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Experimental Analysis of Effect of Various Parameters in Temperature Distribution in Submerged Arc Welding

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Abstract- In large steel fabrication industries such as shipbuilding, and high-speed train guide way, the problem of residual stresses and overall distortion has been and continues to be a major issue. In the last few decades, various research efforts have been directed at the control of the welding process parameters aiming at reducing the distortions and residual stress effects. Yet, in actual practice, large amounts of resources are still being spent in reworking welds, which in turn increases the production cost and delays work completion. It is assumed that in order to reduce the residual stresses and distortions from a welding operation, it is necessary to understand the effects of welding process parameters on the responses. In this paper, an experimental study has been conducted to assess the effects of heat input, speed rate, wire feed rate, plate thickness, and gap on arc welding responses as applied to steel welding. A butt joint Submerged Arc Welding has been chosen in this study. Submerged Arc Welding (SAW) uses the arc struck between a continuously fed additional filler metal under a blanket of granular flux. The thermal effect of Submerged Arc that specially depends on the electrical arc, flux type and temperature field of its work piece, is the main key of analysis and optimization of this process. The arc welding process is simulated using Finite Element Method (FEM) program ANSYS®. Thermal analysis is carried out and with the above load structural analysis is also performed for analyzing the stability of the structure.The simulations were carried out using a two-step process; non-linear heat transfer that produces the dynamic temperature distribution throughout the weld seam and the plates, and the elasto-plastic analysis, which yields residual stresses, strains, and displacement.Numerical simulation of welding process has been done by analysis tool ANSYS Relationships between the parameters and the responses have been drawn based on the simulation results as well as experimental results.

NOMENCLATURE

C - Specific heat , th_e -Thermal expansion, f_h- Convection heat transfer coefficient, k - Thermal conductivity, q- Heat flux, max q - Maximum heat flux, r -Distance from heat source centre,
E - Modulus of elasticity, I –Current, [K] -Stiffness matrix , Q -Heat input, R-Radius of heating spot, T - Body Temperature ,¥ -T Surrounding temperature, U – Voltage, a -Thermal diffusivity ,e -Strain / Thermal emissivity , s -Stress , y s -Yield stress, h - Arc efficiency, r- Density of the material, g-Poisson's ratio

I. INTRODUCTION

Submerged arc welding is similar to gas metal arc welding, but in this process no gas is used to shield the weld. Instead, the arc and tip of the wire are submerged beneath a layer of granular, fusible material formulated to produce a proper weld. This process is very efficient but is only used with steel. In submerged arc welding a mineral weld flux layer protects the welding point and the freezing weld from the influence of the surrounding atmosphere, Figure 3.1. The arc burns in a cavity filled with ionized gases and vapours where the droplets from the continuously-fed wire electrode are transferred into the weld pool. Un-fused flux can be extracted from behind the welding head and subsequently recycled. Main components of a submerged arc welding unit are:

The wire electrode reel, the wire feed motor equipped with grooved wire feed rolls which are suitable for the demanded wire diameters, a wire straightened as well as a torch head for current transmission, Figure 1.1.Flux supply is carried out via a hose from the flux container to the feeding hopper this is mounted on the torch head. Depending on the degree of automation it is possible to install a flux excess pickup behind the torch. Submerged arc welding can be operated using either an A.C power source or a D.C. power source where the electrode is normally connected to the positive terminal. Welding advance is provided by the welding machine or by work piece movement.

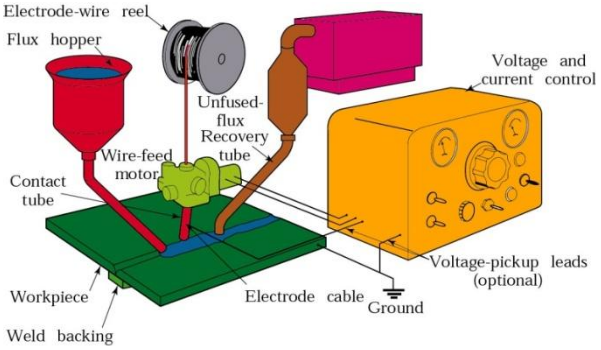


Fig.1 Components of Submerged Arc Welding

In this paper, the problems of distortion and residual stresses are always of great concern in welding industry are discussed in detail. In order to deal with this problem, it is necessary to predict the amount of heat transfer resulting from the welding operations. One way to predict the temperature, distortion and shrinkage of steel welding is through experimental and numerical analysis such as finite element analysis (FEA). Once the techniques to predict the distortion and shrinkage are identified, then the problems can be controlled accordingly. Within the welding procedures, there are many factors such as welding process type, welding process parameters, welding sequence, preheat patterns, level of constraint and joint details that contribute to the distortion of the welded structure. Knowing which parameters have an effect on the quality of the weld and which parameters give the most significant effect on the weld quality are the main issues in welding industry.

