Finite Element Analysis For Predicting Effect of Process Parameters on Von-Mises Stresses In Submerged Arc Welding

Sumit Shoor
Research Scholar, Lovely Professional University, Phagwara, India
Manpreet Singh
Department of Mechanical Engineering, Lovely Professional University, Phagwara, India
Rajeev Kumar
Department of Mechanical Engineering, Lovely Professional University, Phagwara, India

ABSTRACT
In this article study was carried out the effect of process parameters on von mises stress induced in material Submerged arc welding (SAW) is used commonly because of its speed characteristics prevent splattering, excellence welds, automatically operated and less skill required. For improving mechanical properties, the welding process parameters plays a vital role. During welding, a lot of heat is generated which is responsible for changes in mechanical properties and distortion. Parent material and heat affected zone (HAZ) experiences a rise in temperature due to conduction and also effected by convention and radiation. During welding complex stresses and strains are produced which further depends upon process parameter selected and produces distortion.. In this present study three dimensional model was built and result was simulate, analyzed using ANSYS. It was found out that von mises stress is maximum in heat effected zone and further depends upon the process parameter. Increase in value of thickness cause decrease in value of Von misses stress. Simulated result shows the Von-Mises stresses very less as compared to yield stress of material.

Key words: Von-Mises Stress, Submerged arc welding, Finite Element Analysis, ANSYS, HAZ

Introduction

Submerged arc welding is the process in which arc and welding joint are covered in flux which further prevents splattering and emission of radiation. Submerged Arc welding is mostly used in factories and workshop for welding thick plates. Very less study was carried out to predict von misses stress using thermo mechanical analysis. Essential equipment for SAW [1)] are: Power source[2], SAW head (welding gun) [3]Flux handling. Complex thermal stresses produced due to heating and cooling [4]. welding process parameter like temperature and electrode diameter, electrode travel speed, thickness of the work piece, current, voltage greatly effect the temperature distribution.[5]. Major parameters in submerged arc welding are current and voltage [6] welding speed [7] and material properties [8] use of thicker plate reduces angular distortion because of higher rate of heat dissipation[9]. Analyze the effect of constant current and pulsed current on gas tungsten arc welding [10]. Choobi et al states that heating cause change in

ISSN: 0971-1260
Vol-22-Issue-17-September-2019

mechanical properties and further produces stresses. Welding causes change in metallurgical properties. stresses and deformation in weld joint.[11].

Von misses stress is mostly calculated for ductile material to determine fracture or yielding.[12]. Method was developed for analyzing von misses stress in butt welding using the finite element method and result was simulate and further equivalent von misses stress was plotted using ANSYS software. This phenomenon helps in understanding the effect of welding joint and effect of process parameter on submerge arc welding. Finite element helps in understanding the effect on initial stage and optimal parameter can be selected. [13].Prediction of will help in stresses will help in controlling the mechanical properties.[15]

Finite Element Modeling

A)Welding Simulation:

Broadly welding simulation is carried out in two stages thermal analysis and elastic plastic analysis. Result of thermal analysis is used to plot the von misses stress. Temperature dependent properties of material as shown in table1 were used to simulate the result. Three dimensional model is shown in fig1 due to symmetry one plate is considered for analysis

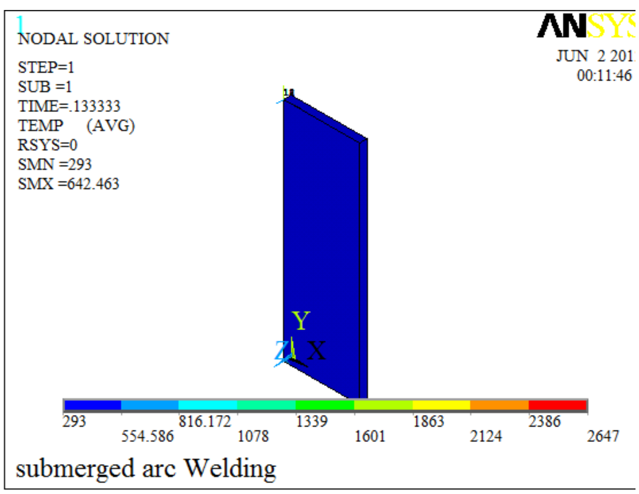


Fig1: Three Dimensional Model (ANSYS)

B) FEA PROCEDURE:

Analysis with ANSYS

A typical ANSYS analysis follows seven steps as listed below [13]
(a) Build the model
(b) Defining element types
(c) Defining material properties

