THE INFLUENCE OF JOINING METHOD OF AW-7020 ALUMINIUM ALLOY ON CORROSION PROPERTIES

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Abstract

The results of corrosion properties research of aluminum alloy AW 7020 (AlZn5Mg1) welded by friction stir welding FSW and MIG were presented. Friction Stir Welding (FSW) – a new technology can be successfully used for butt welding of different types of aluminum alloy sheets. In the article the parameters for friction stir welding of sheets made of AlZn5Mg1 [7020] alloy was presented as well as parameters for MIG. Metallographic analysis of bonds showed a proper structural construction of both, the FSW and MIG welded 7020 aluminum alloys.

The polarization was carried out at changes in the potential speed of 12 mV/min in the range of ± 50 mV with the stationary potential. Atlas 0531EU & IA potentiostat was used for studies. The corrosion resistance research was carried out using three electrode potentiodynamic method. The following parameters were measured: electrode potential Ec [mV] and the corrosion current density Jc [$\mu A/cm^2$]. The tests were carried out on specimens in 3.5% water solution NaCl.

Good resistance to electrochemical corrosion was found of the native material, friction stir welded and MIG welded 7020 aluminum alloys.

Original value are received results of the corrosion properties of new method friction stir welded AlZn5Mg1 alloy compared with traditional MIG method and the native material.

Keywords: *aluminium alloys, friction stir welding (FSW), MIG welding, corrosion.*

1. Introduction

Aluminium alloys are getting more and more interest in the shipbuilding industry as these alloys allow a significant reduction in ship structure weight compared with the weight of steel structures. The use of aluminium reduces the weight by about 50%, thereby increasing the displacement of the vessel and maintaining the displacement for load or speed increase and stability improvement. Among weldable Al-alloys suitable to plastic working the group of Al-Mg alloys (of 5xxx- series) of good weldability and relatively good service conditions are still the most popular. The advantage of these alloys is their relative insensitivity to layer corrosion and stress corrosion, the disadvantage – low strength of welded joints, below 300 MPa. An alternative to these alloys could be the Al-Zn-Mg (7xxx series) alloys. They exhibit higher strength properties than the mechanical properties of Al-Mg alloys. The disadvantage of the 7xxx series alloys is that they are prone to stress and layer corrosion. Many years of research have shown that the resistance of these alloys to stress corrosion is influenced among other things by heat processing, chemical composition and welding technology (welding method, type of fillers, type of joint) [1-7]. Virtually all joints welded using conventional MIG or TIG methods in this group of alloys possess insufficient resistance to stress or layer corrosion.

An alternative to traditional methods such as MIG of TIG welding may be Friction Stir Welding (FSW). In the method a tool fitted with rotarymandrel located in the place of welding the pressed-down plates is used to heat and plastify the material. After putting the mandrel- fitted tool into rotation, friction heating and plastifying the plate material in its direct vicinity occurs, and slow sliding the entire system follows along contact line (Fig. 1). Because this method consists in welding in the solid state, below the melting temperature of the material, the mechanical properties obtained using this joining method may be higher than those for arc welding techniques (MIG, TIG). The main advantage of this method is that it is easy to obtain joints with high, reproducible properties [8, 10]. Because in the FSW method, welding occurs in the solid state, much less heat is supplied to the joined materials than is the case with conventional welding. This significantly reduces the size of the heat-affected zone. Studies of Al-Zn-Mg alloys bonded using MIG and TIG methods exposed to aggressive marine environment have shown a low resistance to stress and layer corrosion occurring just in the heat-affected zone [7, 9, 11].

The aim of the study was to determine the susceptibility of AlZn5Mg1 (AW-7020) joints welded using the FSW method to electrochemical corrosion in 3,5% water solution NaCl compared to the native material and joints welded by traditional MIG method.

2. The research methodology

The testing used EN AW-7020 T6 aluminium alloy (supersaturated and artificially aged.) The chemical composition of the alloy is given in Table 1

Tab. 1. Chemical composition of 7020 aluminum alloy

Chemical composition (%)									
Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr	Al
0.30	0.35	0.10	0.24	1.30	0.14	4.70	0.08	0.07	the rest

Butt joints of AW-7020 alloy sheets made using FSW. Sheet thickness was g = 10mm. The sheets were welded on both sides using identical parameters.

The diagram of friction welding with the commingling of weld material (FSW) is shown in Figure 1 and the parameters are shown in Table 2.

Tab. 2. FSW parameters of 7020 aluminum alloy sheets

Tool dimensions			Angle of tool deflection α [°]	Mandrel's rotary speed V_n [rpm]	Welding speed V_z [mm/min]
D [mm]	d [mm]	h [mm]			
25	10	5.8	88.5	450	180

For the comparison, butt joints were used between sheets with a thickness g = 12 mm, made using the traditional MIG arc welding method. The preparation of welded joints was made in accordance with the procedures required by the shipbuilding industry. AlMg5 (Nertalic AG5 made by SAF) alloy wire was used for the welding. Argon was used as shielding gas with a purity of 99.99. The welding parameters used for joining sheets are shown in Table 3.

