MECHANICAL PROPERTIES OF 5083, 5059 AND 7020 ALUMINIUM ALLOYS AND THEIR JOINTS WELDED BY MIG

Krzysztof Dudzik

Gdynia Maritime University, Faculty of Marine Engineering
Morska Street 81-87, 81-225 Gdynia, Poland
tel.:+48 58 690 15 49, fax: +4858 6901399
e-mail: kdudzik@am.gdynia.pl

Abstract

The article presents the research results on the mechanical properties of aluminum alloy 7020 and its MIG welded joints. For comparison alloy 5083 – the most currently used in shipbuilding alloy was chosen as well as 5059 - the new high-strength alloy. Besides the native material alloys there were investigated their joints welded by MIG - the same method as alloy 7020. Welding parameters used for the connection of the sheets made of 7020, 5083 and 5059 alloys were presented. Metallographic analysis showed the correct construction of structural bonded joints.

The arc welding method - MIG is the most common method of joining aluminum alloys used in shipbuilding. It replaces the TIG method of providing equally high quality of joints with a much higher performance. The research was carried out using a static tensile test in accordance with the requirements of the Polish Standard PN-EN 10002:2004. Flat samples cut perpendicular to the direction of rolling were used. The research was conducted at the temperature of + 20ºC.

The 7020 alloy has higher strength properties then alloys: 5083 and 5059. The yield stress is higher by 14.8% compared to 5083 alloy, and by 11.7% compared to the alloy 5059. Plastic properties of an alloy 7020 are the lowest, but with reserves meet the requirements of classification societies. The joints welded by MIG of 7020 alloy have higher strength properties then joints of alloys: 5083 and 5059. Plastic properties of alloy 7020 compared to 5083 alloy are smaller and at the same level as the connector alloy 5059.

Keywords: *welding MIG, aluminum alloys, mechanical properties*

1. Introduction

Aluminum alloys are materials which find worldwide industrial applications, including shipbuilding. Their application to ship hull structures is increasing as the alloys make it possible to lower significantly mass of structures as compared with that of steel structures. By using Al-alloys lowering the mass by about 50 % can be obtained, which makes it possible to increase ship buoyancy, or at maintained buoyancy to increase its load carrying capacity or speed, as well as to improve its stability [3]. For the reasons Al-alloys are used a.o. for construction of ship hull and superstructures. 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. Their relative insuspectibility to layer and stress corrosion is advantageous, and their disadvantage is low strength of welded joints of elements made of them, not exceeding 300 MPa. In order to more intensive craft of weight Al-Zn-Mg alloys (7xxx series) became more interesting. They are characteristic of higher strength properties as compared with those of Al-Mg alloys. Susceptibility to layer and stress corrosion is a disadvantage of Al-Zn-Mg alloys. Multi-year research has revealed that thermal working, chemical composition and welding technology (welding method, kind of added materials and type of joint) are a.o. responsible for stress corrosion susceptibility of the alloys [1-7]. Practically all welded joints made of alloys of this group by means of traditional MIG or TIG methods do not show sufficient resistance to stress or layer corrosion, hence only Al-Mg alloys of 5xxx- series are the only materials applicable to hull structures of light-weight ships. However, the higher strength alloys are used in ship design elements that have no direct contact with sea water, or are secured by suitable paint coatings.

The purpose of this study is to determine the mechanical properties of the alloy AlZn5Mg1 (AW-7020) and its welded joints MIG compared to 5xxx series alloys and their joints made by the same method. As a reference point were chosen alloys: 5083 – the most often currently used in shipbuilding and the new alloy 5059 - with improved strength.