ISSN: 0971-1260
Vol-22-Issue-17-September-2019

(d) Meshing
(e) Defining analysis type and analysis options
(f) Apply loads and obtain the solution
(g) Review the results (general post processing)

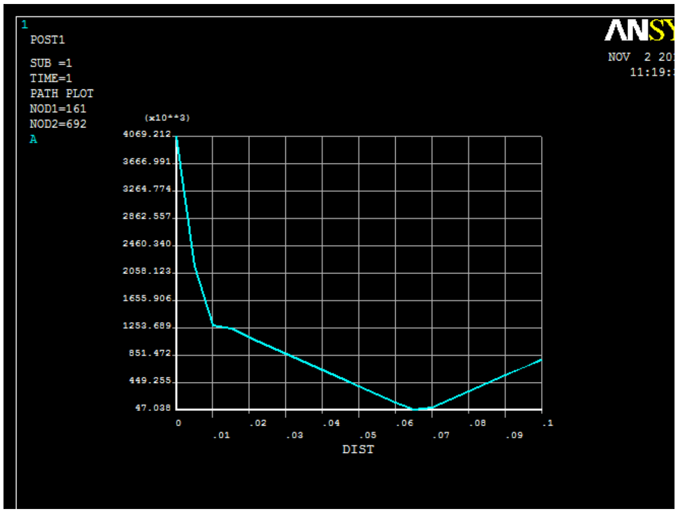
Table1: Temperature Dependent properties of material [14]

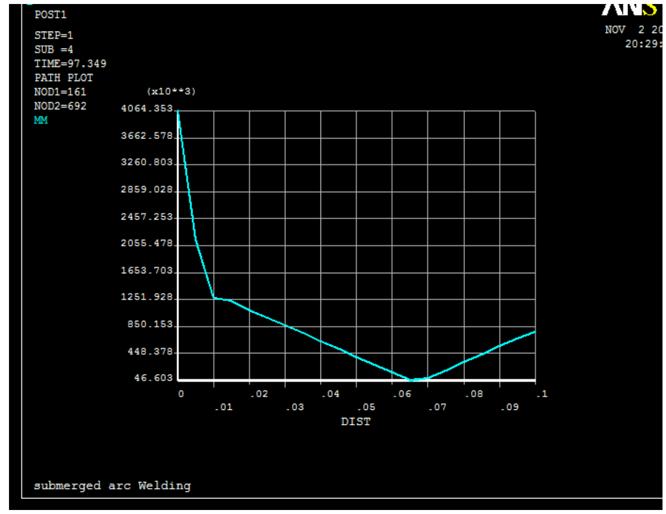
Temperature(K)	**Specific Heat(J/Kg K(c)**	**Thermal Conductivity W/mK(K)**	**Poisson Ratio**	**Young Modulus (GPa)**	**Thermal Expansion coefficient $10^{-6}/^{0}$ C**
0	450	51.9	0.2786	200	10
373	499.3	51.1	0.3095	200	11
573	565.5	46.1	0.331	200	12
723	630.5	41.05	0.338	150	13
823	705.5	37.5	0.3575	110	14
873	773.3	35.6	0.3738	88	14
993	1080.4	30.64	0.3738	20	14
1073	931	26	0.4238	20	15
1723	437.93	29.45	0.4738	2	-
1783	400	29.7	-	0.2	-
1853	735.25	29.7	-	0.00002	-
5273	400	42.2	0.499	0.00002	15.5

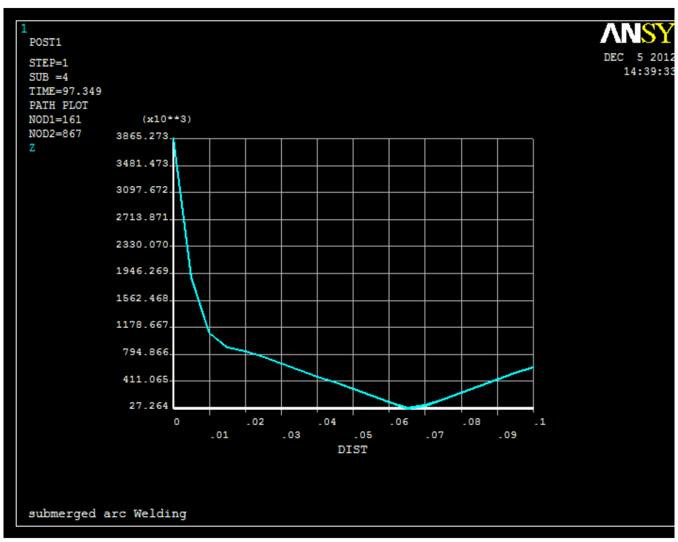
Result and discussion:

