STRUCTURAL ANALYSIS OF CARBON STEELS JOINED WITH DIFFERENT WELDING METHODS BY ULTRASONIC TESTING

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ABSTRACT: Ultrasonic testing is a method that using high frequency sound waves for detecting cracks, cavities, folds, thickness of residues, gaps and cracks that can occur in the welded parts. High frequency supersonic waves generated by the probe to detect faults in the material must be detected by the probe again after the probe has reflected a discontinuity in the material. Carbon steels show different structural properties depending on the carbon content. As the amount of carbon increases, the hardness, yield and tensile strength of the steels increase, while the ductility and impact strength properties decrease. These steels are generally joined with special electrodes, electric and gas arc welding methods. In this study carbon steel plates were joined by using MIG and electric-arc welding methods. The ultrasonic flaw detection device was used to detect cracks and faults in the welded region, HAZ and base metal on the welded carbon steels.

Key words: electric arc welding, MIG, carbon steel, ultrasonic test.

1. INTRODUCTION

With the developing technology, the usage areas of the materials are also developing and their sizes becoming smaller. Since the usage areas of metal materials are quite high, the number of pieces produced from these materials is much more. [Lahiri, 2017; Alam,2017]. The need for joining of metal parts used in lots of areas where the production is so high has been increasingly higher. Depending on the types and sizes of the metal used, the joining methods vary. The most common method for joining the materials is the welding. Various welding methods are used for joining the metal parts and these are becoming more technological according to part sizes [Sun et.al., 2014;Guo et.al.,2015; Khodir et.al.,2012]. The parameters used in joining metal parts affect the quality of the welding. For this reason, it is necessary to find the most suitable parameters and the welding method for the used part and it is necessary to carry out a lot of research and trials [Eroğlu et.al.,1999; Cui et.al.,2006; Chung et.al.,2006].

It is known that metals undergo microstructure changes at high temperatures, and that leads to change in mechanical properties. For this reason, there are many issues that need to be considered when joining metals with the welding process. These issues can be listed as follows; According to the sensitivity of the metal to oxygen environment, the vacuum should be provided, also as low as possible current and voltage should be applied, suitable diameter of the electrode should be selected, the welding process should be slow and controlled and suitable welding method for materials must be

selected [Chung et.al.,2010;Talabi et.al.,2014].

In this study, low and high carbon content steels were joined with electric arc welding and gas welding methods and structural cracks were examined by ultrasonic testing method.

2. MATERIALS AND METHODS

Steels are used as the main material of many products in our daily life. Low carbon steels used in this study also known as mild steel contain 0.05% -0.32% amount of carbon. Low carbon steels are soft and offer good ductility, tough but have low wear resistance, excellent formability and in some cases carburizing and annealing properties. They usually used for making screw, nuts, bolts, rivets, thin canes, chains, small forging, wire. The other material used in this study is high carbon steels. High carbon steels also known as 'tool steel' contain 0.55%-1.5% amount of carbon. This type of steel has highest tensile strength and hardness, lowest ductility and machinability properties and mechanical properties can be easily changed by various heat treatment process. Due to good tensile strength and hardness properties, high carbon steels find extensive application in hand tools, cutting tools, drill, chisels, punches and saw blades productions [Alam, 2017]. Due to the good properties of them, the joining of these steels, which have a wide application area, is used also frequently. Since welding is an efficient, dependable and economical process, the welding has been one of the most commonly used methods of joining up to this time. As steels are generally metals with good weldability, electric arc welding and MIG have been chosen as the methods to be used in the study. The joining of low and high carbon steels was carried out and the crack formation in the weld seams was examined by ultrasonic testing then comparison was made between two different welding methods [Zakaria et.al.,2010; Askeland et.al.,2010; Gündoğdu et.al.,2015].

