Effect of welding parameters on distortion: A Review

Sumit Shoor
Department of Mechanical Engineering 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: As in welding lot of heat is produced and it undergoes lot of thermal processes. Due to this welding goes non uniform heating and cooling process which cause change in metallurgical properties , residual stresses and distortion. Distortion and residual stresses affect the welded structure significantly. Welded structure distorted significantly if panel is thin and long. Effect of welding parameters and different cause of distortion has been reviewed in this paper. Paper gives overview of different types of distortion and effect of welding parameters on distortion

Keywords: Welding parameters, Distortion

Introduction: In all welding process heat is required to accomplish the joint depending upon heating and cooling different microstructure were obtained in weld bead and heat effected zone. It produces a different mechanical properties thus to obtain welding of desire specification it is essential to know the heat flow in welding. This is achieved by temperature distribution during welding so as to determine the cooling rates in different directions with respect to weld axis. Temperature distribution depends upon so many factors nature of welding process used ,type of heat source employed ,energy input per unit time ,configuration of joint(linear or circular) ,type of joint(butt ,fillet etc) ,physical property of metal being welded nature of surrounding medium.(ordinary conditions or under water).in welding heat flows from welding source to work piece and after this heat flow into the work piece by conduction. Heat loss is also occurred due to convention and radiation. Since this heat which flow into the body of work piece is responsible for changes in mechanical properties and microstructure it is is important to know the amount heat produce and at certain critical points . This heat flow also produces distortion in metallic structure.

Application of welding

Cover Pressure Vessel, Line Pipe, Storage Tank, Heavy structural ships, railway wagon and coaches**.**

Distortion in Welds: Any unwanted physical change or departure from specification in fabricated structure or component as a consequence of welding is called welding distortion. after lot of experiment it has been found out that departure not only complicate the fabrication but also effect the purpose for which it is design also cost of rectifying the welding distortion by straightening distorted component may be more than

actual welding .distortion always caused by non uniform expansion and contraction with respect to the base material during cooling and heating cycle of welding process before welding areas of plate are cold and during welding metal melts and try to expand and after solidification it to contract produces a stresses and distortion. Thermal expansion and contraction is responsible for the welding distortion if we restraint the body movement by restricting its degree of freedom then internal stresses will develop and if increases yield point of the material then plastic deformation occur Thus both material properties and welding procedure effect the distortion.[3]

Effect of material properties on distortion

(a**) Co efficient of Thermal Expansion**: it is the property of material to expand and contract higher the thermal expansion more the is the distortion.[3]

(b)**Thermal conductivity**: It indicates heat flow through the material. Low thermal conductivity cause more distortion.[3]

(c) **Yield strength**: Higher the yield strength means the more force is required for plastic deformation and it produces more stresses and cause more distortion.[3]

(d)**Modulus of elasticity**: it indicates about the stiffness of material more modulus of elasticity it can resist more distortion.[3]

Types of Welding Distortion

(a) Longitudinal shrinkage

(b) Transverse shrinkage.

(c) Angular distortion

(d)Longitudinal distortion (Bowing or Bending)

(e)Buckling and Twisting..[3]

Literature survey: Tsai et al observed that welding thin panel structure results in warping and distortion control of certain variables always help in reducing the distortion it includes fillet weld size using high speed welding it has also been found out that controlling distortion of thick plates cooling the weld zone immediately after the welding while heating both sides of the joints creates appropriate temp gradient that results in min angular distortion. Both finite element method (FEM) and results found during the experiment match, so appropriate parameters can be set to minimize angular distortion [4].

