROCESS USING FEM ANALYSIS AND HEAT SOURCE MODEL OF MATERIAL SS316

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Abstract:- A finite element simulation of the Tungsten Inert Gas (TIG) welding process is done by using the commercial used software MSC MARC to analysis the properties of stainless steel plates of grade SS-316 with the single pass. The thermal analysis is done with the MSC thermal solver with the element type Quad 4 which is having the single degree of freedom. The maximum temperature of the weldment is coming as 1800^0C which is the main factor for the change in the metallurgical changes and the changes in the mechanical properties of the material. In this paper the temperature profiles at the different location in the transverse direction from the weld centre line and the transient thermal histories are plotted which can be used for the evaluation of the mechanical properties of the structure. The welding heat source model which is used in the study is the Double Ellipsoidal Heat source model which is the latest heat source model in the welding simulation.

Keywords:- Finite element analysis, residual stresses, temperature distribution, welding

Introduction:- Arc welding process is the main manufacturing process which is used in all the main industries like the oil and gas industries, pressure vessels, auto mobiles, aerospace industries etc. In this process due to the high heat input there are lot of defects which hinder the life or in service condition of the structure. This can also effect the life of the people and can also effect the environment. For all this the simulation is require to get best parameters and can verify it will not collapse during in -service. Here the Gas Tungsten arc welding (GTAW) process is used which is the non consumable welding process. his procedure utilizes the heat produced by an electric bend between the non-consumable tungsten terminal and work piece (generally responsive metals like stainless steel, Al, Mg and so on.) for liquefying of faying surfaces and latent gas is utilized for protecting the curve zone and weld pool from the barometrical gasses. Many researchers had done wok on that [1-10] in 1946 [1] build up a connection for the different heat source point heat source and line heat source. In 1969 Gaussian type of circulation which is utilized by numerous specialists and has been utilizing the same on account of its effortlessness and precision of such a presumption. Later [2] presented a twofold ellipsoidal warmth dissemination demonstrate.[3] built up a changed twofold ellipsoidal warmth circulation show.

Senior member [4] developed a 3D FE demonstrate for recreating lingering worries amid multipass welding of a pipe. The circulation of remaining worry in welded pipe structures relies upon a few factors, for example, auxiliary measurements, material properties, warm information, number of weld pass and welding grouping, and so forth.

In the present examination, a three dimensional limited component demonstrate is created to mimic the temperature fields and leftover anxiety fields created amid welding of funnels. The model is approved utilizing the trial comes about introduced by [5]

The following tasks are performed in this study[6]:-

- Welding simulation
- Check the weld bead profile
- Use modelling and FEM to input the structure, perform the analysis and visualize the result.
- To get the meshed model for better accuracy.
- To provide the fundamental concepts of the theory of the FEM
- To find the heat source model of the model.
- Find the parameters of heat source model.
- Plot the temperature profile of welding.

The scope of the study is the examination understands the reenactment of the TIG welding. Welding errors can be avoided and the welding quality can be increased. The experimental measurements are costly, requires equipment and may cause time related problems. The measurements results can be obtained by only the desired parameters. It can be improved in a way that will include not only single-pass, but multi-pass welding. When the temperature curves are obtained rising of the curve is same in the experimental as well as for the simulation of the welding processes.

Finite element modeling and Experimentation

Thermal Modeling

By utilizing proper work improvement strategy, generally fine work is produced in and around the weld lines and relatively coarse work is in ranges far from weld line as appeared in figure 1 hub block warm component is utilized for the warm investigation. The administering condition for transient warmth exchange amid welding is given by equation 1[7].

$$\rho c \frac{\partial y}{\partial x}(x.y.z,t) = -\nabla.q(x,y,z,t) + Q(x,y,z,t) \qquad .... (1)$$

Where ρ is the density, c is the particular warmth limit, T is temperature, q is the warmth motion vector, Q is the inner warmth age rate, x, y and z are the directions in the reference framework, t is time and ∇ is the spatial slope administrator. To play out the investigation, the warmth dispersion demonstrate is adjusted keeping in mind the end goal to oblige tube shaped directions. The pipe geometry is produced and TIG welding light is connected along the boundary utilizing the welding parameters.

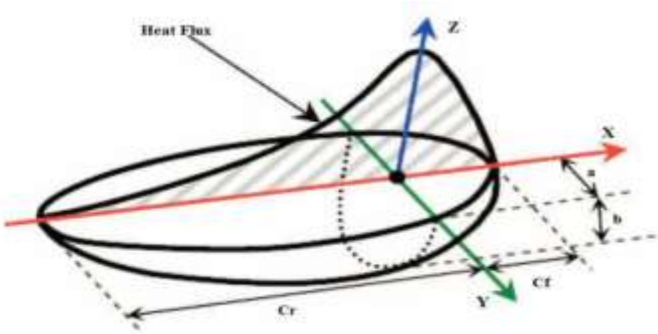


Fig 1. Double ellipsoidal heat source [8]

Simulation methodology and sequence

- Firstly we open MSC PATRAN and make a rectangle.
- Then give the length, width and thickness to the model and extrude it get the desired length of rectangular plate.
- Then go to geometry and make model into solid.
- Then we apply the all setting to get the meshed model.

