THERMAL ANALYSIS OF STEEL PIPE

B Velan[1], V Senthil Kannan[2], A P Sivasubramaniam[3]

[1]B Velan Department of Mechanical Engineering & Paavai Engineering College, Namakkal, Tamilnadu
[2]V Senthilkannan Department of Mechanical Engineering & Paavai Engineering College, Namakkal, Tamilnadu
[3]A P Sivasubramaniam Department of Mechanical Engineering & Paavai Engineering College, Namakkal, Tamilnadu

---***---

Abstract - This study is based on the general heat transfer between two pipe joints. Three sample tubes are used in this study. A different connection method is treated Arc welding method is used to connect pipes. Two identical pipe sections are joined together. In this study, the thermal conditions of heat transfer between the pipes are determined using Ansys software.

***Key Words*:** Welding, Pipe, Heat Transfer, Temperature…

1. INTRODUCTION

Welding is the joining process of similar or dissimilar metal parts pieces there. This study deals with the joining of steel pipe steel so steel pipes are joined together using the arc welding process method Different specimens are used in this study.

Fabrication is often referred to as a known secondary manufacturing process because the process is based on methods of raw material obtained from the manufacturing process such as extrusion and rolling.

Fabrication is a process of joining two or more elements into a single part. The most common examples are aircraft, ship hull bodies, building trusses, welded machine frames, sheet metal parts, etc. The fabrication process can be classified as follows.

- Mechanical joining
- Adhesive bonding
- Welding, brazing, and soldering

A particular fabrication method depends on a number of factors

1.1 Type of Assembly

Permanent, semi-permanent, or temporary Joining those obtained by bolts or screws and can be disassembled whenever necessary are temporary in nature.

Rivets are semi-permanent fastening devices that involve making holes in the mating parts. Materials being joined Steel, cast irons, aluminium, similar or dissimilar metals

Type of service required

Assembly subjected to heavy loading, impact loading, high temperatures

1.2 Principle of welding

The welding process is a complex process that involves heat and liquid-metal transfer, chemical reactions. A gradual formation of the welded joint is obtained through liquid-metal deposition and subsequently, there is a transformation from cooling into the solid state.

- **Brazing**

Brazing is a coalescence of a joint with the help of a filler metal whose liquidus temperature is above 4500 and is below the solidus temperature of base metal. In brazing the base metal is not melted. Dissimilar metals can be joined by brazing. Except for aluminum and magnesium, brazing can join almost all metals. The brazed joint is not useful for high-temperature welding because of the low melting temperature of the filler metal. Here the filler metal reaches the joint by capillary action, it is necessary to control the clearance between the two parts. The temperature at which filler metal is entering the joint is also important.

- **Soldering**

Soldering is the method of joining similar or dissimilar metals by means of a filler metal whose liquid temperature is below 4500. The joint design used for soldering is similar to that of brazing as in both cases filler metals enter the joint by capillary action.

Like brazing, soldering also needs solvent cleaning, acid pickling, and mechanical cleaning of the joint surface. In order to remove the oxides from the joint surface to prevent filler metal from oxidizing, fluxes are generally used in soldering.

1.3 Aims and Objectives

- ➢ Studying the effects of welding in order to understand the thermal analysis – especially in clad pipes.
- ➢ Discovering the effects of thermal and in similar joint welds of clad pipelines.
- ➢ Determining the weakest point of a burst of the welded similar material joint.
- ➢ Carrying out Finite Element Analysis (FEA) and Simulation of the weld by developing 2D axis-symmetric and 2D finite element models of pipes and plates for thorough examination of the thermal of the welded structure.
- ➢ Creating a 3D Strip model of the Pipe for the study of the thermal analysis.
- ➢ Understanding the heat distribution during the welding process and its influence on the thermal stress formation via weld experiments mechanical testing and laboratory investigation as well as FEA simulations.