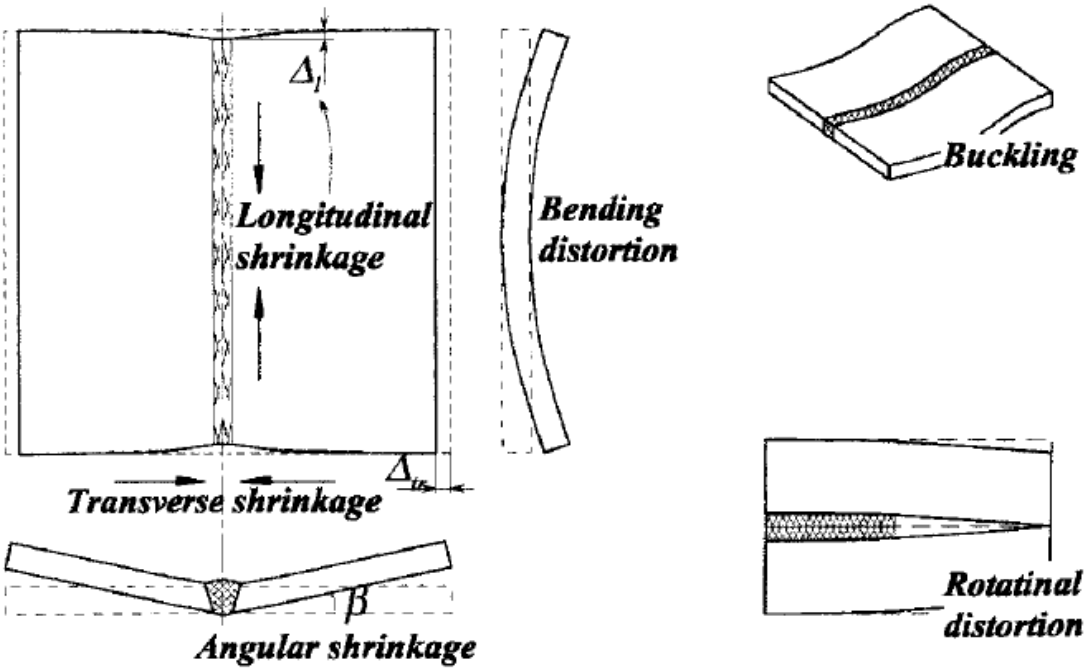

Fig 1: Different types of distortion [3]

In another study, Mollicone et al [5] suggested that the distortion and residual stresses are formed due to transient thermal strain during the passage from heat source shape deviations usually occurred due to contraction forces and distortion occur in non-linear manner. Magnitude of distortion usually depends upon amount of thermal energy input to the welding process. Thermal properties of weld zone are time dependent and rate dependent and they are subjected to step variations due to material phase changes. It has also been found out that peak temperature reached is responsible for angular distortion. A closed match between algorithm generated and result generated by FEA using material properties, it has been found out that FEA is more efficient method for analysis.

Mahapatra et al [6] have discussed that welding process parameter like temperature and electrode diameter ,electrode travel speed, thickness of the work piece, current, voltage greatly affect the temperature distribution author uses eight nodded brick element for structural analysis and tool maker microscope was used to find out the heat effected zone. Use of

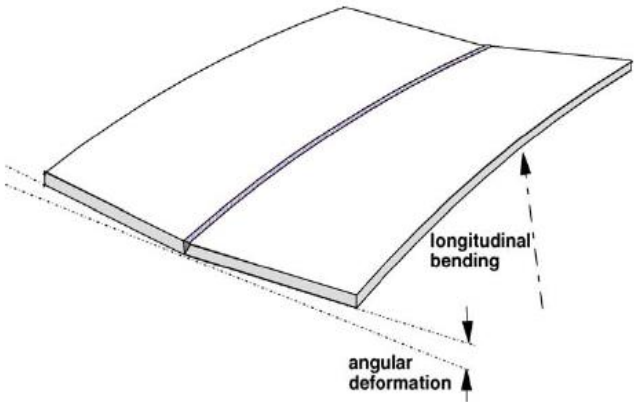

Fig.2 Angular distortion and Longitudinal Distortion [6]

\

thicker plate reduces angular distortion because of higher rate of heat dissipation and even angular distortion is less when constraints are applied at two ends. Result calculated by FEM closes matches with the experiment.

It has been observed that SAW [7] is influenced by welding speed, electrode stick out, arc voltage. Authors have used a Taguchi method and regression analysis and it has been found out that welding current and arc voltage has effect on bead width and external bead appearance.

In one of the studies conducted by HUSSAIN et al [8], it has been observed that during SAW:

1Distortion depends upon the input heat source even not varying the plate thickness.

2) Distortion depends upon plate thickness and inversely proportional to each other keeping heat source constant

3) If cooling area is increased distortion can be decreased.