One of the welding methods used in this study is MIG (Metal Inert Gas) welding, which is formed under inert gases, helium or argon. The electrode is sent to the pliers from a reel in the form of a thin wire. This welding is performed automatically or semi-automatically. This welding method has advantages such as providing a strong and clean welding application, low welding area temperature and narrow weld seam [Geliş, 2014]. All important metals such as carbon steel, stainless steel, aluminum and copper can be welded with this process in all positions by choosing the appropriate shielding gas, electrode and welding condition [Suban,2001]. The other welding method Electric Arc Welding is a manual arc welding method where the heat required for the welding occurs due to the arc formed between the electrode and the work piece. Electric arc welding has an important place in the machine field. Although the use of automatic machines in the field of welding is increasing day by day in the field as well as in all other fields in the industry, it is an important area to make welding manually in the repair and production stages. Because it is impossible to use that the automatic and semi-automatic machines in everywhere and position [Ministry of Education,2013].

The crack examination of high and low carbon steels joined with Electric Arc Welding and MIG welding was performed

using an MFD500 Ultrasonic Flaw Detector device. Ultrasonic inspection is a non-destructive testing method used in metal and non-metal materials. With this method, errors, inclusions, gaps etc. can be detected both in the surface and in the volume of the material. The ultrasonic method utilizes high frequency sound waves produced in a piezoelectric transducer. The sound wave moving in the material gives information about the location and size of this error by being reflected back when it encounters a discontinuity or error in the structure [Baydur,1998].

3. EXPERIMENTAL

High-carbon and low-carbon steel specimens were joined using electric arc and gas welding methods. The dimensions of the samples and the used welding methods are shown in Table 1 and the steel plates were joined using the welding parameters shown in Table 2. After welding process the samples are shown in Figure 1.

Table 1: Welding methods and sample sizes used for samples.

	Electric Arc Welding	**MIG Welding**
High carbon steel alloy	10x5.5x1 cm	8.5x6.8x0.5 cm
Low carbon steel alloy	8.2x7.2x0.6 cm	8.2x7.2x0.6 cm

Table 2: Welding Parameters.

Parameters	**Electric Arc Welding**	**MIG Welding**
Time	1 min	1 min
Amper	80 A	80 A
Electrode Diameter	3.25 mm	1 mm

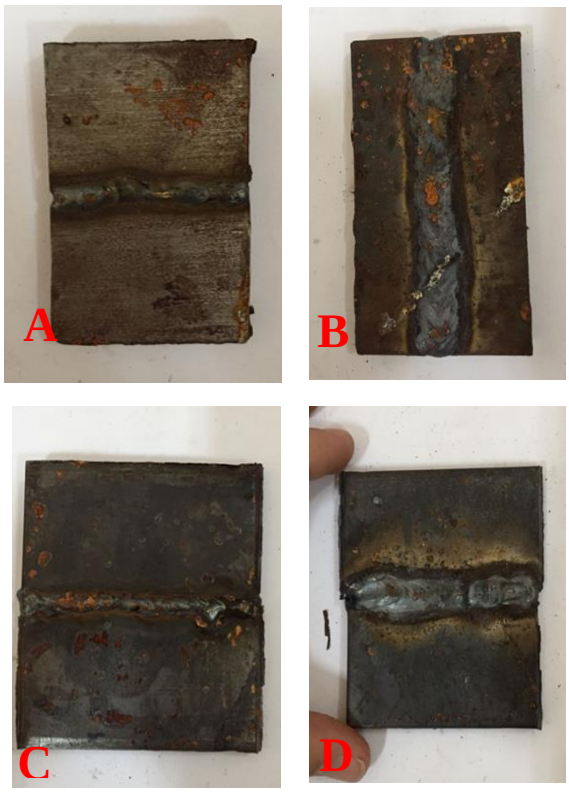

Figure 1: Electric Arc Welded samples; A) low carbon steel alloy, B) high carbon steel, MIG Welded samples; C) high carbon steel alloy and D) low carbon steel alloy.

After the steel plates were welded, the weld zone was examined with ultrasonic flaw detector as shown in Figure 2.

Figure 2: Ultrasonic examination of welded samples.

4. RESULTS

The result graphs of the welded samples were obtained and examined by ultrasonic fault detector. The welded zones of each sample were investigated by the detector. The fracture and porosity levels in the three regions were examined and a comparison was made between Electric Arc and MIG welding methods and the most uniform joining method was determined.

The analysis results of welded samples by the ultrasonic test are shown in Figure 3. It was found that the highest structural errors and discontinuities were found in the welding zone and it was found that the most intense and near-surface faults and discontinuities were in the sample joined with the MIG welding method.