Objectives of this paper is to study the temperature results experimentally and then to simulate the complex arc welding process by using the finite element code ANSYS®. Then, after the model is built and verified, the main objective of the thesis is to study the effects of varying the welding process parameters on the thermo-mechanical responses. In addition to that, the aim of this thesis is also to find a relationship between welding parameters and thermo elasto-plastic responses. A finite element software ANSYS® has been used to evaluate the temperature flow along the length of the plate. The study of this thesis covers only the effects of varying heat input, welding speed and time of welding. These thermo mechanical responses included directional and total displacements (i.e., X, Y, Z directions and USUM), directional stresses, vonmises stress, directional elastic strains, directional plastic strains, and directional total strains. Experimental setup of SAW:

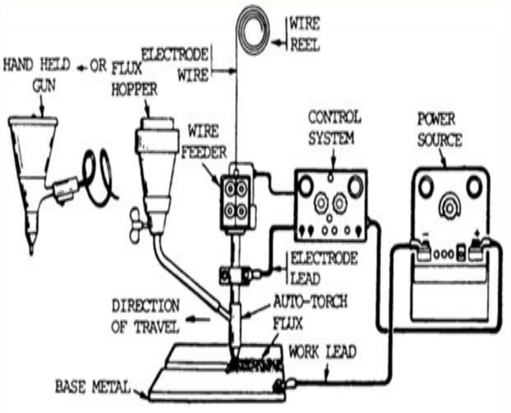


Fig.2 Experimental Set Up

II. ELECTRODE SPECIFICATIONS

AWS - ASF-A 5.17EH14, DIN-8557-S4, SIZE--3.15mm (Diameter)

Material used: In this project base material SA 516 gr 70 also called as ASTM A516 Grade 70 has been selected. 10mm thickness of base material has chosen for experimentation. SA 516 gr 70 is categorized as Carbon Steel. It is composed of (in weight percentage) 0.31% Carbon (C), 0.85-1.20% Manganese (Mn), 0.035% Phosphorus (P), 0.04% Sulphur (S), 0.15-0.30% Silicon (Si), and the base metal Iron (Fe). Another common designation of SA 516 gr 70 carbon steel is UNS K02700.Steel is the common name for a large family of iron alloys. To perform the experimentation, it is required to optimize the process parameters and also to know which combination of these parameters will give the full penetration. For that, we are done so many trails after that we chosen these parameters as final which will give the more efficient penetrated welding

Carriage moving rate (m/min)
Electrode feed rate (m/min)
Voltage (volts) and
Distance between electrode and work piece (mm)

Table 1 Process Parameter Values

Trails	Ocv (volts)	Wfr (m/min)	Ws/Cs (m/min)	Npd (mm)
Trail 1	29	4.0	0.3	22
Trail 2	34	5.5	0.2	22

Trail 1 Experimental Results

Distance (mm)	Cooling (sec)	Current (amp)	Temperature (Kelvin's)
5	240	475	976
10	158	475	842
15	150	475	609

Note: for Trail 1 heating time is 61sec.

Table 2 Trail 2 Experimentation Result

Distance (mm)	cooling (sec)	Current (amp)	Temperature (Kelvin's)
5	300	580	1080
10	228	580	946
15	210	580	713

Note: for Trail 2 heating time is 132sec.

Table 3 Temperature Readings for Trail1, I.E. For 5mm Distance from Weld.

Time (min:sec)	Temp. in 0C
00.00 (Start)	28
0.46	603 (Max.)
1.15 (End)	509
1.20	493
1.30	471
1.40	443
1.50	418
2.00	395
2.50	310
3.00	298
4.00	244
5.00	208
6.00	182
7.00	163
8.00	147
9.00	135
10.00	120
15.00	90
20.00	75

Table 4 Temperature Readings For Trail 1, at 10mm Distance From Weld.