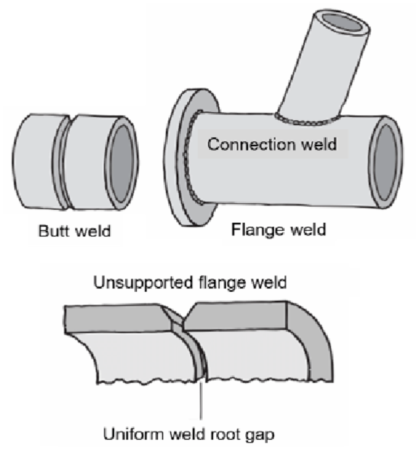

Fig -1: Welding object

2. MANUAL METAL ARC WELDING

In this process, the heat is generated by an electric arc between the base metal and a consumable electrode. As the electrode movement is manually controlled it is termed as manual metal arc welding.

This process is extensively used for depositing weld metal because it is easy to deposit the molten weld metal at the right place where it is required and it doesn't need separate shielding. This process is commonly used for welding metals, which are comparatively less sensitive to atmospheric gases. This process can use both AC and DC.

The constant current DC power source is invariably used with all types of electrodes (basic, rutile, and cellulosic) irrespective of base metal (ferrous and non-ferrous). However, AC can be unsuitable for certain types of electrodes and base materials.

Therefore, AC should be used in light of the manufacturer's recommendations for the electrode application. In the case of DC welding, heat liberated at the anode is generally greater than the arc column and cathode side.

The amount of heat generated at the anode and cathode may differ appreciably depending upon the flux composition of the coating, base metal, polarity, and the nature of arc plasma.

In the case of DC welding, polarity determines the distribution of the heat generated at the cathode and anode and accordingly, the melting rate of the electrode and penetration into the base metal are affected.

3. CAD MODELLING AND WELDING PROCESS

- Select sketcher is used to create a 2D representation of the part and create a pipe profile.
- After creating a profile exit from Sketcher and enter part design.
- By using the padding option add material to the profile of the spur pipe.
- Finally, by using the slot option make a slot inside the hole created by the pocket on the pipe face. Final modeled pipe as shown in Fig.

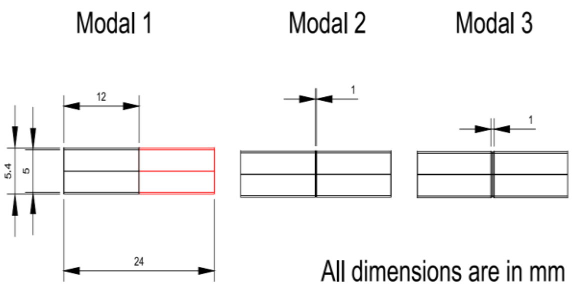

Fig -2: 2D pipe design

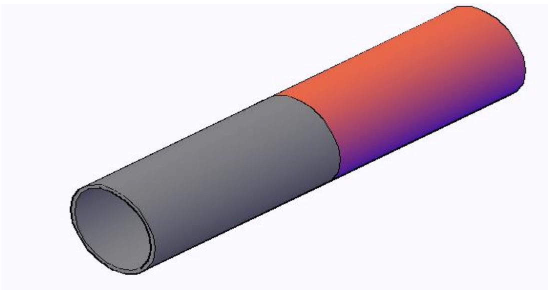

Fig -3: 3D pipe modal 1

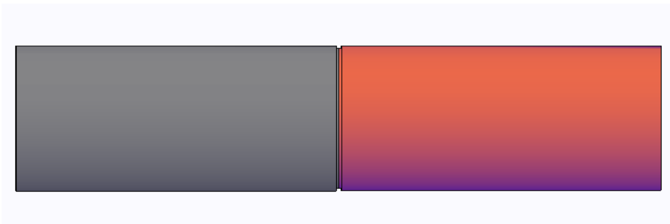

Fig -4: 3D pipe modal 2 side view

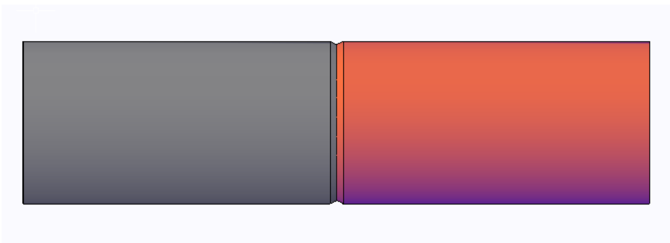

Fig -5: 3D pipe modal 3-side view

Fig -6: Pipe modal 1

Fig -7: Pipe modal 2

Fig -8: Pipe modal 3 V type

4. FEA THERMAL ANALYSIS

The FEA thermal analysis reported in this paper is part of a more complete FE simulation intended by the authors to determine welding thermal analysis for a similar welded pipe.

