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Modelling, Simulation and Thermo-Mechanical FEA of Gas Tungten Arc Welding of Austenitic Stainless Steel

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***Abstract:** The objective of study variation of temperature in TIG welded SS 318 plate of 3 mm work piece thickness in this work thermal analysis with help of ANSYS workbench carried out for [T -joint and corner joint] stainless steel base metal (ss) using gas tungsten arc welding process. thermo-mechanical simulation is developed. Comparison with the temperature measured by the thermos couple's records shows result present test data. The major components developed for usage construction various grade of stainless steel like SS318 Land some various nuclear grade special material and various thickness.*

I. INTRODUCTION

Welding is material joining process which produces coalescence of materials by heating them to suitable temperature with or without the application of pressure or by the application of pressure alone with or without use of filler material. Welding is used for making permanent joints it is used for making permanent joints it is used in manufacture of automobile bodies, aircraft frames, railway wagon, machine frames, structural works, tanks, furniture, boilers, general work and shipping building.

II. WELDING TECHNOLOGY

Welding technology is major part of any mechanical, manufacturing facility in world .it is considering most wide spread metal joining process in industries. Welding can be defined as any process in which two or more process piece of metal are joined together by application of heat, pressure or combination of both. Most of the welding processes may be group in to two categories
Pressure welding: welding achieved by apply of pressure.
Heat welding: welding achieves apply of heat.

III. BENEFITS &THREATS OF WELDING

Welding represents most complex manufacturing process number of variable involved and factors contributing final output or response. Welding methods include thermal strains in weld metal and bade metal region near weld resulting in stress which is turn combine and react to produce internal forces cause bending, bulking, and rotation.

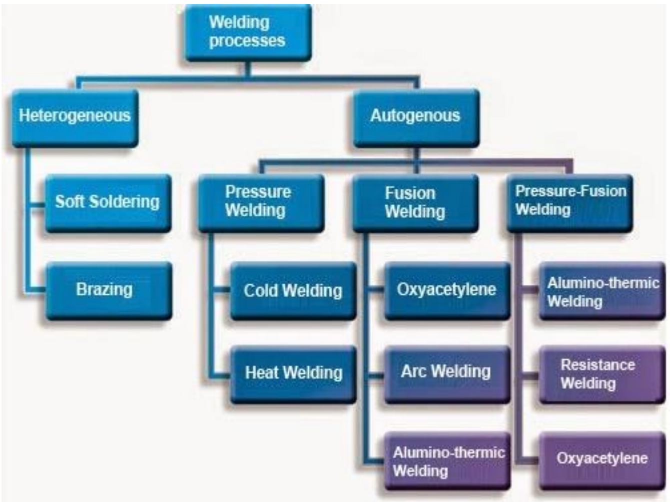
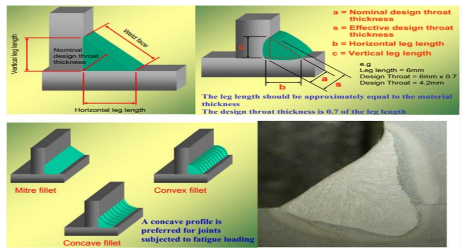


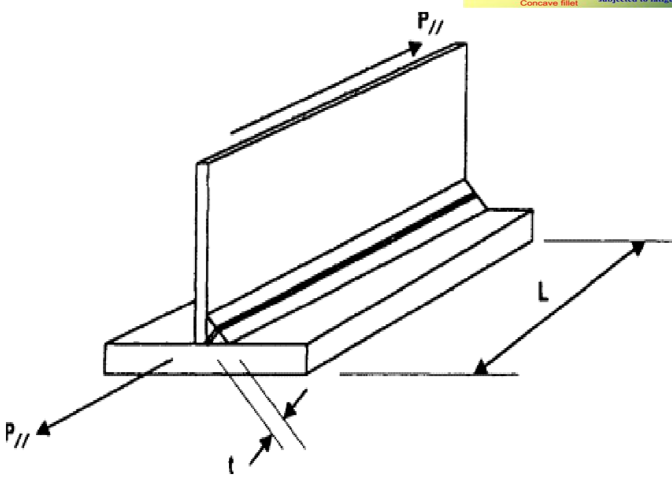
Fig:1 explains welding process and its types.

IV. WELD INDUCED RESIDUAL STRESS

Residual stress is that exist in body if all external loads and restraints were removed. Various technical term used to refer such as internal stress, initial stress, inherent stress, reaction Stress, and locked-in stress. During manufacturing phase include casting and forging, sheet metal forming and shaping (shearing, bending, grinding, machining etc.) and welding.

welding stress are produced the plastic deformation by local temperature of rapid heating and subsequent cooling phase. Residual stress and structure deformation are highly affected by using of welding fixture during welding process control of deformation and residual stress field of weldments.





