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Examination on Weldability of 500 HBW Armour Steel with ER110 Wire

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Abstract**:** *In this study, the weldability of 500 HBW armour steel with ER110 welding wire has been examined. Two different samples which have different welding heights (3 mm and 5 mm) were prepared and hardness values of the samples were determined with Vickers hardness testing under 10 kgf. The hardness measurements were conducted for both fusion zone and heat effected zone. The experimental study revealed that for both 3 mm and 5 mm welding samples, the hardness values were under the lower limit of the supplier data. For the samples of 3 mm welding, the hardness decrement was observed for 13 mm and 18 mm long distances and for the 5 mm samples, those distances were 16 mm and 25 mm. The study indicated that, welding parameters should be optimized to prevent the hardness decrement for the welding process.*

Keywords: Armour, *steel, welding, hardness, ballistic.*

1. Introduction

Armour materials have critical importance for the integrity of the combat vehicle and its occupants [1]. The armor materials are selected in engineering design according to their price, ballistic performance, density properties [2]. One of the most important characteristics for the armour materials is the processability. The material should maintain its properties after the manufacturing processes.

Welding is one of the most densely used manufacturing processes for armoured vehicle production. The fusion welding processes gas metal arc welding (GMAW), the shielded metal arc welding (SMAW) and the flux cored arc welding (FCAW) are the mostly preferred for the welded joint applications [1,3-4]. After the welding processes, the weld metal, base metal and the heat effected zone shows different mechanical behaviour [5]. For the trustworthiness of the design and the combat vehicles, welding processes should be optimized and mechanical characteristics of the welded joints should be known.

In this study, 500 HBW armour steel plates have been welded with metal inert gas welding process using ER110 welding wire. Two different samples which have 3 mm and 5 mm welding height. After the welding processes, the hardness measurements were conducted on the base metal, weld metal, and in the heat effected zone. The obtained results were evaluated for improving the integrity of the welded joints in combat vehicle production.

2. Material and Method

2.1. Materials

500 HBW armour steel and ER110 welding wires have been used for sample production. Chemical compositions of the steel and welding wire are given in Table I.

TABLE I: Chemical composition of the 500 HBW armour steel and the welding wire

Chemical	500 HBW Armour Steel Content (%-max)	ER110 Welding Wire
C	0.30	0.09
Si	0.70	0.75
Mn	1.70	1.70
P	0.030	-
S	0.015	-
Cr	1.50	0.30
Ni	0.80	2.00
Mo	0.50	0.50
B	0.004	-
Cu	-	0.20

2.2. Methods

The dimensions of the plates were 200x400 mm and the thickness of the steel plates were 8 mm. Metal inert gas melding (MIG) process was applied for joining the plates. The welding parameters are given in Table II. The welding heights (a) were 3 mm and 5 mm. After the welding processes, the samples were examined with hardness measurements. Emcotest Durascan 30 G5device was used for the hardness measurements. 10 kgf force was applied for the measurements.

TABLE II: Welding parameter

Parameter	Value (3 mm welding height)	Value (5 mm welding height)
Run	1	1
Process	135 Fronius	135 Fronius
Pre-heating	No	No
Wire Size (diameter)	1.2	1.2
Wire Class	4 Mn Ni 2Cr Mo EN ISO 16834	4 Mn Ni 2Cr Mo EN ISO 16834
Current (A)	140-150	170-180
Voltage (V)	21-22	24-25
Type of Current	Puls	Puls
Wire Feed (m/min)	5.2	6.3
Travel Speed (cm/min)	17.3	22
Heat Input (kJ/mm)	0.81-0.91	0.89-0.98

3. Results and Discussion

The armor steel was welded and the welded samples are shown in Figures 1-4. The hardness measurements were conducted in three different line as horizontal line, vertical line and the bottom line. In the Figures 5-7, the hardness measurement results are illustrated on the photographs for the sample which have 3 mm welding height. Similarly, hardness results for the sample which have 5 mm welding height are illustrated in Figures 8-10.