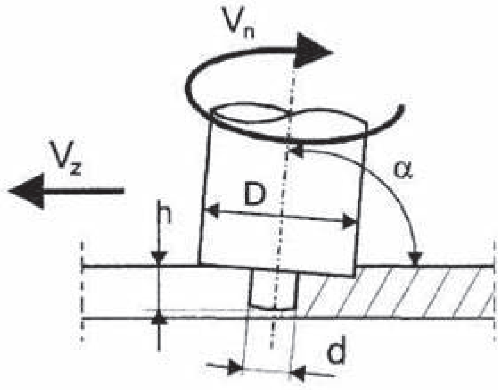

Fig. 1. The diagram of FSW [8]

Welds made using both the FSW and MIG method were checked using X-ray flaw detection and showed no welding defects.

Tab. 3. MIG welding parameters of 7020 aluminum alloy sheets

Diameter of welding wire [mm]	Welding current [A]	Voltage [V]	Number of layers	Argon consumption [m^3/h]
1,6	190 - 230	28	4 + prewelding	16 - 18

The corrosion resistance researches were carried out using three electrode potentiodynamic method. The sample, an auxiliary electrode (polarizing) of titanium and platinum reference electrode (saturated calomel electrode) were placed in a tank with 3.5% water solution NaCl. Active surface samples for the base metal and welded joints by FSW was 1 cm^2 and weld using MIG 0.5 cm^2. Samples attached to copper wires, PVC insulated. Not tested surface is isolated from the corrosive environment. Before the measurements the samples were exposed in the electrolyte to stabilize the corrosion potential. During measuring the electrolyte was continuously mixed using a magnetic stirrer [11]. The samples were degreased before the test.

The polarization was carried out at changes in the potential speed of 12 mV/min in the range of ± 50 mV the stationary potential.

Atlas 0531EU & IA potentiostat was used for studies. Determination of the corrosion process parameters was performed computer programs: AtlasLab 2.0 and Elfit 2.5.

3. The research results

The results of potentiodynamic selected samples carried out in artificial sea water are summarized in Table 4. Average values of electrochemical potentials Ec and corrosion current densities Jc obtained from three measurements for: native material and joints welded by FSW and MIG of 7020 aluminium alloy.

For the experimental points obtained matched the theoretical curves describing the electrochemical electrode processes including the influence of diffusion limitations. Sample Tafel curves for individual samples are shown in Figures 2, 3, 4.

Tab. 3. The corrosion research results of 7020 alloy and their joints

Specimen	Potential Ec [mV]	The standard deviation	Corrosion current density Jc [μA/cm^2]	The standard deviation
Native material	- 960	15.55	13.06	0.68
FSW	- 923	4.24	8.63	1.40
MIG	- 904	3.78	13.21	0.40

4. Summary and conclusions

The analysis of the corrosion current density indicates that this is lower for joints welded by FSW by about 35% relative to the native material. This means better resistance to electrochemical corrosion than the native material AW 7020 alloy. Despite such a large percentage differences in the values of corrosion current densities of their absolute values are at the same low level (a few μA/cm2), which confirms the high corrosion resistance of the tested alloy and its joints. The corrosion current density values obtained for the joints made by MIG are the same as the native material, and the differences between the measurements fall within the standard deviation. This means that the rate of corrosion in the joint should be the same as for the native material.