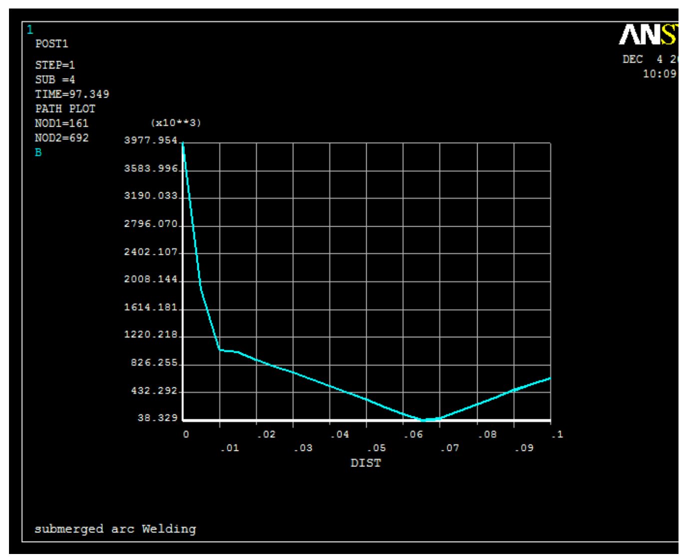
Finite element method is a method used to simulate physical phenomenon using numerical technique which further solved mathematical equations in each element. Main objective of this study was to check and analyze the Von Misses stresses induced during the submerged arc welding process .Simulated result of von misses stress by varying the process parameter is shown in figure2. Graph was plotted by selecting the node at welding region and extreme end of the plate. Von misses stress gives information about the region which is highly stressed. As shown stress intensity is very high near the heat affected zone in welding and further it reduces Von misses stress might cause to change in mechanical properties. Von misses stress calculated is far below the yield strength of material.

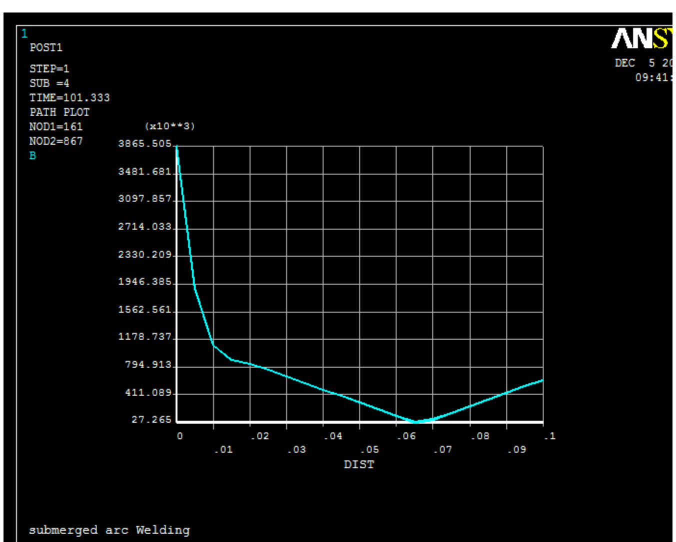
ISSN: 0971-1260
Vol-22-Issue-17-September-2019