Fig. 1: Welded sample (a=3 mm)

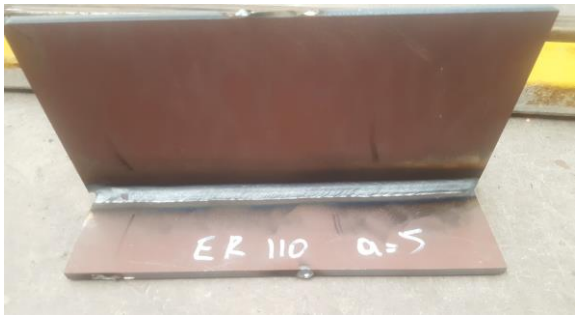

Fig. 2: Welded sample (a=5 mm)

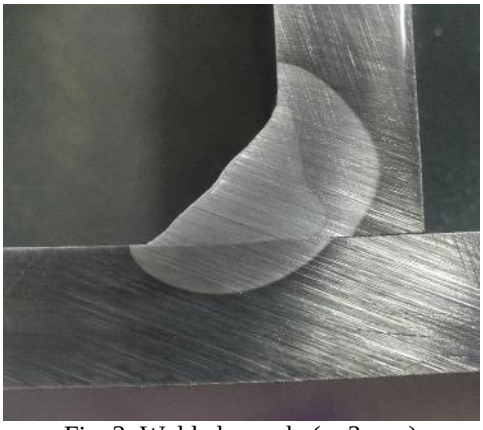

Fig. 3: Welded sample (a=3 mm)

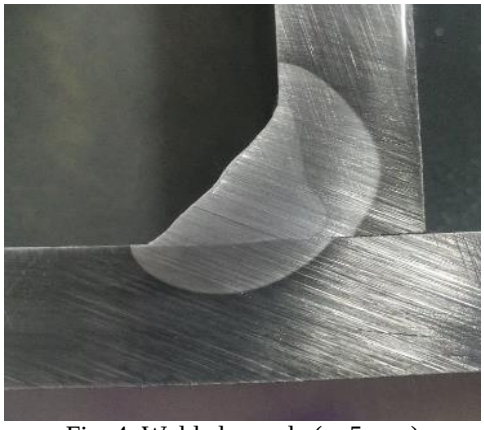

Fig. 4: Welded sample (a=5 mm)

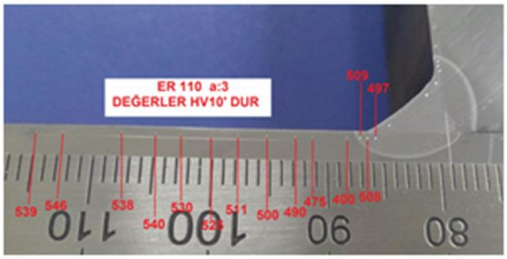

Fig. 5: Hardness values of the sample with 3 mm welding height (horizontal line)

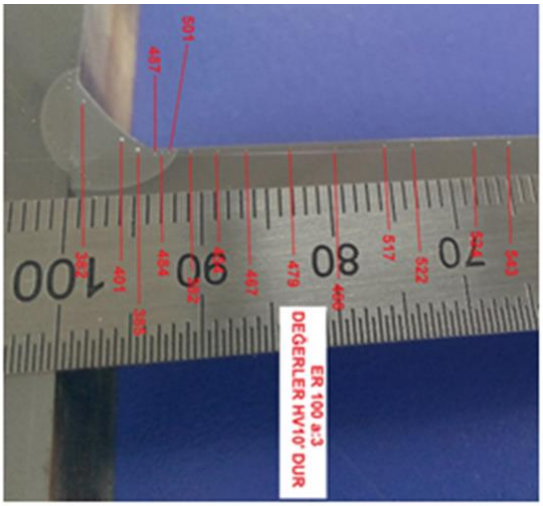

Fig. 6: Hardness values of the sample with 3 mm welding height (horizontal line)

