iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 5 **Issue:** VII **Month of publication:** July 2017

DOI:

Effect of Post Weld Heat Treatment on Impact Toughness of SA 516 GR. 70 Low Carbon Steel Welded by Saw Process

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Abstract: This paper is focused on influence of post weld heat treatment on impact toughness value. The purpose of this study is to measure and analyze impact toughness value before and after post weld heat treatment (PWHT) with three different soaking temperatures. The specimens are welded by Submerged Arc Welding (SAW) process and auto melt B-31 flux is used with welding parameters of welding current 500 A, welding voltage 28V, welding speed 500 mm/min^2 and 25 mm of electrode stick out. The specimens in PWHT process were subjected to three different soaking temperatures which are 500^{0}C, 560^{0}C and 620^{0}C. Significant improvement in impact toughness at 620^{0}C of soaking temperature is recorded against risk of decrease in tensile strength.
Keywords: Post weld heat treatment, submerged arc welding (SAW), welding parameter, impact toughness, tensile strength.

I. INTRODUCTION

Post weld heat treatment (PWHT) is a well known method used for reducing and redistributing residual stresses in the material that have been introduced during welding. PWHT also tempers the heat affected zone (HAZ). Many researches have been conducted to study the effect of PWHT on the properties of constructional and pressure vessel steel weldments. PWHT may have beneficial, detrimental or negligible effect on the mechanical properties (especially toughness) of the weldments, depending upon the chemical composition of steel, welding process used and PWHT time and temperature. The purpose of the current study is to provide detailed information on the effect of PWHT on the microstructure and mechanical properties of a ASME SA 516 Gr. 70 preassure vessel steel joint. The mechanical properties of weldment were determined by charpy impact toughness test and tensile test (on UTM).

II. EXPERIMENTAL WORK

The base material used in this process is ASME SA 516 Gr. 70 low carbon steel. It is easy to machine, fabricate and is weldable. Its chemical composition is summarized in Table 1. For welding, ASME SA 516 Gr. 70 steels were cut into size of 300×150×10 mm by gas cutting.

TABLE I
Composition Of Base Plate

Element	C	Mn	Si	P	S	Cr	Ni	Mo	Nb	V
Content %	0.23	0.9	0.2	0.035	0.035	0.3	0.3	0.08	0.01	0.02

A. SAW Welding Process

The specimen is welded together using submerged arc welding (SAW) process. Auto melt B-31 flux and copper coated mild steel filler wire are used for welding. The pre-heat (200^{0}C) and inter-pass (250^{0}C) temperature were maintained in this welding process. Welding parameter variables are summarized in Table 2.

TABLE II
Welding Parameter

Welding current (A)	Welding voltage (V)	Welding speed (mm/min)	Electrode stick out (mm)
500	28	500	25

B. Post Weld Heat Treatment (PWHT)

The machined specimens were subjected to stress relieving heat treatment. Three different soaking temperatures were used. The process of heat treatment started with heating at 120^0C/hr. up to soaking temperature and maintaining the soaking temperature for 3 hr. and then cooling at the rate of 60^0C/hr. in the furnace up to 300^0C and then air cooled up to room temperature. The weld samples were soaked under specified range[1][2][3].

TABLE III

Pwht Soaking Temperature

Specimen	Soaking temperature (^{0}C)
Sp-1	480
Sp-2	560
Sp-3	630

C. Charpy Impact Testing

The charpy impact toughness test was carried out to examine the ability of different microstructure to absord energy during the process of fracture. The standard charpy test specimens of size 55×10×10 mm were cut from the joint with the notch of 2 mm located in the HAZ region. 98% alcohol + 2% nitric acid were used etching of weld zone.

Figure 1: Post weld heat treated charpy impact specimen

III. RESULT AND DISCUSSION

A. Impact Toughness Test

Table 4 shows the result of impact toughness of as welded and after PWHT at 480^0C, 560^0C and 630^0C for 3 hr. in as welded condition, weld region exhibit a low toughness value as compared to PWHT specimens. The increase in toughness makes the material softer. These three soaking temperature are under lower critical temperature which is 700^0C.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 5 Issue VII, July 2017- Available at www.ijraset.com

TABLE IV
Impact Toughness Test Result

Source	Charpy impact test value (J)
As welded	235
After PWHT at 480^{0}C for 3 hr.	245
After PWHT at 560^{0}C for 3 hr.	250
After PWHT at 630^{0}C for 3 hr	265