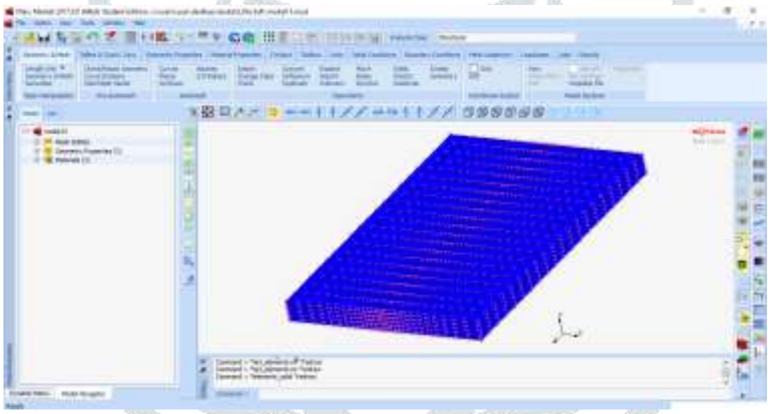


Fig 2. Meshed model of the stainless steel plate

- Then we import the model into MSC Marc Mentat and apply the condition to get required model.
- Then applied the all using command to get final results and plot a temperature profile of weld bead.

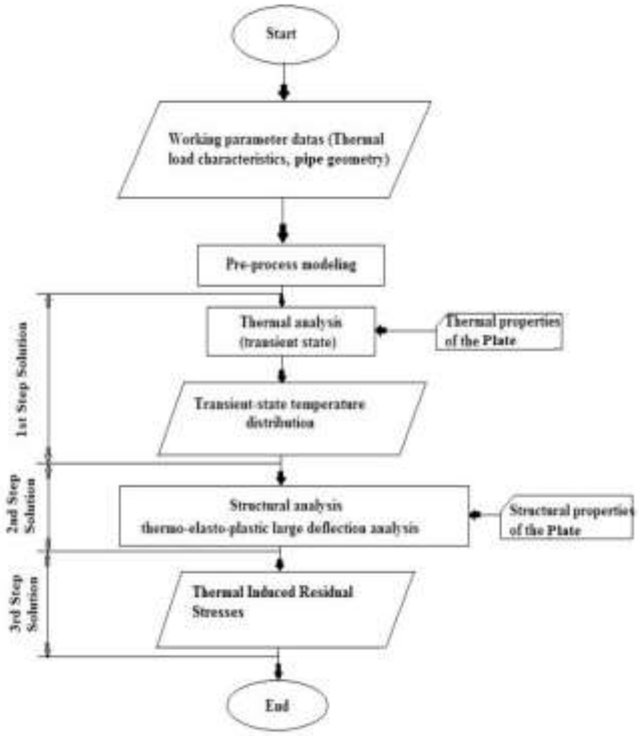
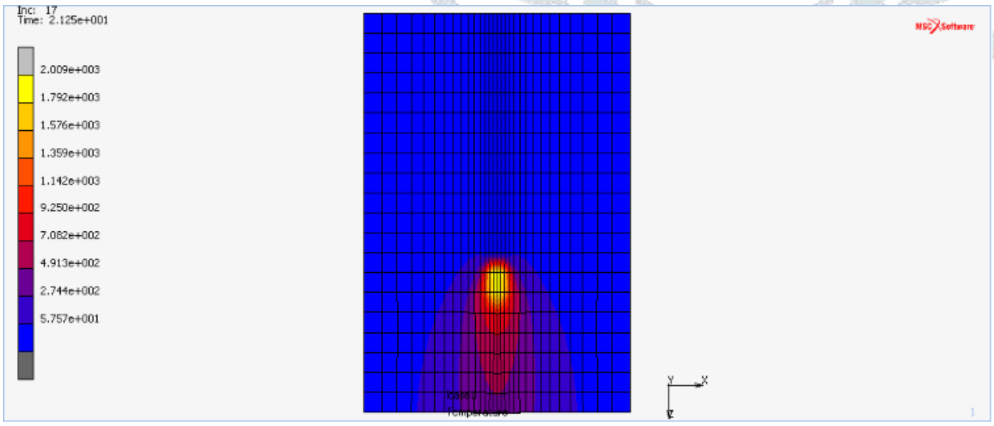