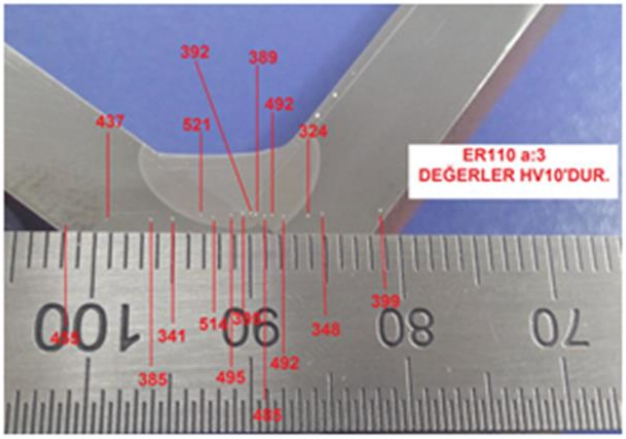

Fig. 7: Hardness values of the sample with 3 mm welding height (bottom line)

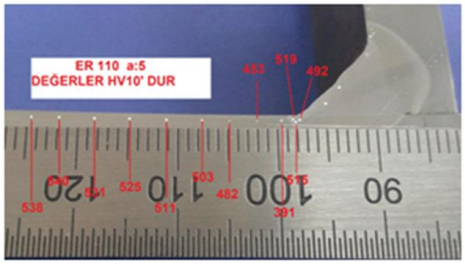

Fig. 8: Hardness values of the sample with 3 mm welding height (horizontal line)

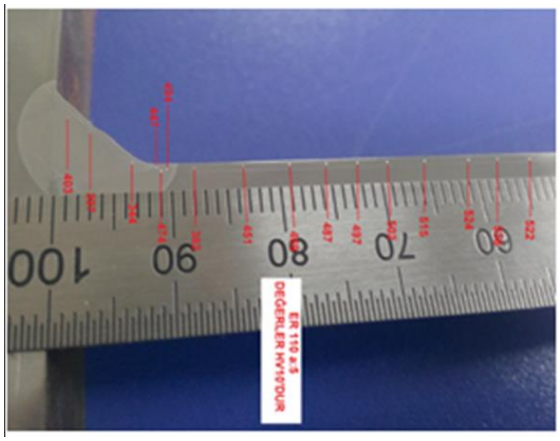

Fig. 9: Hardness values of the sample with 3 mm welding height (horizontal line)

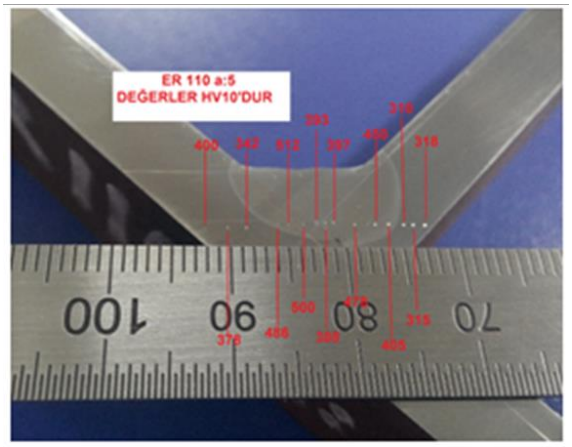

Fig. 10: Hardness values of the sample with 3 mm welding height (bottom line)

From the hardness results it was seen that, the decrement in hardness value was observed for the both samples. According to supplier data, the minimum value of the hardness is determined as 513 HV10 (480 HB). When the samples were examined, significant decrement were observed for the both samples. At some points, hardness values below the 400 HV10 have been measured. The dimensions of the decrement lines for the were

13-18 mm and 16-25 mm, for the sample 1 (3 mm welding height) and sample 2 (5 mm welding height), respectively.

4. Conclusions

In this study, the weldability of 500 HBW armour steel with ER110 wire have been examined. Two different welding heights of samples were prepared and hardness measurements were conducted. According the test results the weldability of 500 HBW armour steel with ER110 wire have been evaluated and the followings were concluded;

- Hardness values were lower in the fusion region and heat effected zone than the non-effected regions.
- The dimensions of the low hardness region were higher when the welding height is higher.

As conclusion, ER110 wire could be used for welding of the 500 HBW armour steel for combat vehicle applications. But, to determine the optimum welding parameters further studies are needed. The pre-heating of the steel before the welding process could be possible solution for the solving the low hardness values on the fusion and heat effected zones.

5. Acknowledgements

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