The FEA thermal analysis, which forms the first part of the simulation, is reported here, whereas the sequentially coupled structural analysis, which forms the second part of the simulation, is to be reported in a future publication.

The type of simulation adopted by the authors is described as solid-mechanical, modeling the heat flux delivered to the pipe by the heat source and allowing for the thermo-physical behavior, such as conductivity, and then translating the thermal effects into structural mechanical effects, such as volume expansions and plasticity, without allowing for any fluid effects of the molten regions.

The solid mechanics approach is justified in ignoring the fluid effects since stresses become significant only when the material has solidified and is relatively cool. When the material is molten or close to being molten, it is soft enough not to sustain any significant stresses.

4.1 FEA model of the welded pipe

The FE simulation of the fusion welding of the dissimilar welded steel pipe starts with generating an FE model by first creating an FE mesh.

The commercial package used for this purpose and indeed for performing the complete FE thermal analysis, reported in this paper, is ANSYS R2022.

A complete FE mesh has been generated from the start, which includes the pipe and the weld region. The weld pass sequence in the FE model is identical to that in the actual weld, as shown in Fig. The shape of the weld passes in the FE model does not have to accurately match the actual shape of the weld beads to produce representative and realistic thermal contours.

Although the shapes of the FE passes are rather square compared to the actual weld, the resulting thermal contours emerge rounded and realistic. Nonetheless, it is believed that the final layer of weld passes has the most significant effect on residual stresses, and therefore an attempt has been made to make the final layer closer in shape to the actual weld beads.

The shape of the final layer of beads can easily be adjusted without unduly complicating the FE model, which is not the case for the other beads. The actual FE mesh which has been generated for the model is shown in Figs. The mesh is refined in the weld region and HAZ and it becomes gradually coarser as it moves away from the weld, as shown in Fig.

The complete 2-D axisymmetric FE mesh comprises 9022 nodes and 2919 elements. The element type used throughout the FE model is an eight-node continuum solid quadratic axisymmetric diffusive heat transfer quadrilateral.