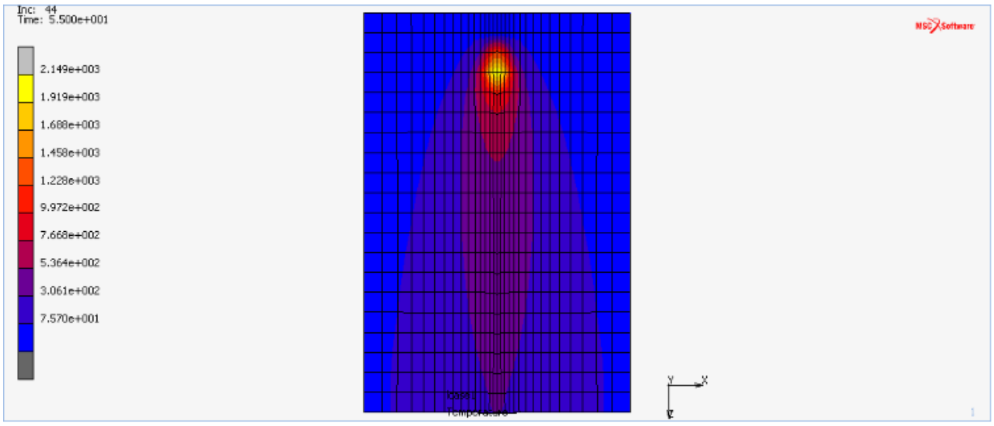
Fig. 3. Flow chart of Methodology [9]

Results and Discussion

The double ellipsoidal heat source model is used in this study with the heat source dimension as front ellipsoidal length ‘C_f=5 mm’, ‘C_r=15 mm’ , ‘a=3mm’ and ‘b=5mm’ the fraction $f_f+f_r=2$. The front ellipsoidal fraction is taken as f_f =0.4 and the rear ellipsoidal fraction is taken as f_r =1.6. Figure 4a and 4b shows the welding temperature contour at different time figure 4a is the welding temperature contour at time 21 sec from the weld start and the figure 4b is the welding temperature contour at time 55 sec from the weld start.



(a)



(b)

Fig. 4. Welding temperature contour (a) at 21 seconds (b) 55 seconds

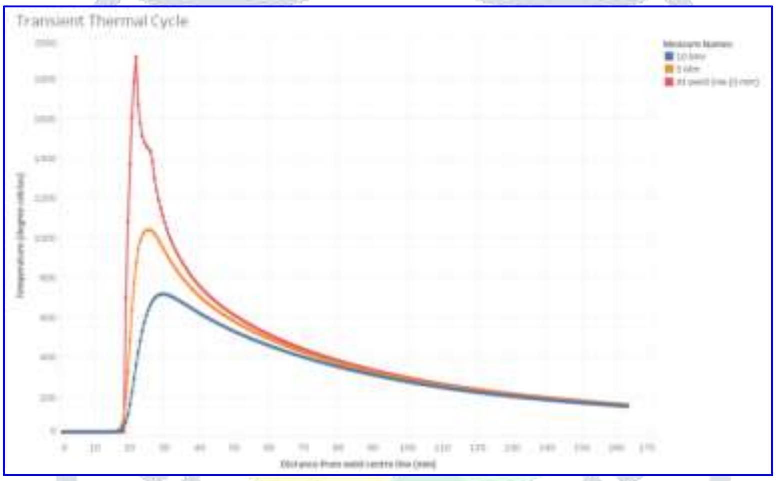


Fig. 5. Transient temperature history profile

Figure 5 shows the history plot of the temperature profile at different locations at 0, 5 and 10 mm from the weld centre line. This shows the temperature at 0 mm is maximum as moving away that the peak temperature decreases. With the low in the elevated temperature there will be change in the cooling rate which effects in the metallurgical and mechanical properties of the material.

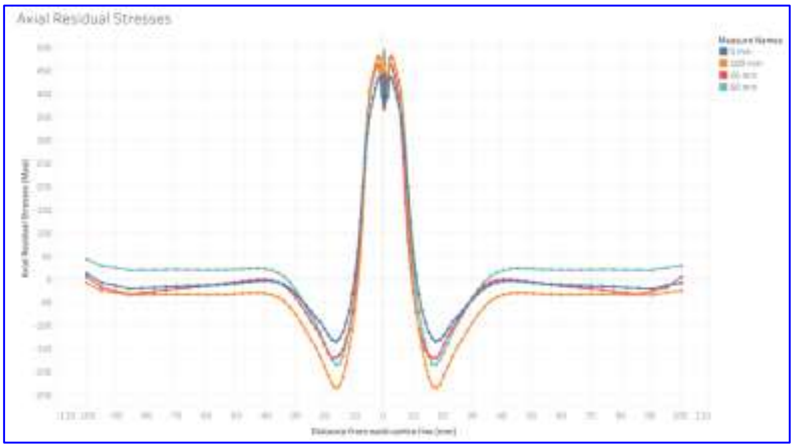


Fig. 6. Axial residual stress

The axial residual stress at the different locations is shown in the figure 6. It shows that the tensile residual stresses are induced at the weld fusion zone of about 450Mpa and as go away from the weld bead area the nature of the residual stresses changes to the compressive residual stresses of about 150 Mpa.

Conclusion

- The maximum temperature of the TIG welding process is around 1900^0C
- The nature of the residual stress is tensile in or near the fusion zone and compressive residual stresses away from the fusion zone.
- With the change in location along the weld line there in not any significant change in the welding residual stresses.

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