Bag et al [9] have developed a two dimensional finite element model to analyze heat transfer process using a combination of heat flux and volumetric heat source and calculated various result of weld pool of various power of heat source in laser welding. Goldak equation used by the author fairly matches with result. Process parameter can easily be set up by analyzing with FEA. It has also been found out that due to symmetry along faces two dimensional problems is sufficient instead of three dimensional and gives simplicity and easy to apply boundary conditions. Meshed model generated along with Gaussian heat input is shown:

Shoor et al [10] uses finite element method for simulating the effect of process parameter on distortion. Author calculated the value experimentally and with ANSYS and found to closely matched. Thermal analysis are also performed using ANSYS and experimentally using thermocouple and find out to be closely matched

Goldak et al [11] Proposed double ellipsoidal heat source model as shown The heat source model in X,Y,Z coordinate is shown:

$$q_f(x,y,z,t) = \frac{6\sqrt{3}f_f Q}{abc\pi\sqrt{\pi}} e^{-3x^2/a^2} e^{-3y^2/b^2} e^{-3[z+v(\tau-t)]^2/c^2}$$

and for the remaining half

$$q_r(x,y,z,t) = \frac{6\sqrt{3}f_r Q}{abc\pi\sqrt{\pi}} e^{-3x^2/a^2} e^{-3y^2/b^2} e^{-3[z+v(\tau-t)]^2/c^2}$$

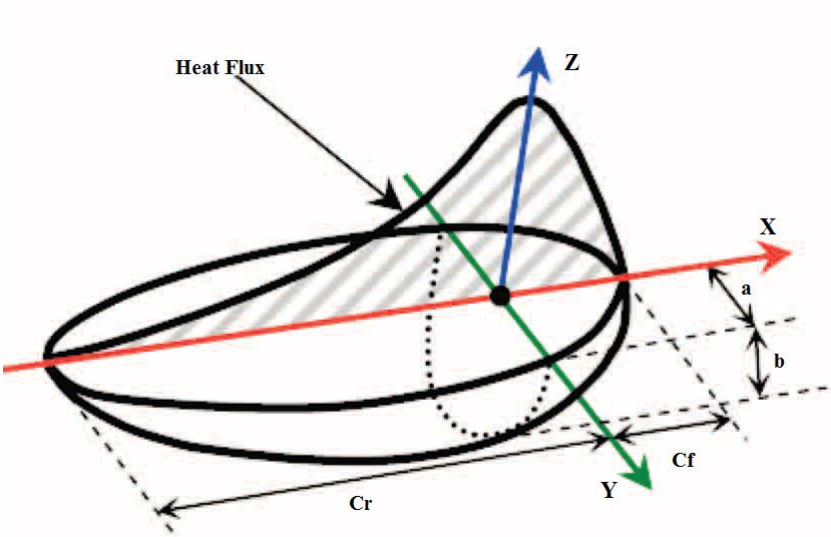

Fig.3 Double ellipsoid heat source [11]

Conclusion : Welding parameters effect the temperature distribution and distortion. In this literature review is carried out to study the welding parameters on distortion. Welding parameters also effect the material properties. Several author uses different techniques to simulate the effect of distortion and it has been found out that increase in heat input, decreasing the thickness can cause increase in value of distortion.

REFERENCES

1) http://www.weldinginfocenter.com/history

2) http://www.google.co.in/search?q=submerged+arc+welding

3) R.S Parmar, Welding process and technology, 3rd Edition, Khanna publisher, New Delhi, India.

4) C. L. Tsai, S. C. Park and W. T. Cheng ,Welding Distortion of a Thin-Plat Panel , Welding Research Supplement, pp 156-166, May 1999.

5) P. Mollicone, D. Camilleri, T.G.F. Gray , T. Comlekci ,Simple thermo-elastic–plastic models for welding distortion simulation, Journal of Materials Processing Technology 77–86,2006.

6) Mahapatra, M.M Datta ,G.L Pradhan, B.Mandal N.R, 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, International Journal of Pressure Vessels and Piping 721–729 ,2006.

7) S Kumanan,Je Win Raja Dass and K Gowadhman , Determination of submerged arc welding process parameters using taguchi method and regression analysis.

8) Dr.imad A ,Hussain ,Dr Sameara Radi ,Study of Thermal Distortion in Thick Plate Using finite element technique, Journal of Engineering and Development, Vol. 12, No- 1, March -2008.

9) S. Bag , A. Trivedi , A.De ,Development of a finite element based heat transfer model for conduction mode laser spot welding process using an adaptive volumetric heat source, International Journal of Thermal Sciences 48 ,2009.

.10) M. Seyyedian Choobi, M. Haghpanahi1 and M. Sedighi, Investigation of the Effect of Clamping on Residual Stresses and Distortions in Butt-Welded Plates Transaction B, Mechanical Engineering Vol. 17- No. 5, pp. 387-394, 2005.

11) John A. Goldak and Mehdi Akhlaghi ,Computational Welding Mechanics ,springer, 2005.