4.2 Pipe modal 1(Normal Weld)

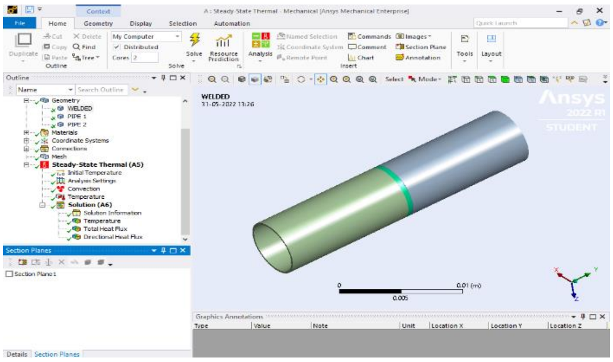

Fig -9: Named section of pipe

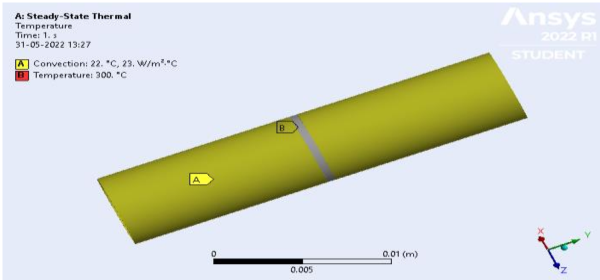

Fig -10: Boundary condition of pipe modal 1

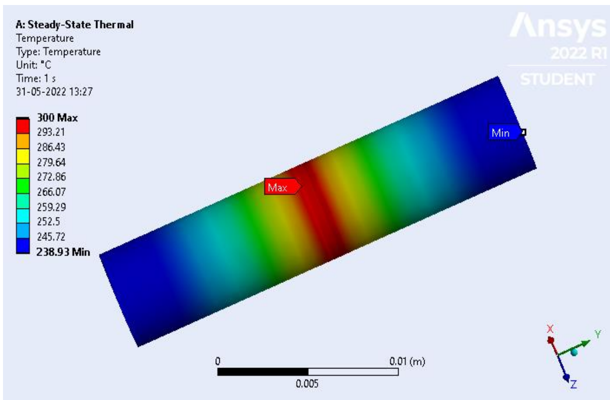

Fig -11: Temperature distribution of pipe modal 1

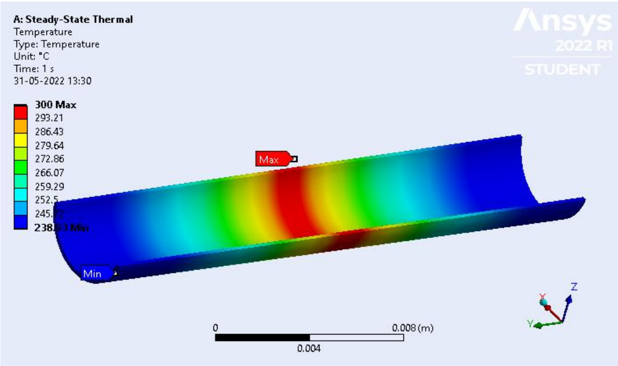

Fig -12: Temperature distribution of pipe modal 1 cross-section view

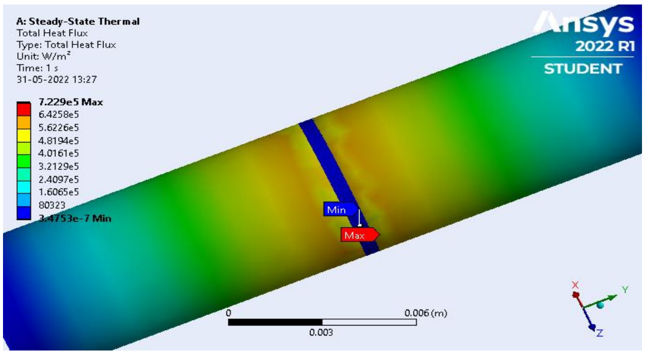

Fig -13: Total heat flux of pipe modal 1

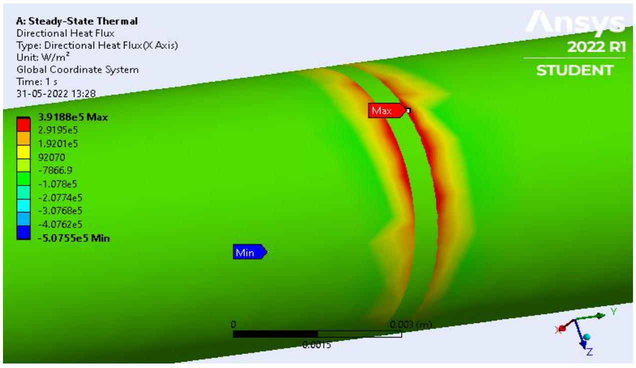

Fig -14: Directional heat flux of pipe modal 1