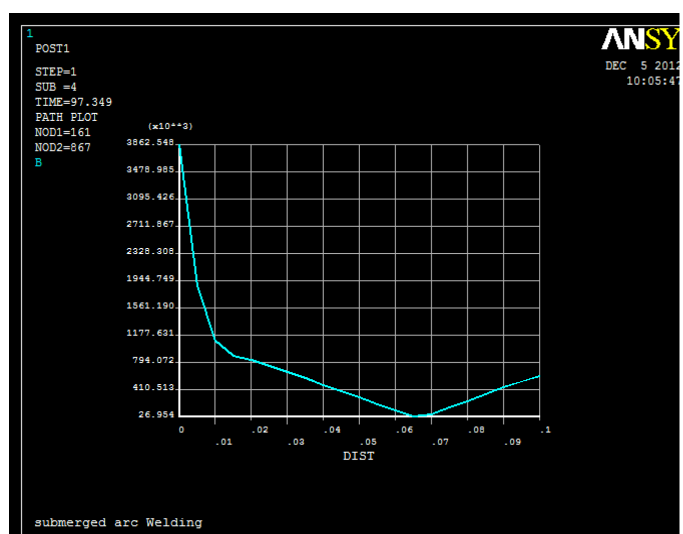




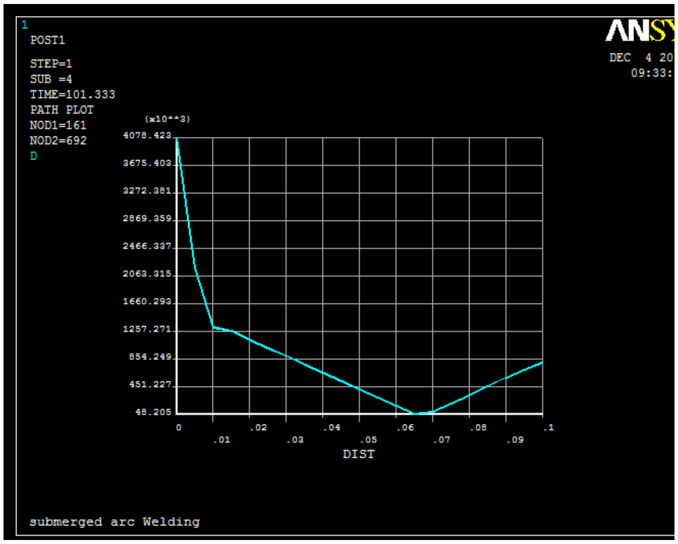








ISSN: 0971-1260
Vol-22-Issue-17-September-2019



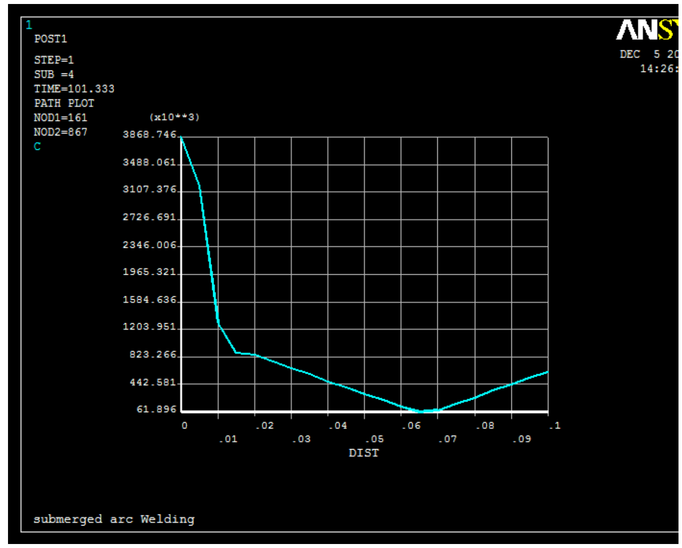


Fig 2: Simulated Result of von misses stress of process parameters

Parameters which were used for simulation are thickness, current, welding speed is shown in table 2 along with von misses stress. As shown in simulated result von misses stress is highly influenced by process parameter thickness. It has also been observed that increasing the current keeping plate thickness constant also increase in value of von misses stress.

Table2: Effect of parameters on von misses stress.

PARAMETERS	THICKNESS (mm)	CURRENT (A)	WELDING SPEED(m/min)	Von misses stress
SET A	8	450	0.45	4.069 MPa
SET B	8	450	0.5	4.064 MPa
SET C	8	500	0.45	4.078 MPa
SET D	8	500	0.5	3.977 MPa
SET E	10	450	0.45	3.865 MPa
SET F	10	450	0.5	3.862 MPa
SET G	10	500	0.45	3.868 MPa
SET H	10	500	0.5	3.865 MPa

Fig 3 clearly shows the effect of thickness on von misses stress. Stresses can be reduces by increasing the thickness and decreasing the current.

ISSN: 0971-1260
Vol-22-Issue-17-September-2019

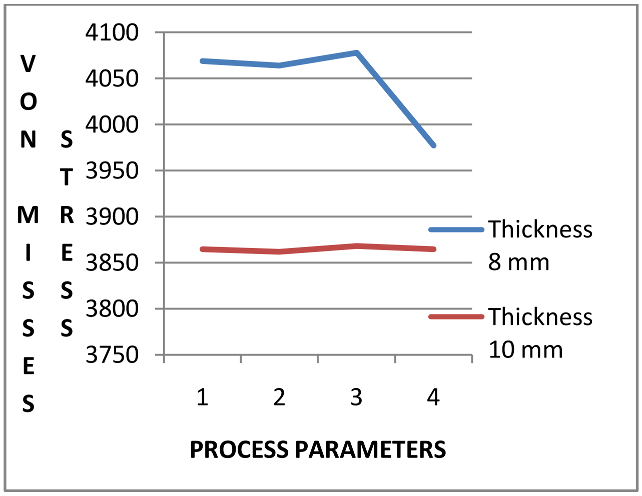


Fig 3: Von misses stress for different process parameter

Conclusion:

Three dimensional Finite element model was developed to simulate the result. Following conclusion were drawn.