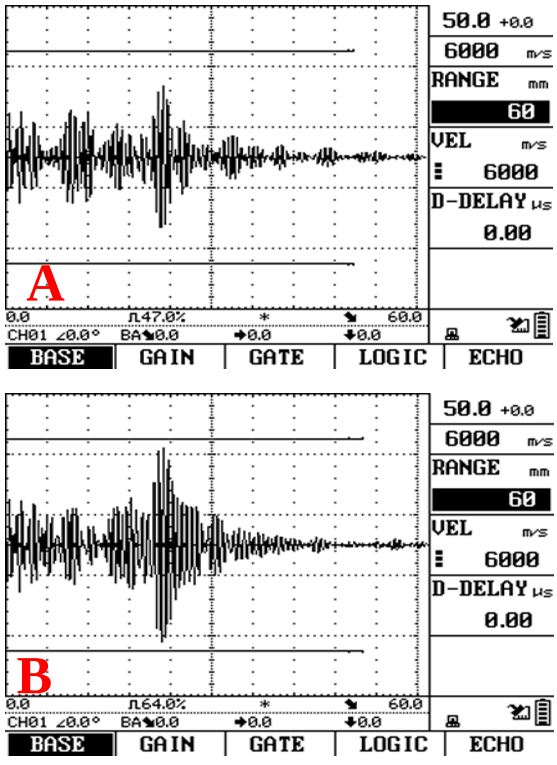

Figure 3: A) Electric Arc and B) MIG welded low carbon steel alloys ultrasonic examination result.

On the other hand, when we examined the ultrasonic test results of the high carbon steel alloy joined with the electric arc and MIG welding methods shown in Figure 4, it was determined that the highest structural errors and discontinuities were found in the welded region. Although there are not very high error differences between the two welding methods, it was found that the most intense and near surface faults and discontinuities were in the sample joined with Electric Arc welding method.

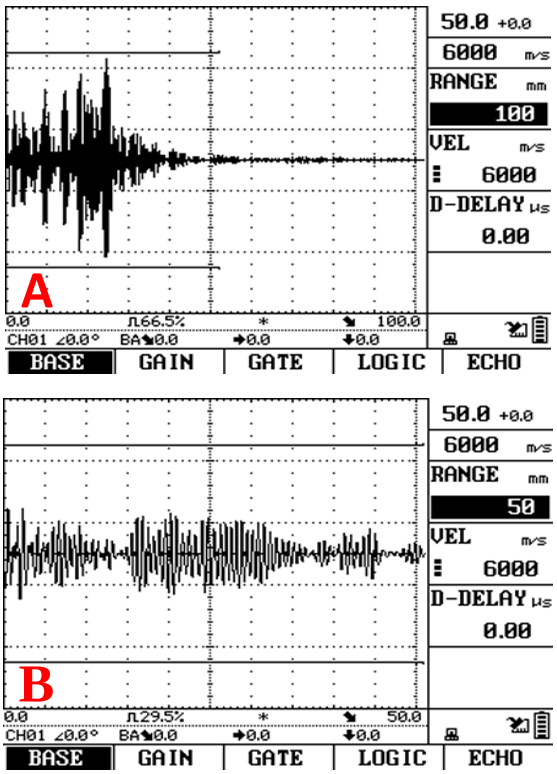

Figure 4: A) Electric Arc and B) MIG welded high carbon steel alloys ultrasonic examination.

Referring to Fig. 1 (B), the welded seam of the low carbon steel plate joined with the MIG welding method appears to be irregular and very thick. Similarly, when looking at Figure 1 (D), the welded seam of the high-carbon steel plate joined with the electric arc welding appears to be distorted and irregular.

5. CONCLUSION

In this study, low and high carbon content steels were joined with electric arc welding and gas welding methods and structural

cracks were examined by ultrasonic testing method. From this investigation the following conclusions were derived:

(1) MIG welded low carbon steels have wider weld seam than electric arc welded samples but has more oxide layer and discontinuities in weld zone. As there is no protective gas, the low carbon steels affected more from the welding process.

(2) Electric Arc welded high carbon steels have more errors in welding zone than MIG welded samples.

(3) The thick and oxidized weld seam shows more errors in ultrasonic test graphs. Because there is more porosities in wider weld seam.

6. REFERENCES

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