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FATIGUE CRACK GROWTH STUDIES ON CORTEN STEEL

T. Sunil Prasad* & Dr. R. Ramadoss**
* PG Student, Department of Mechanical Engineering, Easwari Engineering College, Ramapuram, Tamilnadu
** Professor, Department of Mechanical Engineering, Easwari Engineering College, Ramapuram, Tamilnadu

Abstract:

Corten steels are widely used in railway constructions and some structural works due to its high strength to weight ratio and high hardness. The main purpose of the research presented herein was to the fatigue crack growth both in base metal [BM] and in welded region. Recent studies proved that low hydrogen ferrite steel (LHF) consumables can be used to weld steels, which can give very low hydrogen levels in the weld deposits. Hence, in this investigation an attempt has been made to study the weld consumable and weld process on fatigue crack growth behavior of corten steel joints. Shielded metal arc welding (SMAW) was used for fabrication of joints using LHF consumables. The joints fabricated by SMAW process using LHF exhibited superior fatigue crack growth resistance.[4-5]

Index Terms: Corten Steel, Fatigue Crack Growth, Shielded Metal Arc Welding & Low Hydrogen Ferrite Steel

1.Introduction:

The main purpose of the research presented in this manuscript is to study the fatigue crack growth in corten steel. Corten steels are widely used in ship building, railway constructions and some structural applications due to high hardness, high strength to weight ratio and excellent toughness. Shielded metal arc welding (SMAW) were used for fabrication of joints using low hydrogen ferrite steel (LHF) consumables. The joints fabricated by SMAW process using LHF exhibited superior fatigue crack growth resistance.

Due to heterogeneity induced from welding, base metal (BM) and weld metal (WM) have different mechanical behaviors. For structural steels, the strength of the welded joints determines the strength of the whole structure. Welded joints are subjected to various forms of cyclic loading in practical applications and fatigue failure is common. Thus, welding is a major factor in the fatigue lifetime reduction of components. Failure analysis of the weldments indicated that fatigue alone is to be considered for most of the failures. This present study assumes significance as fatigue crack growth studies have not been reported in this class of corten steel fabricated by SMAW using LHF consumables [4].

2. Experimental Work:

2.1 Joint Fabrication:

The base metal used in this study is corten steel, closely confirming to AISI specification. The microstructure of the material exhibits ferrite and pearlite (Fig. 1).15mm thick plate were machined into required dimensions (200mm * 100mm) using cutters and grinding.

The direction of welding was normal to the rolling direction. All necessary steps were taken in order to avoidjoint distortion. Low hydrogen ferrite steel (LHF) Consumables were used to fabricate the joints. The chemical compositions of base metal and weld metals were determined using optical emission spectroscopy.

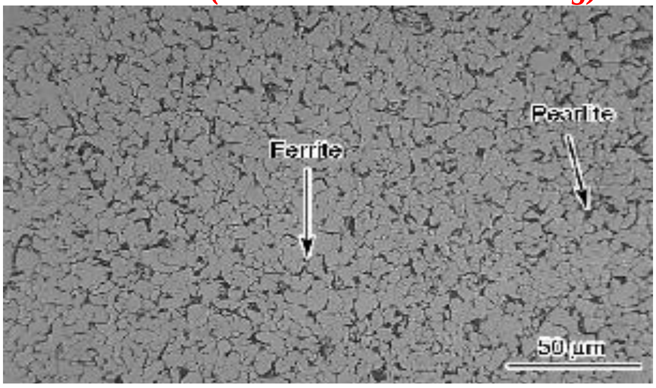


Figure 1: Microstructure of the Base Metal

Figure 2: Optical Emission Spectroscopy

The chemical composition of the base metal and weld metal were determined and are presented in Table 1. The process parameters used to fabricate were presented in Table 2.