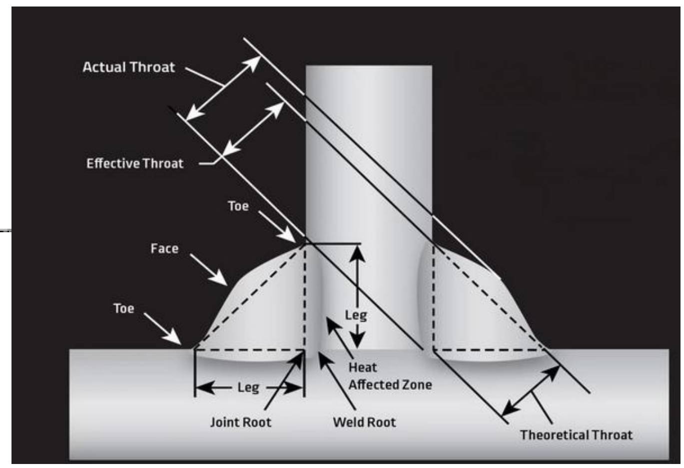
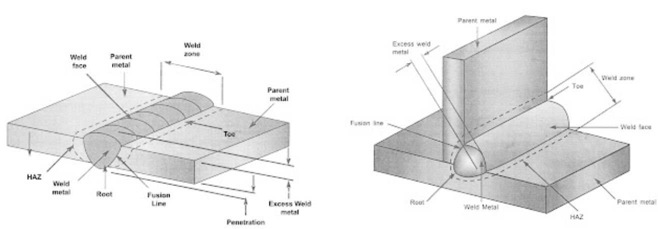


Fig:2,3,4 explains t-joint welding process and nomenclature.

The three different type of residual stress induced distortion can be found in manufacture structure. Longitudinal and transverse shrinkage can cause in plane distortion of work piece whereas plane or axisymmetric angular shrinkage can cause distortion perpendicular of plane of welding component and another distortion is bending due to grids with longitudinal and transverse welds.



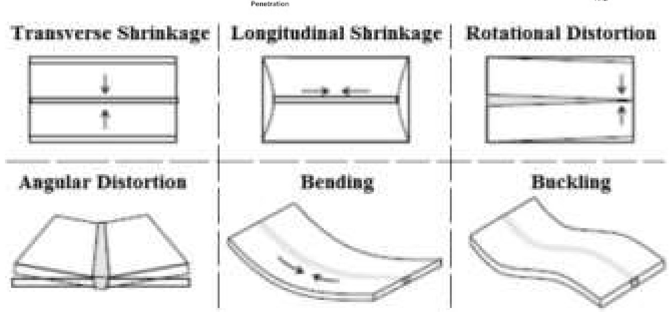


Fig:5,6 explains t-joint welding process and defects.

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The residual stress and structure deformations are highly affected by highly affected by using of welding fixture during welding process and amount of restraint control distortion and residual stress field on weldments. generally welding residual stress, strain behave in opposite ways with degree of restraint.

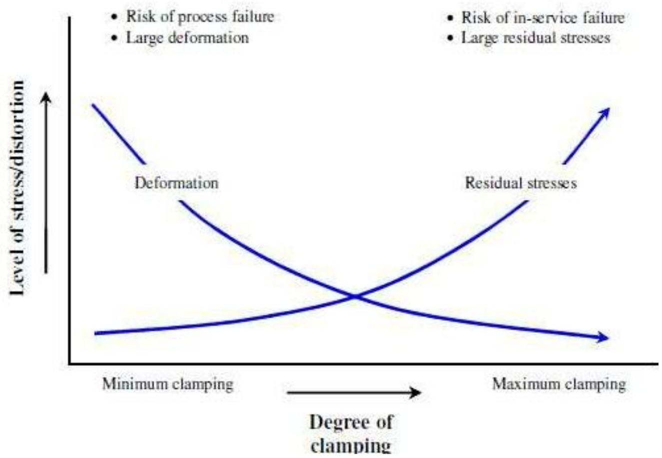

Fig:7 explains welding process of defects during process.

1) T – JOINT:

Hold electrode nearly perpendicular to the meatal work although titling ahead in direction of travel to produce best result travel at uniform speed and feed electrode downward at constant rate its melt.