4.3 Pipe modal 2 (Section cut Weld)

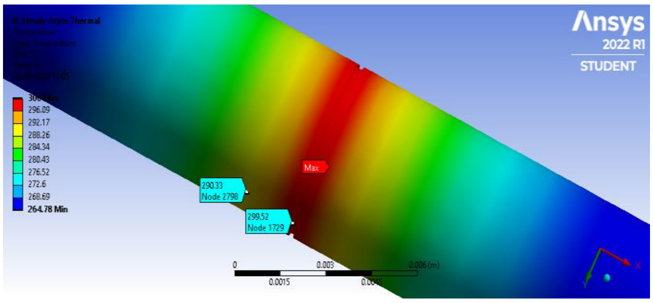

Fig -15: Temperature distribution of pipe modal 2

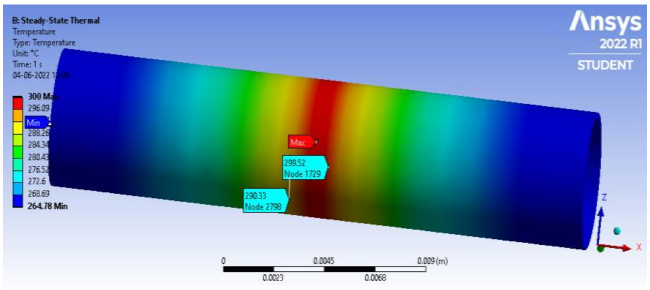

Fig -16: Temperature distribution of pipe modal 2 side view

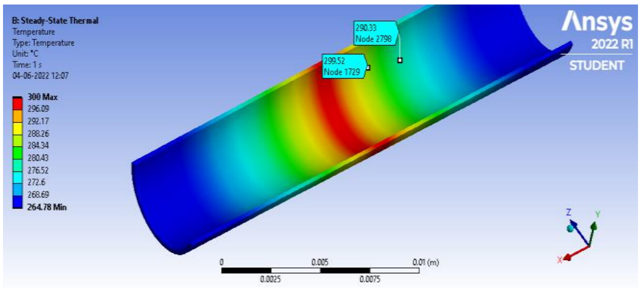

Fig -17: Temperature distribution of pipe modal 2 cross-section view

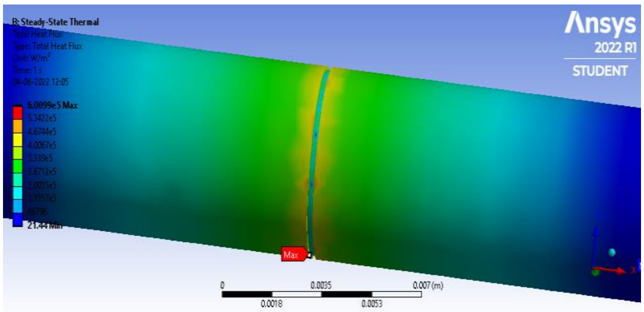

Fig -18: Total heat flux of pipe modal 2

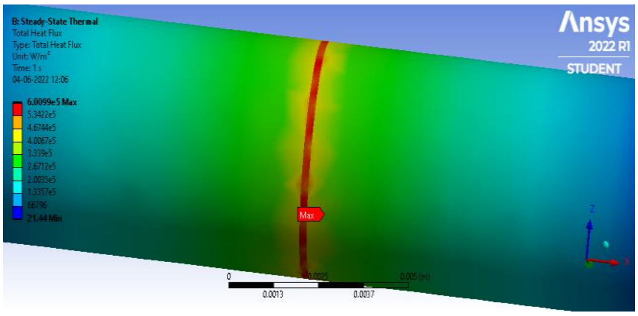

Fig -19: Total heat flux of pipe modal 2(welded area)