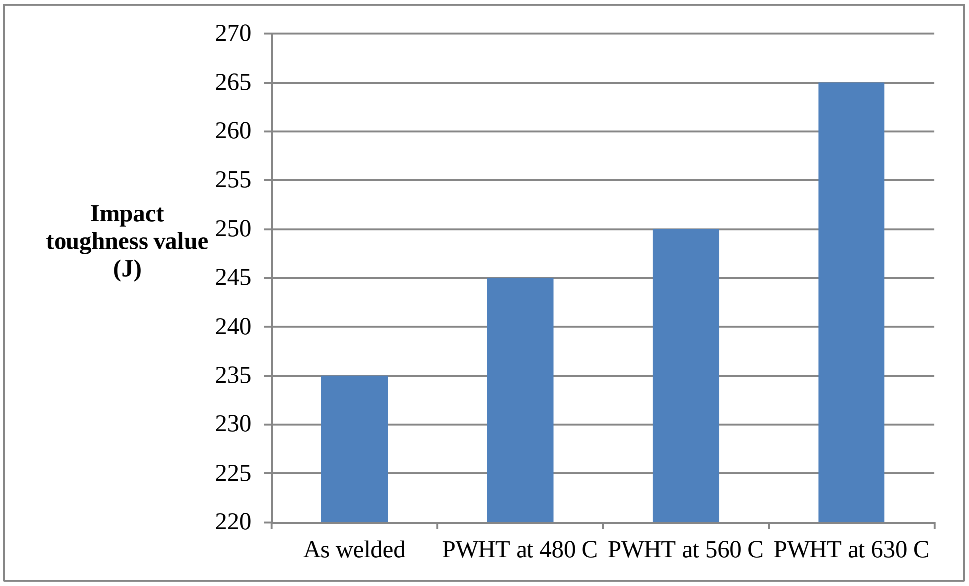

Figure 2: Impact toughness

B. *Microstructure*

Figure 3: As welded specimen

Figure 4: PWHT specimen

The above figure shows microstructure at 100X magnification of as welded plate, figure-3 which shows fine grain structure and result in brittle fracture and figure-4 shows microstructure of PWHT specimen at 630^{0}C for 3 hr. which shows coarse grain and result in ductile fracture.

IV. CONCLUSION

The testing is successfully done and the result is compared between before and after post weld heat treatment (PWHT) with three soaking temperature which are 480^{0}C, 560^{0}C and 630^{0}C. The data and result show that the increase of charpy impact toughness value occurred after post weld heat treatment. From the results obtained, these studies conclude that the ductility of the metal is increased because of the mechanical property change in the microstructure [4].

The phase for the metal is pearlite with ferrite and the metal is heated below lower critical temperature of material. The pearlite is known for tougher, extremely strong and highly deformed. After PWHT formation of acicular ferrite were observed in weld zone which results in increase in impact toughness.

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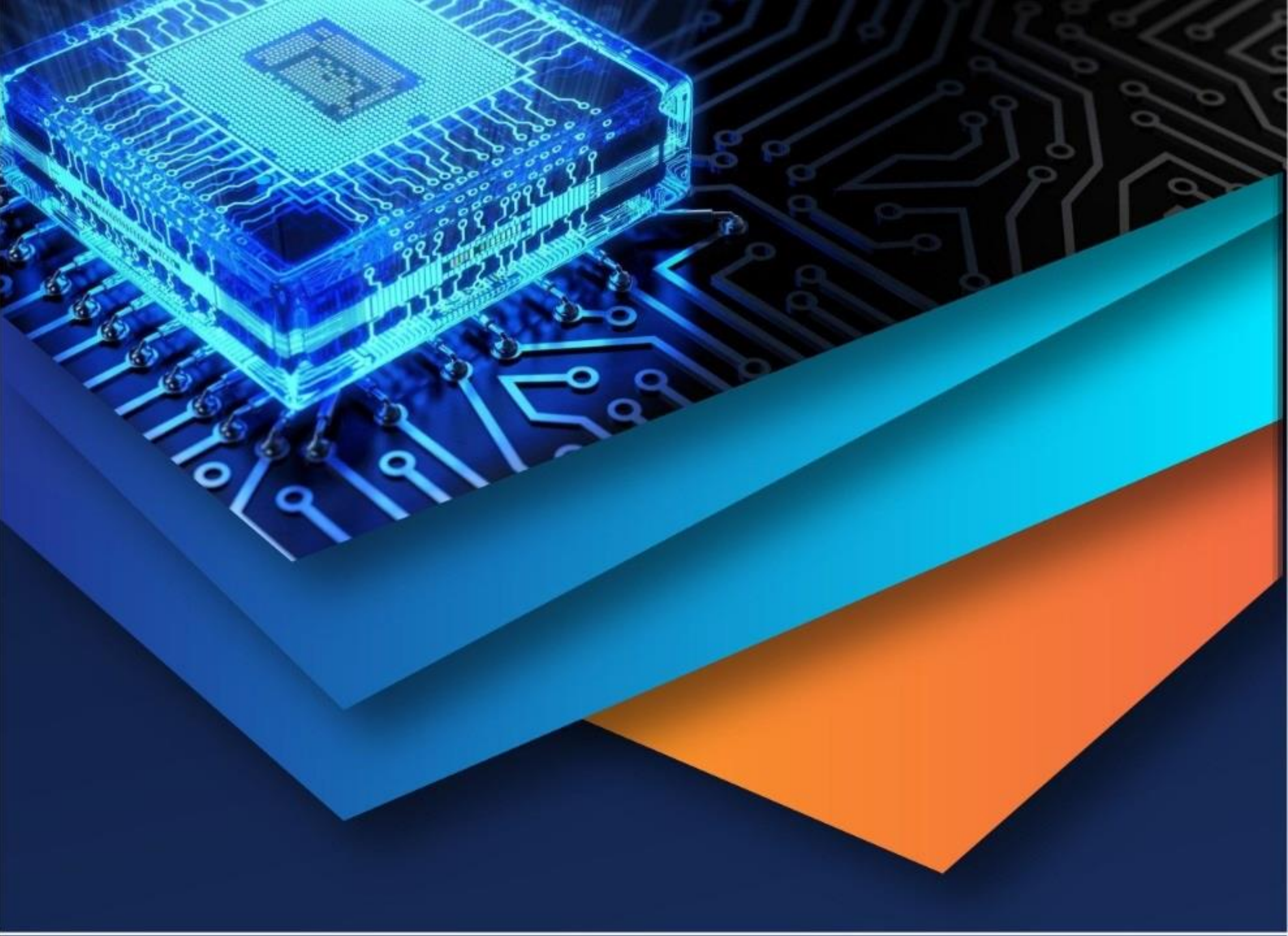

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