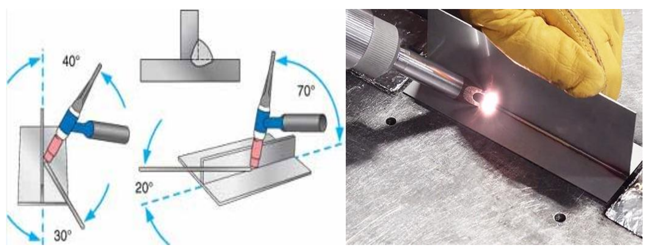

Fig:8 explains t- welding process.

2) CORNER – JOINT:

Hold electrode 45degree to work to produce best result hold arc travel to uniform speed and feed electrode download constant rate its melt.

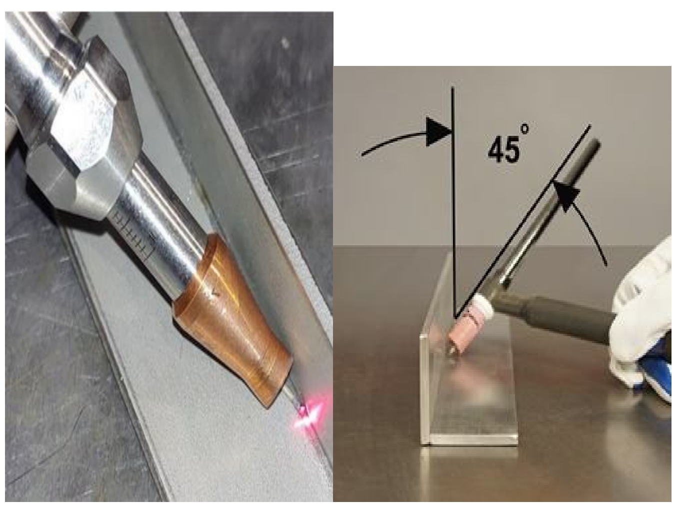

Fig:8 explains corner welding process.

V. MODELLING OF TIG WELDING USING FEM

The process of forming FILLET joint and T – joint that joins two steel plate was simulated. The overall dimension adopted are 150 x 75 x 3mm. the welding procedure is moulded as a single pass inn analysis. Weldment was assumed to be symmetric so that one half of model was analysed. The FEA analysis was carried out in two steps non-linear transits thermal analysis conducted first to obtain temperature during welding process. Stress analysis was developed with temperature obtain from thermal analysis used as loading to stress model. The mesh used to stress analysis was identical to thermal analysis.

VI. PROBLEM DEFINITION

A finite element simulation of welding process included stress in fillet and t joint plate is presented. In fusion welding weldment is locally heated by welded heat source. Due to non-uniform temperature distribution during thermal cycle incompatible strains lead to thermal stress. These incompatible strains due to dimensional changes associated with solidification of weld metal metallurgical deformation and plastic deformation are source of residual stress and distortion welding induced residual stress and distortion can play important role in reliable design of welding joints and welded structures here a finite element simulation of welding temperature distribution welding -induced residual stress and distortion in fitted and t joint are presented.

Parameter	specification
Supply voltage	30 – 450 volts
Frequency	50
Phase	3 phases
Max input amps	40 – 80 amps
Kva	30
Range of hand amps	40 -450 amps
Shielding gases	Argon
Tungsten electrode	2% thoriated tungsten
Polarity	Dc – dcen
Workpiece	150 x 75 x 2mm

VII. EXPERIMENTAL RESULTS

Experimental results are carried out on SS318 plate 150 x 75 x 2mm dimension parameters shown below

s.no	parameter	unit	Level - 1	Level - 2
1.	Welding current	A	70	80
2.	Welding voltage	V	14	15
3.	Welding speed	mm	2	2
4.	Thickness of the plate	mm /sec	1.5	2.5

The process of finite element method:
Finite element method used to solve physical method in engineering analysis and design. The mathematical method is solved and checked for accuracy refinement is required. the level of accuracy, shape and section by linking optimization techniques wit finite element method.
The procedure for ANSYS analysis consists of three main steps build model, obtain solution, review results. FEA reduce design manufacturing cost and useful when manufacturing process to verify final stage before prototype.