2. The research methodology

The study was aluminum alloy EN AW-7020 T6. For a comparative study was carried out using aluminum alloy EN AW-5083 (AlMg4, 5Mn0, 7) and AW-5059 ALUSTAR (AlMg5Mn0, 7). The chemical composition of alloys are given in Tab. 1

Tab. 1. Chemical composition of 7020, 5083 and 5059 aluminum alloy

Alloy	Chemical composition [%]									
	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Zr	Al
7020	0.30	0.35	0.10	0.24	1.30	0.14	4.70	0.08	0.07	The rest
5083	0.195	0.18	0.09	0.662	4.745	0.111	0.042	0.025	0.037	The rest
5059	0.037	0.09	0.01	0.76	5.41	0.003	0.57	0.024	0.11	The rest

Sheet alloy 7020, 5083 and 5059 with a thickness g = 12 mm were welded by the MIG method. All welds were made in one of the companies producing marine structures of aluminum alloys - Wisla Aluminium International Ltd. shipyard in Gdansk.

Preparation of welds was made in accordance with the procedures required by the shipbuilding industry. Cutting and bevelling the edges (an alloy of 7020 - at the Y, the alloy 5083 and 5059 - on the X) was performed by mechanical processing. 7020 alloy sheet chamfered to Y by an angle of 60º. Plates of alloys 5083 and 5059 chamfered at an angle X 70° with no threshold. The surfaces of the groove and lying in its immediate vicinity, before welding were cleaned of oxides by means of rotating stainless steel brushes and then skimmed petroleum ether. Preparation for welding and weld joints were made in a closed position to protect against weather. To avoid distortion welding joints was performed in an arrangement, and the relief was only after the terminal connector has cooled down. Installation of the joints was carried out using the bonding joints. During the welding of cracked tack welds were cut, because of the possibility of cracks even after careful melting cracked welds. In the case of alloy 7020 welds after the stitches were cut finishes bottom of the weld face, and then put a layer root pass.

For the 7020 alloy welding wire used alloy AlMg5 (5356) - Nertalic AG5 SAF. For the 5083 alloy welding wire used 5383 alloy and 5059 alloy welding wire alloy 5183. Wire electrodes immediately prior to welding was etched. The chemical composition of various alloys used for welding wire is shown in Tab. 2

As the argon shielding gas was used with a purity of 99.99%. Welding parameters of individual plates are presented in Tab. 3

Welds were checked by X-ray flaw detection and showed no defects in welding.

In order to determine the mechanical properties was carried out static tensile test. Tensile test was carried out in accordance with PN-EN 10002:2004 [8]. Used flat samples cut perpendicular to the direction of rolling. The study was performed at ambient temperature, i.e. + 20 ° C ± 2 Tensile testing was carried out on samples with flat-type testing machine EU-40 on the strength of 200 kN ± 1 During the study determined parameters such as ultimate tensile strength UTS, yield stress YS, and elongation EL.

Tab. 2. Chemical composition of welding wire alloys

Alloy of welding wire	Chemical composition [%]							
	Mg	Zn	Cu	Si	Fe	Mn	Ti	Al
5356	5.0	max. 0.10	0.10	max. 0.25	0.40	0.15	0.10	The rest
5383	4.0 - 5.2	0.4	0.4	0.25	0.25	0.8	0.15	The rest
5183	4.86	0.001	0.001	0.04	0.12	0.64	0.006	The rest

Tab. 3. MIG welding parameters of 7020, 5083 and 5059 aluminum alloy sheets

Alloy	Diameter of welding wire [mm]	Welding current [A]	Voltage [V]	Number of layers	Argon consumption [m^3/h]
7020	1.6	190 - 230	28	4 + prewelding	16 - 18
5083	1.6	240-260	28	1 in face of weld side + 1 in back of weld side	18-20
5059	1.2	210	28	1 in face of weld side + 1 in back of weld side	16

3. The research results

The mechanical properties of alloys 7020, 5083 and 5059, and their connections bonded MIG are shown in Tab. 4.