Table 1: Chemical composition of (%wt) of base metal and filler metals

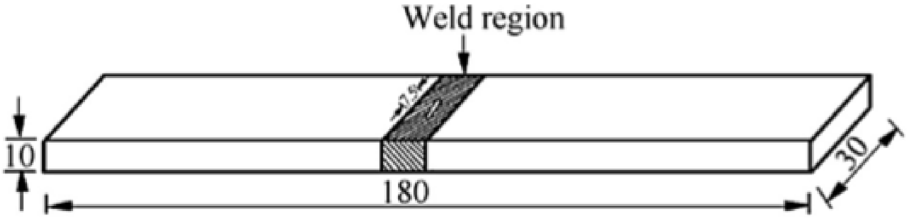
Type of Metal	Base Metal	Weld Metal
C	0.09	0.05
Si	0.32	0.242
Mn	0.26	1.30
P	0.016	0.02
S	0.008	0.014
Cr	0.72	0.133
Mo	-	0.222
Ni	0.41	2.12

Table 2: Welding conditions [4]

Parameters	LHF
Preheat temperature	100 C
Interpass temperature	150 C
Filler diameter	4mm
Welding current	160Amps
Arc voltage	22Volts
Heat input	1.22KJ/mm

2.2 Fatigue Crack Growth Testing:

Centre crack tension (CCT) specimens were prepared to the dimensions as shown in Fig 3. The specimens were reduced to a thickness of 10mm by shaping process to obtain flat and required surface roughness. Procedures prescribed by the ASTM E 647-05 were followed for the preparation of the specimen.



All dimensions are in mm.

Figure 3: CCT specimen.[4]

2.3. Tensile Testing:

Tensile specimens have been carried out as per ASTM E8M-04 standard as shown in Fig 4 to evaluate yield strength and tensile strength. Tensile test has been carried out in Universal Testing Machine 1000KN, make FIE shown in Fig 4.

Figure 4: UTM 1000KN make FIE with tensile specimen at the time of testing

2.4 Microstructure:

The microstructure analyses of the weldment were carried out using a optical microscope. The specimens were used to reveal the micro structure of the weld region of low hydrogen ferrite joint.

3. Results:

3.1 Tensile Properties:

The tensile properties such as yield strength, tensile strength and percentage of elongation of base metal were evaluated and presented in Table 3. The joints fabricated by using LHF consumables exhibited superior tensile properties.

Table 3: Tensile properties of base metal

Joint type	Yield strength	Tensile strength	Elongation (%)	Location of failure
Base metal	1150Mpa	1226Mpa	16	Centre of the specimen

3.2 Microstructure and Hardness:

The micrograph taken at the weld metal region are displayed in Fig 5. The weld joint with low hydrogen ferrite exhibits ferrite morphology.

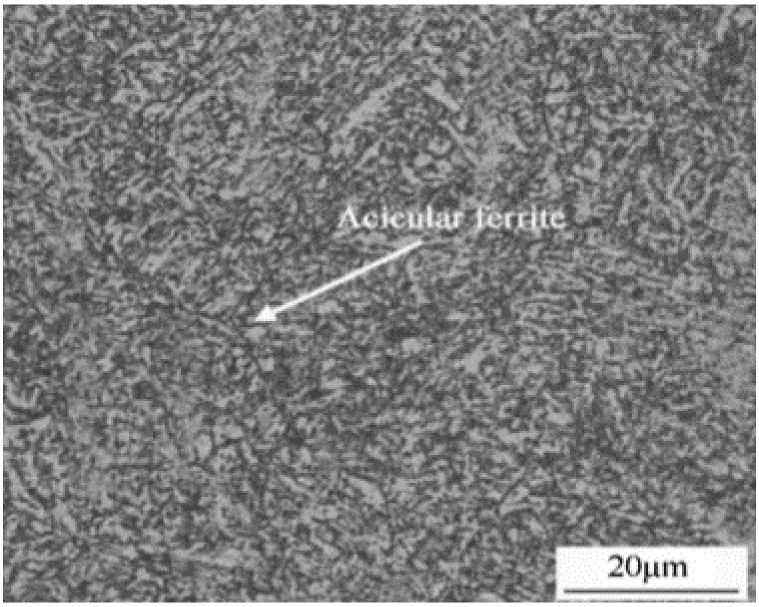


Figure 5: Microstructure of weld metal region

The hardness of the base metal and welded region were tabulated and displayed in Table 4.

Table 4: Hardness (VHN) values

Base Metal	Weld Metal Region
557	312

4. Conclusions:

Theresults obtained from the fatigue crack growth test indicate that the base metal having more crack growth resistance than weld joints. The joint fabricated using LHF consumables exhibited superior fatigue crack growth resistance.

- ❖ The use of low hydrogen ferrite steel consumables is found to be beneficial to establish fatigue crack growth.
- ❖ The weld joint exhibits good crack growth resistance.
- ❖ The mechanical properties, microstructures are reasons for better fatigue crack growth resistance.

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