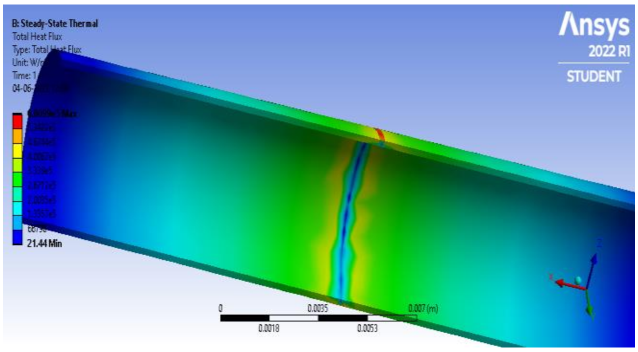

Fig -20: Total heat flux of pipe modal 2 cross section view

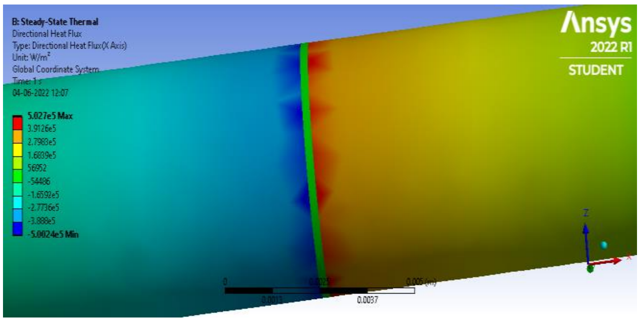

Fig -21: Directional heat flux of pipe modal 2

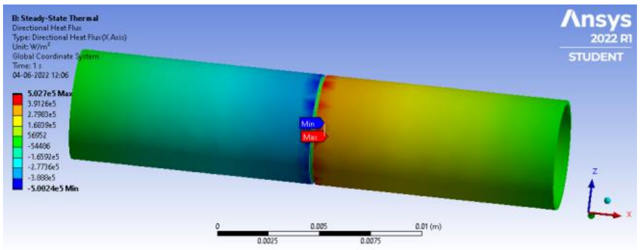

Fig -22: Directional heat flux of pipe modal 2 welded area

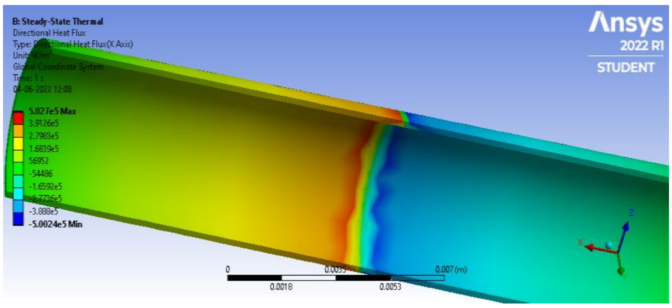

Fig -23: Directional heat flux of pipe modal 2 cross-section area

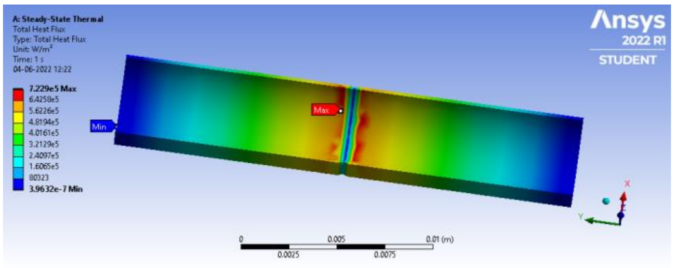

Fig -24: Directional heat flux of pipe modal 2 section view

4.4 Pipe modal 3 (V Type Weld)

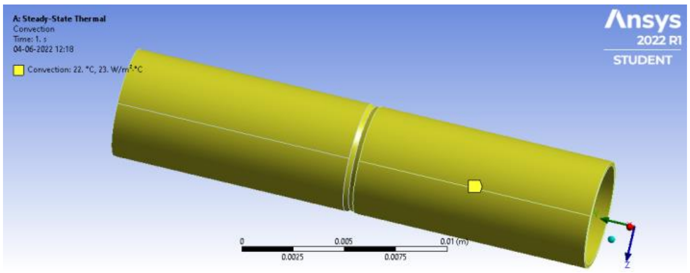

Fig -25: Boundary condition of V-type modal

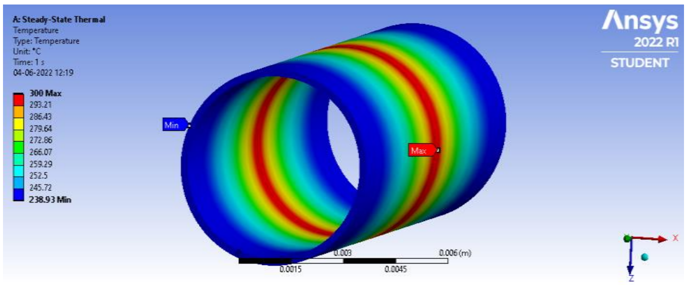

Fig -26: Temperature on modal 3

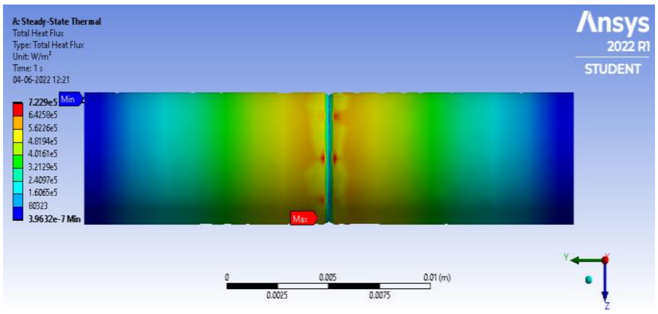

Fig -27: heat flex on modal 3

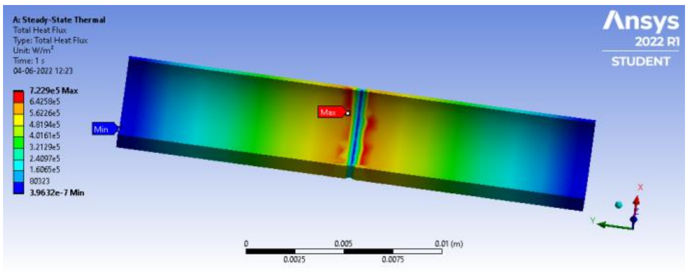

Fig -28: Total heat flex on modal 3