Pre – processing phase	Solution phase	Post – processing phase
Geometry definitions	Element matrix formation	Post solution operation
Mesh generation	Overall matrix triangularization	Post data printout

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Constraint and load definitions	Calculation of displacements stress	Post data scanning
Model displays		Post data display
Material definitions		

VIII. MECHANICAL ANALYSIS

To evolute the distortion and residual stress heat transfer analysis performed in order to find nodal temperature as function in time. second part of analysis non linear structural analysis was carried temperature where obtain to heat transfer analysis.

s.no	Voltage V	Current I	Area A m^2 x10^{-6}	Efficiency Ƞ	Heat Q = VI Ƞ watts	Heat flux, q=Q/A(W/m^2 x10^{+6}
1.	15	80	4.5 x 300	0.6	720	0.53
2.	15	70	4.5 x 300	0.7	735	0.54
3.	15	80	4.5 x 300	0.8	960	0.71
4.	15	70	4.5 x 300	0.9	945	0.7
5.	15	80	4.5 x 300	0.75	900	0.66
6.	15	70	4.5 x 300	0.65	682	0.50

Calculation of heat flux(q):

q = Q/A

where Q = V * I * Ƞ

= 15 x 80 x 0.7

= 840 W

A = 4.5 x 300 x 10^{-6} m^2

Therefore, q = (840) / (4.5 x 300 x 10^{-6}

= 0.62 x 10^{+6} W/ m^2

= 0.62E6 W/ m^2

Fig 9 welding process completed in t -joint and corner joint method.

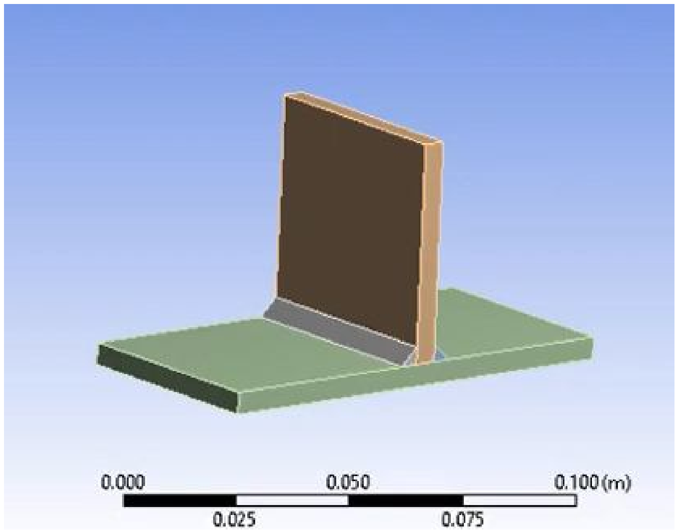

Fig 10 ansys model create in t – joint model.

Simulating 3 -D effect of arc traveling by applying ramped heat input function in model. The model created by using ansys software to input to create t-joint model.

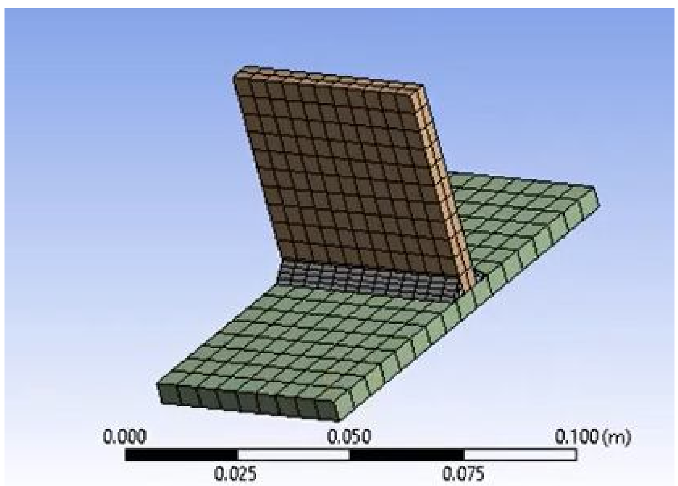

Fig 11 ansys model created in t-joint welding process.

The meshing option used to analysis object to complete mechanical properties in function of meshing value of object to created t-joint component. The weld zones region where heat flux is applied where electrode initially comes in contact region of metal plate hence maximum temperature is applied in region of component.

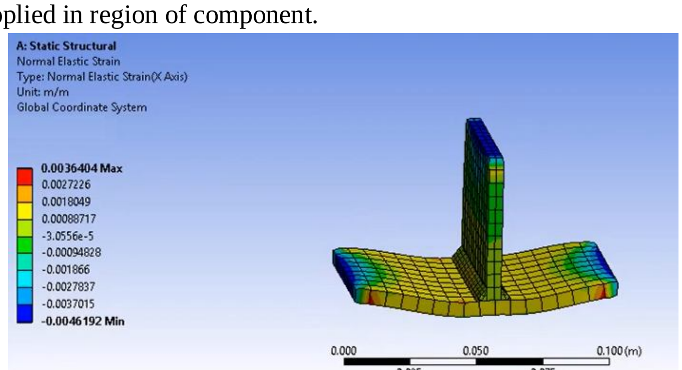

Fig 12 ansys mesh method used in t - joint process of welding process.