Time (min:sec)	Temp. in 0C
00.00 (Start)	28
0.59	569 (Max.)
1.15 (End)	541
1.20	529
1.30	510
1.40	494
1.50	478
2.00	461
2.50	375
3.00	361
4.00	301
5.00	260
6.00	230
7.00	190
8.00	160
9.00	140
10.00	130
15.00	100
20.00	90

Table 5 Temperature Readings for Trail 1, I.E. For 15mm Distance from Weld.

Time (min:sec)	Temp. in 0C
00.00 (Start)	28
1.08	336(Max .)
1.15 (End)	330
1.20	309
1.30	294
1.40	295
1.50	281
2.00	269
2.50	223
3.00	215
4.00	182
5.00	159
6.00	142
7.00	128
8.00	117
9.00	108
10.00	100
15.00	75
20.00	70

Fig. 3 Thermocouple Setup

Fig. 4 & Fig. 5 Complete Experiment Setup, Trail1_5mm_Start.

Table 6 Temperature Readings For Trail2, at 15mm Distance From Weld.

Time (min:sec)	Temperature in 0C
00.00 (Start)	28
0.53	440 (Max.)
1.15 (End)	550
1.20	540
1.30	520
1.40	501
1.50	484
2.00	460
2.50	430
3.00	390
4.00	348
5.00	284
6.00	234
7.00	210
8.00	177
9.00	160
10.00	141
15.00	115
20.00	75

Fig. 6 Digital Thermocouple Reading In Celsius

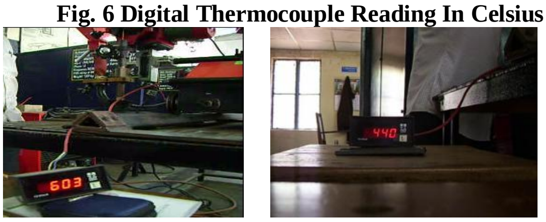


Fig. 7 & Fig. 8 Maximum Temperature_Trail1_at 5mm and Trial 2 at 15mm Distance From Centre of the Plates Respectively

Verification Of Butt Welding Process Using Ansys®: In this study, a finite element simulation of a butt joint welding was verified using the work of Friedman (1975). To do this, a simple butt-joint welding whose welding parameters are consistent to those of Friedman's model; heat input Q=821666.7 Watts, and welding speed of 4.0 and 5.5m/min was simulated using ANSYS® codes. The model then was verified by comparison of its temperature distribution at some chosen nodes.

III. NUMERICAL RESULTS

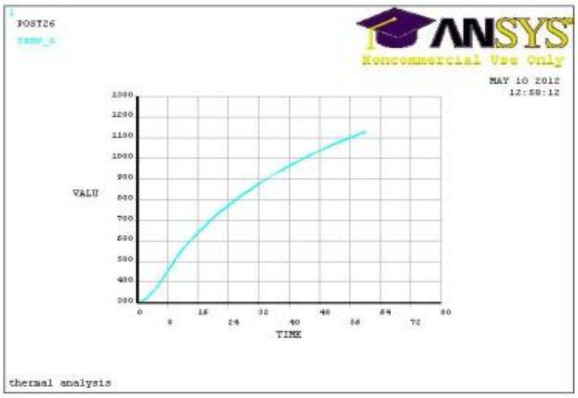


Fig. 9 Shows Time vs. Temperature

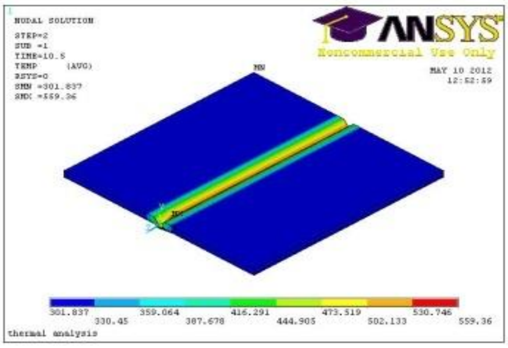


Fig. 10 Shows Nodal Temperature Distribution after 10seconds from Start Of the Weld

In above figure maximum temperature is obtained after welding operation and is 1205 K at the middle of the plates. After 10 sec. starting of the weld, Maximum Temperature is 559.36K and shows temperature distribution at the middle of plates