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 07 Issue: 09 | September - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

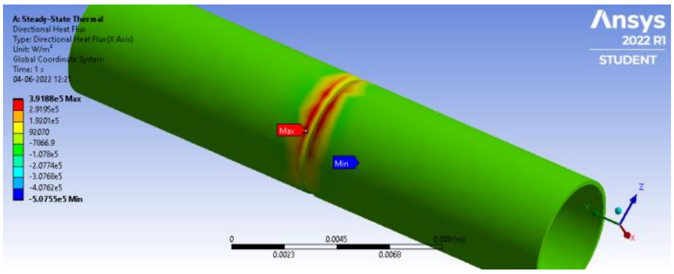

Fig -29: Directional heat flex on modal 3

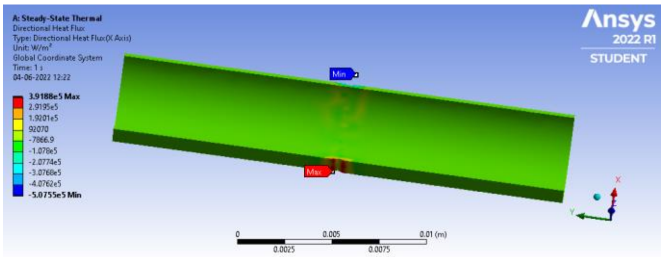

Fig -30: Directional heat flex on modal 3

5. RESULT AND DISCUSSION

Table -1: Thermal analysis of pipe modal 1

Results	Minimum	Maximum	Units	Time (s)
Temperature	238.93	300.	°C	1.
Total Heat Flux	3.9632e-007	7.229e+005	W/m²	1.
Directional Heat Flux	-5.0755e+005	3.9188e+005	W/m²	1.

Table -2: Thermal analysis of pipe modal 2

Results	Minimum	Maximum	Units	Time (s)
Temperature	264.78	300.	°C	1.
Total Heat Flux	21.44	6.0099e+005	W/m²	1.
Directional Heat Flux	-5.0024e+005	5.027e+005	W/m²	1.

Table -3: Thermal analysis of pipe modal 3

Results	Minimum	Maximum	Units	Time (s)
Temperature	238.93	300.	°C	1.
Total Heat Flux	3.4753e-007	7.229e+005	W/m²	1.
Directional Heat Flux	-5.0755e+005	3.9188e+005	W/m²	1.