Tab. 4 Mechanical properties of alloys: 7020, 5083, 5059 and their joints welded by MIG

Alloy	Welding method	UTS [MPa]	YS [MPa]	EL [%]
7020	Native material	373	317	14.2
	MIG	315	283	8.2
5083	Native material	346	270	19.7
	MIG	282	206	15.1
5059	Native material	401	280	16.2
	MIG	296	192	7.6

Comparing the mechanical properties of the same alloys with each other can be seen that 7020 alloy has higher strength properties of alloys 5083 and 5059. While the tensile strength of 7020 alloy is higher compared to alloy 5083 by 7.2% and less than the 5059 alloy by 7.5%, its yield stress, a parameter which is a rams into account by the designers, is much greater .This parameter is higher respectively by 14.8% compared to 5083 alloy, and by 11.7% compared to the alloy 5059. When considering plastic properties of an alloy 7020 are the lowest, but with reserves meet the requirements of classification societies, including the PRS. The minimum value of elongation must exceed 10%.

In considering the mechanical properties of the joint made by MIG and of the native material are the best for the 7020 alloy. Both the tensile strength and yield stress achieves the highest values. Only the plastic properties of the alloy as compared to 5083 is nearly twice smaller and at the same level as the connector alloy 5059.

The results are presented graphically in the chart (Fig. 1).

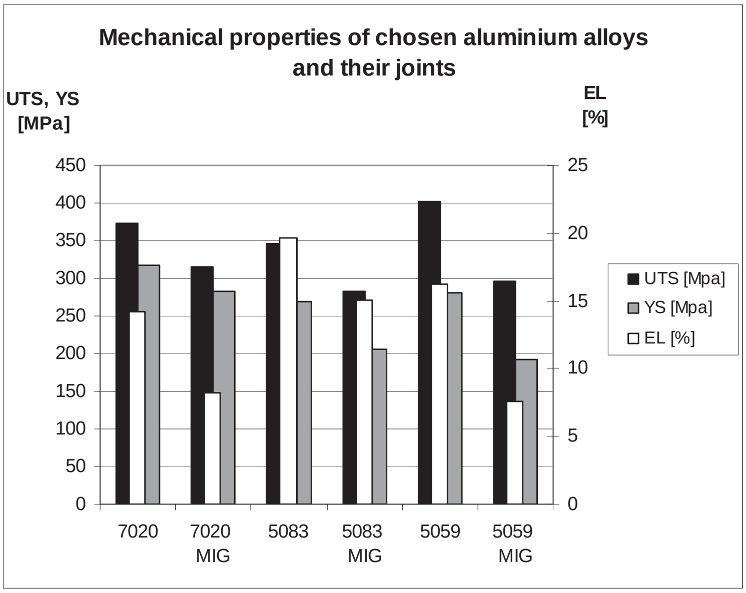

Fig. 1. Graphic interpretation of mechanical properties of compared alloys: 7020, 5083, 5059 and their joints welded by MIG

4. Summary and conclusions

Testing the mechanical properties conducted using a static tensile test on flat specimens of alloys 7020, 5083 and 5059 showed that the alloy 7020 is characterized by the highest strength properties. Plastic properties of the alloy are the lowest, however, sufficient for applications in the shipbuilding industry.

In the case of a MIG welded joints of aluminum alloys selected mechanical properties of the alloy are the highest for the 7020th The plasticity of this connection is, unfortunately, far lower than the alloy 5083rd Elongation A5 reaches a value of 8.2% which is insufficient due to requirements of classification societies. Also, Stop 5059 is characterized by lower ductility than the requirements of the shipbuilding industry. Both the alloy 7020 and 5059 had higher strength properties but low ductility of welded joints can be a big problem. Especially in the case of alloy 7020, which is heat treated to make large amounts of heat causes large structural changes in the heat affected zone. This results in greater susceptibility to the occurrence of cracks in this zone. The use of alloy 7020 in the shipbuilding industry is possible provided the method of finding the bonding, which will improve the plastic properties of bonded joints in comparison to the MIG.

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