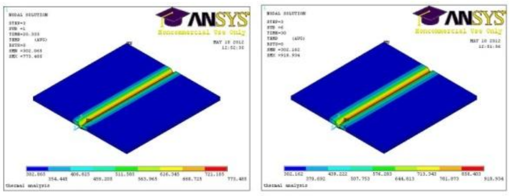
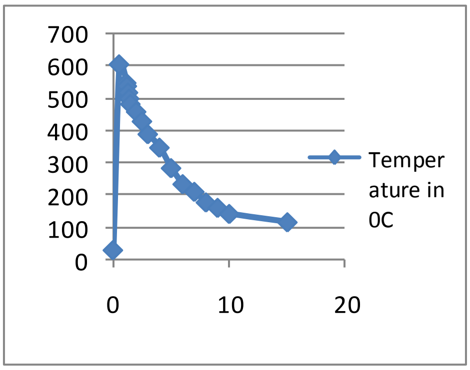


Fig. 11 Shows Nodal Temperature Distribution after 20.333 and 30m Seconds from Start of the Weld



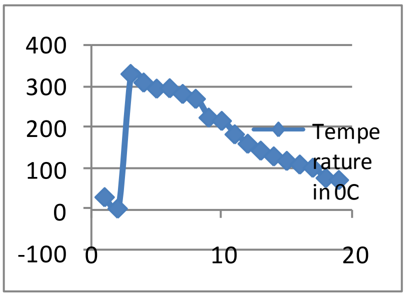
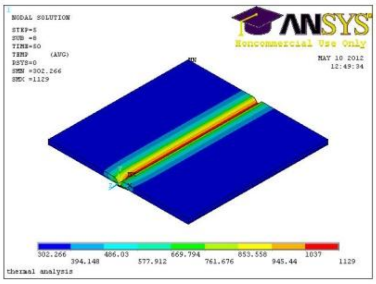
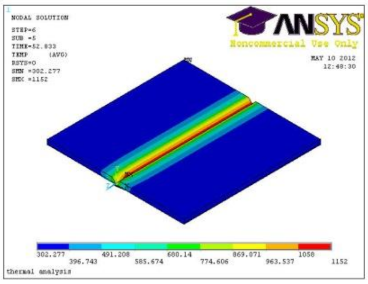


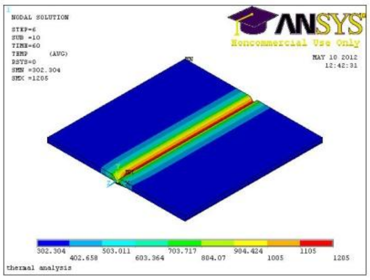
Fig. 12 (a), (b) Shows Trial 1 and Trial 2 Heating and Cooling at 15mm Distance



(a)



(b)



(c)

Fig. 13 (A), (B), (C) Shows Nodal Temperature Distribution after 50, 52.833 and 60seconds from Start of the Weld

After 20.333 sec. starting of the weld, Maximum Temperature is 773.485K and shows temperature distribution at the middle of the plates. After 30 sec. starting of the weld, Maximum Temperature is 918.934K and shows temperature distribution at the middle of the plates. After 36 sec. starting of the weld, Maximum Temperature is 992.057K and shows temperature distribution at the middle of the plates. After 41sec.starting of the weld, Maximum Temperature is 1046K and shows temperature distribution at the middle of the plates.

IV. CONCLUSION

As we know from the above results as the distance increases from 5mm to 15mm of centre point of the base material temperature decreases. So that process parameters can be optimize by completing many trails so that better penetration can get So temperature distribution on experimental and numerically obtained so that it is primarily for production of high quality BUTT weld in thicker steel plates. Submerged arc welding (SAW) is used for faster welding jobs it is possible to used larger welding electrodes (12 mm) as well as very high currents (4000A) that very high metal deposition rate of the order of 20kg/hr or more can achievable with this process. Also, very high welding speed 5m/min is possible in SAW.

In consumable electrode welding process in saw using DC current with electrode positive or AC the heat going to both the electrode and the work piece finally lands upon the work piece through transfer of molten metal . Thus the heat transfer efficiency of these processes is high. In SAW process the heat transfer efficiency is the further increased because the arc remains under a blanket of flux, the heat loss to the surroundings is thus minimized. SAW is used where high metal deposition at high rate is major criteria which could not be possible to achieve by regular welding processes. It is also used where oxidation problems need to be overcome without compromising efficiency.

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