The results from the FE thermal analysis have been validated by comparing them to experimentally measured temperatures at five locations on the outer surface of the pipe.

Although the FE simulation is axisymmetric, it still provides a temperature history that is considered to be sufficiently accurate for the purpose. Peak temperature contours, which determine fusion zones and the HAZ, have been obtained through a user-defined subroutine and depicted for the FE model.

6. CONCLUSIONS

This clearly means that the temperature response was dependent on several factors such as the nature of the material, material thickness (depth, height, and width), the thermal conductivity of the material mild steel 36[W/mK]); distance from the heat source and time of transmission time at which the temperature reading is taken. Welded pipe thermal analysis done in ANSYS R2022, three models are analysed. Temperature and heat flex and directional heat flex are determined. Modal 3 (V type) has better thermal analysis than the other two models. Overall welding process and thermal analysis are good (V type). The role of different pipe weld heat treatment processes in the manufacturing process was studied numerically. The higher the peak temperature of tempering treatment. However, a longer holding time has no obvious effect on the reduction of residual stress. If the main purpose of post-weld heat treatment is to reduce residual stress, the holding time can be appropriately shortened to obtain higher economic benefits.

REFERENCES

[1] Devinder Pal Singh, Mithlesh Sharma, Jaspal Singh Gill, "Effect of Post Weld Heat Treatment on the Impact Toughness and Microstructural Property", IJRMET Volume-3, Issue- 2, May – Oct-2013, pp 216-219.

[2] Dr. Leijun Li, "Effect of Post-Weld Heat Treatment on Creep Rupture Properties of Grade 91 Steel Heavy Section Welds", Mechanical & Aerospace Engineering, Utah State University (435)797-8184, 2012.

[3] Material data sheet, editor Thyssenkrupp Materials International Gmbh, Technical Sales / Quality_Management, Am Thyssenhaus 1.

[4] ASME sec II-A, Boiler And Pressure Vessel Code, Ferrous Material Specification, SA 335 / SA 335M, pp 573 -584.

[5] Katarzyna Makowska , Zbigniew L. Kowalewski, Boleslaw Augustyniak, Leszek Piotrowski "Determination Of Mechanical Properties Of P91 Steel By Means Of Magnetic Barkhausen Emission", Journal Of Theoretical And Applied Mechanics, Warsaw. Volume-52, Issue-1, 2014, pp. 181-188.

[6] "Welding Technology for Engineers", Editors: Baldev raj, V Shankar & A. K. Bhaduri, Narosa Publishing House, third reprint – 2009, pp 22-36.

[7] Hattestrand, M., and Andren, H., 2001, "Evaluation of Particle Size Distributions of Precipitates in A 9% Chromium Steel Using Energy filtered Transmission Electron Microscopy", Micron, Volume-32, pp 789-797

[8] Newell, N., 2007, "Guideline for Welding Creep Strength-Enhanced Ferritic Alloys", EPRI, March 2007.

[9] Tabuchi, M., et al, 2001, "Creep Crack Growth Behavior in the HAZ of Weldment of W Containing High Cr Steel", Intl J. Pressure Vessels and Piping, Volume-78, pp 779-784.

Volume: 07 Issue: 09 | September - 2023 SJIF Rating: 8.176 ISSN: 2582-3930

[10] Watanabe, T., M. Tabuchi, M. Yamazaki, T. Tanabe, and H. Hongo, "Creep Damage Evaluation Of 9Cr-1Mo-V-Nb Steel Welded Joints Showing Type IV Fracture", Intl. J. Pressure Vessels and Piping, 83, 2005, pp 63-71.

BIOGRAPHIES

	B Velan, UG student, Department of Mechanical Engineering, Paavai Engineering College, Namakkal, Tamilnadu
	V.Senthil Kannan, Associate Professor,Department of Mechanical Engineering, Paavai Engineering College, Namakkal, Tamilnadu
	A.P.Sivasubramaniam, Professor,Department of Mechanical Engineering, Paavai Engineering College, Namakkal, Tamilnadu