1) Von Mises stress highly influenced by process parameter. Decrease in thickness cause increase in value of von misses stress.

2) Von Mises stress is maximum near the welding region and decreases in a region away from Heat effected zone

3) Maximum value of von Mises stress is 4.069 MPa when process parameter was thickness 8 mm, current 450 A, and welding speed was 0.45m/sec

4) Finite element method can be used for selecting optimal parameters which reduced stresses induced during welding.

References

1) Miller (1993). Submerged Arc Welding guide".

2) Mandal NR. Welding and distortion control, 1st ed. New Delhi,
India: Narosa Publishing House; 2004.

3) M. Submerged and A. Solutions, “Submerged Arc Welding Equipment.”

4) S. J. Vaghela and S. Kumanan, “FINITE ELEMENT ANALYIS OF SUBMERGED ARC WELDING,” no. January 2014, pp. 1–6, 2016.

ISSN: 0971-1260
Vol-22-Issue-17-September-2019

5) M. M. Mahapatra, G. L. Datta, B. Pradhan, and N. R. Mandal, “Three-dimensional finite element analysis to predict the effects of SAW process parameters on temperature distribution and angular distortions in single-pass butt joints with top and bottom reinforcements,” *Int. J. Press. Vessel. Pip.*, vol. 83, no. 10, pp. 721–729, Oct. 2006.

6) I. A. Hussain, S. K. Radi, and M. Majeed, “Study of Thermal Distortion in Thick Plate Using Finite Element Technique *,” vol. 12, no. 1, pp. 118–130, 2008.

7) P. Sathiya, G. R. Jinu, and N. Singh, “Simulation of Weld Bead Geometry in GTA Welded Duplex Stainless Steel (DSS),” *Sch. Res. Exch.*, vol. 2009, pp. 1–9, 2009.

8) [R. N. S. Fassani and O. V Trevisan, “Analytical Modeling of Multipass Welding Process with Distributed Heat Source,” vol. XXV, no. 3, pp. 1–4, 2003.

9) J. Goldak, A. Chakravarti, and M. Bibby, “A New Finite Element Model for Welding Heat Sources,” vol. 15, no. June, pp. 299–305, 1984.

10) N. Karunakaran and V. Balasubramanian, “Procedure for Thermal Analysis in Pulsed Current Gas Tungsten Arc Welding of AZ 31B Magnesium Alloy Sheets,” pp. 267–274, 2011.

11) M. Seyyedian Choobi, M. Haghpanahi, and M. Sedighi, “Investigation of the effect of clamping on residual stresses and distortions in butt-welded plates,” *Sci. Iran.*, vol. 17, no. 5 B, pp. 387–394, 2010.

[12] O. Oluwole and E. Emagbetere, “Finite Element Analysis of In-Plane Displacements and Von-Mises Stresses in Ellipsoidal and Circular Cylinderical Petroleum Tankers,” *Engineering*, vol. 05, no. 02, pp. 167–177, 2013.

13) E. Madenci and I. Guven, *The finite element method and applications in engineering using ANSYS®*. Springer, 2015.

14) S. Shoor, R. Rosy, and R. Kumar, “Numerical and experimental investigation of submerged ARC welding on mild steel,” *Int. J. Mech. Eng. Technol.*, vol. 8, no. 7, pp. 1844–1853, 2017.

15) P. Biswas, M. M. Mahapatra, and N. R. Mandal, “Numerical and experimental study on prediction of thermal history and residual deformation of double-sided fillet welding,” *Proc. Inst. Mech. Eng. Part B J. Eng. Manuf.*, vol. 224, no. 1, pp. 125–134, 2010.

16) M. R. Nezamdost, M. R. N. Esfahani, S. H. Hashemi, and S. A. Mirbozorgi, “Investigation of temperature and residual stresses field of submerged arc welding by finite element method and experiments,” *Int. J. Adv. Manuf. Technol.*, vol. 87, no. 1–4, pp. 615–624, 2016.

17) Ansys, Inc. Theory reference. Southpointe, Canonsburg, PA