The temperature distribution which is cooling step where indicate slow temperature after heating step again reaches slow in component. Whereas heating temperature where changes in form deformation in component after welding is applied in region the temperature change indicate the value of component and withstand heat during flux range and heat speed in changes during flow of welding process.

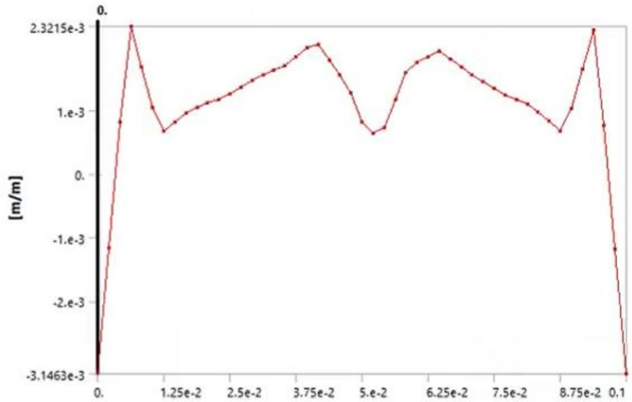

Fig 13 variation of temperature along distance from weld

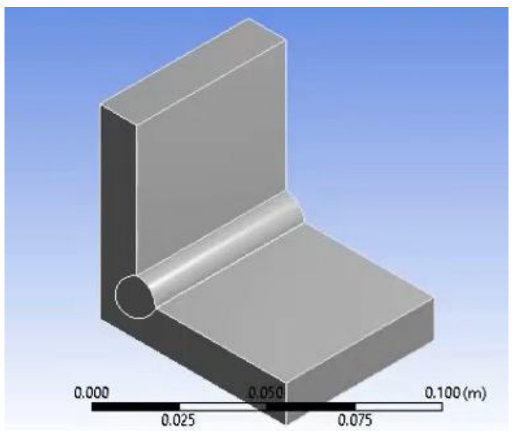

Fig 14 corner joint component create using ansys model.

The corner joint 3D model of create using ansys software four type of geometry entities in processer like key point area, lines and volume. the entities are independent and have unique label is component has created in form of unique object is obtain in process.

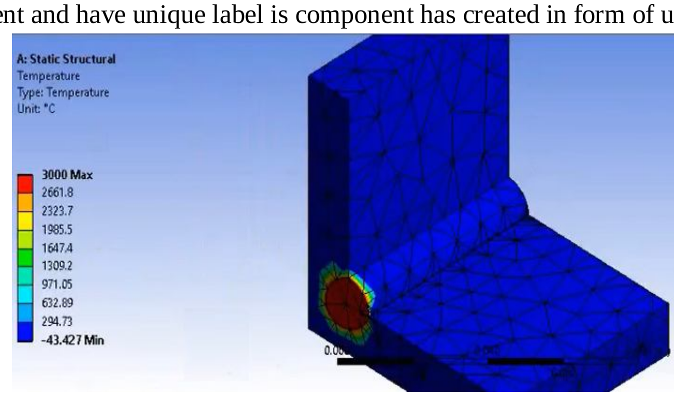

Fig 15 corner joint mesh is created in component.

The meshing has done between two plate same material the mesh is nothing but network of element if mesh is finer then adopted to study effect of mesh style on result.

Various experimental methods for measuring temperature developed in welding but experiment measures are costly and time consuming so that FEM model enough for getting better results with negligible variation of experimental results so simulation process carried out were welding application deals with complex products.

Welding current amp	Welding voltage volt	Efficiency %	Area mm^2	Heat flux W/m^2	Temperature distribution °C
80	15	0.6	1350	0.53E6	320.4
80	15	0.65	1350	0.57E6	350.1
80	15	0.7	1350	0.62E6	372.1
80	15	0.75	1350	0.66E6	379.1
80	15	0.8	1350	0.71E6	405.1

IX. CONCLUSIONS

Development of 3-dimentional thermos-mechanical finite element model of welding process describes in this work. The heat flux is calculated and input for finite element analysis in corner and t-joint plates. analysis of weld joint process condition carryout Realtime to save money, time, resources.

Maximum temperature of 503°C was observed by applying heat flux value of 0.84 x 10^6 W/m^2 variation of temperature welding voltage joint efficiency and weld plate is observed. Temperature is gradually increasing from 294 -370°C voltage is varied from 12 to 15V. coupled field analysis is caried out to estimate residual stress the maximum induced stress observed due to temperature distribution of 503° is 136 Mpa. Resultant distortion observed in weld plate is 0.043mm.

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