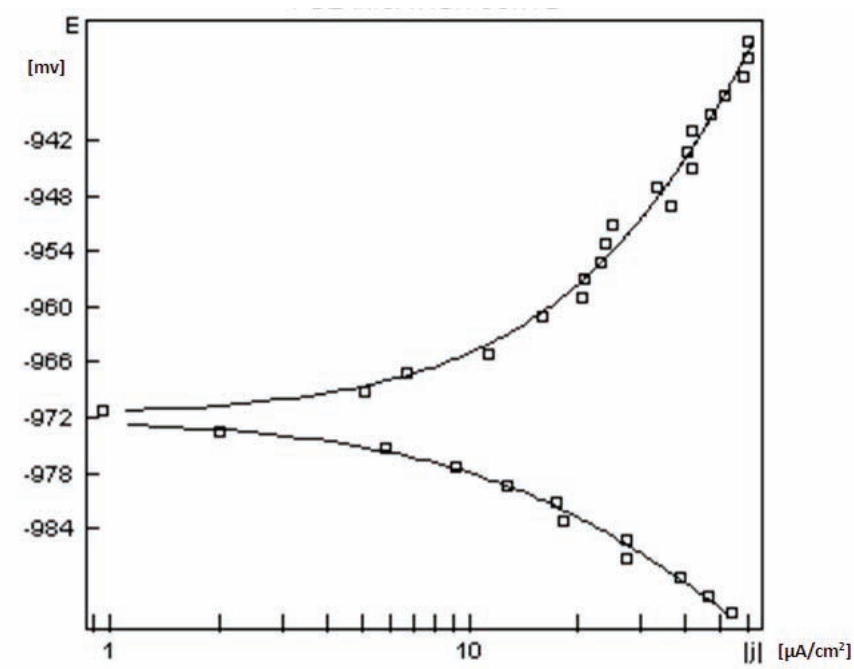

Fig. 2. Polarization curves - the native material

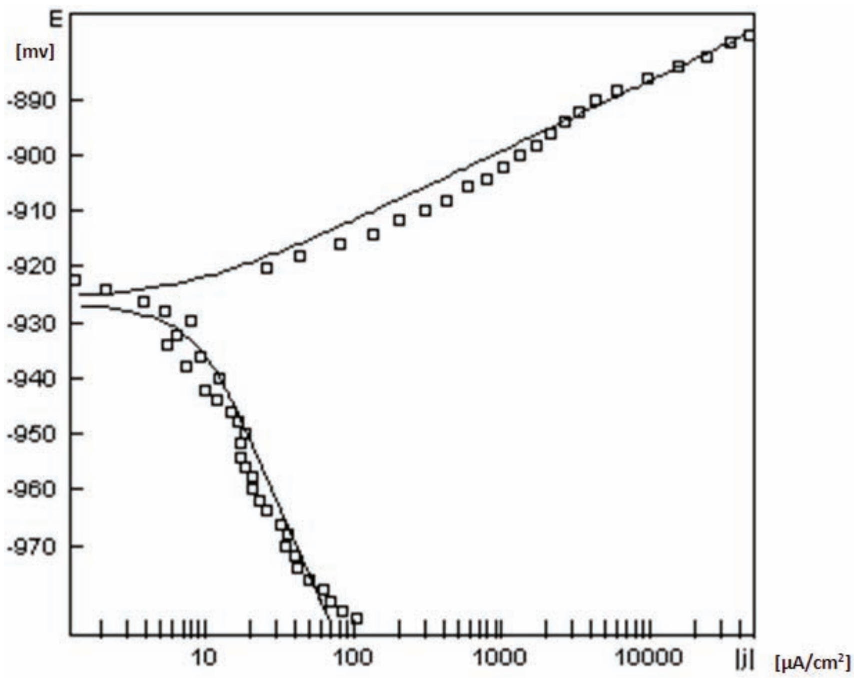

Fig. 3. Polarization curves - the FSW joint

Native material has a lower potential than their joints, both welded by FSW and by the traditional method MIG, and therefore it is the native material will be the anode while the cathode joint will. This means that the weld will not corrode because it will be catholically protected. The difference between the values of stationary potentials is so small that it is not essential for the formation of corrosion cells. On the basis of test results, it can be concluded that the friction stir welded joints (FSW) and MIG welded alloy AW-7020 (AlZn5Mg1) are resistant to electrochemical corrosion in sea water environment.

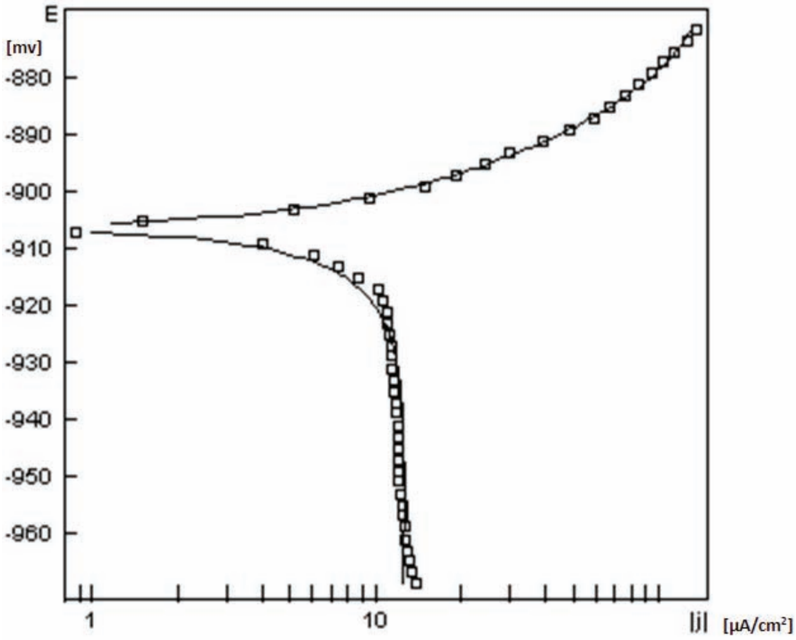

Fig. 4. Polarization curves - the MIG joint

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