12th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2008, Istanbul, Turkey, 26-30 August, 2008

THE EFFECT OF WELDING PARAMETERS ON THE PROPERTIES OF AlMg4.5Mn WELD METAL

Radica Prokic-Cvetkovic
Faculty of Mechanical Engineering,
University of Belgrade
Serbia

Sandra Kastelec Macura
Tehnikum Taurunum Zemun
Serbia

Radomir Jovicic
Faculty of Mechanical Engineering,
University of Belgrade, Serbia

Olivera Popovic
Faculty of Mechanical Engineering,
University of Belgrade, Serbia

Vencislav Grabulov
Military Technical Institute, Serbia

Meri Burzic
Gosha Institute, Serbia

ABSTRACT
In this paper is shown the influence of shielding atmosphere on the quality and appearance of AlMg4.5Mn alloy welded joints. Prepared plates were welded by TIG process in four different gaseous protective atmospheres. It has been shown the effect of type of gaseous protective atmosphere on the weld appearance, depth of penetration, spilling of filler material and weld metal toughness. Weld metals obtained by welding in Ar+50%He+0.015%N_2 protective atmosphere have the best weld appearance, good spilling of filler material and satisfactory width to hight ratio. It is also shown that these welds have the lowest weld metal porosity and the best toughness.
Keywords: AlMg4,5Mn, shielding atmosphere, TIG welding, weld metal

1. INTRODUCTION
The welding of aluminum alloys involves a number of problems, such as the presence of pores and inclusions, the presence of the oxide layer Al_2O_3, and the tendency to hot and cold cracks, as well as gradual softening in HAZ and higher susceptibility to corrosion. [1,2,3]
The forming of pores is one of the greatest problems in the process of welding aluminum and its alloys. Pores develop as a consequence of absorption, diffusion and dissolution of the gases on the surface and in the solidified weld metal. Pores are mostly generated by hydrogen, which dissolves in the liquid metal pool and diffuses through the whole of its volume. Hydrogen has the greatest solubility in pure aluminum. In the process of solidification its solubility abruptly decreases, at which point hydrogen remains trapped in weld metal in the form of pores. [4-7]

2. EXPERIMENTAL RESEARCH
Aluminum alloy AlMg4,5Mn plates were cut, their dimensions 500x250x12 mm, and their edges bevelled by milling. The experimental plates were butt welded, in four types of protective atmosphere, by the TIG process. Wire, also made of AlMg4.5Mn alloy was used as additional material. All the plates were welded in four layers: one root layer + 3 filling layers. All the layers were manufactured by the forward welding technique. The parameters of the welding process, strength of electric current,

voltage, welding speed, and the calculated heat input used in the process are shown in table 1. The flow rate of the protective gas was 17-19 l/min. The heat input was calculated on the basis of the welding parameters according to equation (1) and is given in table 1.

$$Q=(60UI/v)10^{-3} \quad (1)$$

Q – heat input [kJ/cm]
U,I – voltage [V] and current of electric arc[A]
V_z – welding speed [cm/min]

The ambiental temperature during the welding process was 20°C. The interpass temperature was always above 110°C (checked by a contact thermometer). The preheating temperature of all the plates was above 110°C. It is important that only one plate was welded in the shelding atmosphere of pure argon, but without preheating. The weld metal of this plate shown greater porosity than the weld metal of a plate welded under the same conditions but involving preheating. Bearing this fact in mind, the conclusion was reached that preheating is essential, notwithstanding the fact that technical literature recommends preheating in cases of sheets thicker than 14 mm. Neither the welding parameters nor the experiment results of the plate welded in the protective atmosphere of pure argon without preheating are shown in this paper.

Table 1. Welding parameters

Shelding gas	Pass No.	Curent A	Voltage V	V_z, cm/min	Q, kJ/cm	Q_{sr}, kJ/cm	Plate No
Ar	1	220	21,8	15,2	18,9	17-26	4
	2	215	22,1	11	25,9		
	3	215	20,2	15,2	17,1		
	4	220	20,6	11,5	23,6		
Ar+0,015%N_2	1	220	20,2	9,9	26,9	20-26	2
	2	224	20,2	10	27,1		
	3	217	21,2	13,9	19,9		
	4	214	21,3	13,3	20,6		
Ar+15%He+0,015 %N_2	1	232	17,2	11,8	20,3	18-26	1
	2	232	17,1	9,3	25,6		
	3	232	17,2	14,4	16,6		
	4	232	16,8	12,5	18,7		
Ar+50%He+0,015 %N_2	1	234	20,3	17,2	16,6	13-17	5
	2	234	20,2	16,7	17,0		
	3	234	19,5	21	13,0		
	4	234	19,1	20,2	13,3		

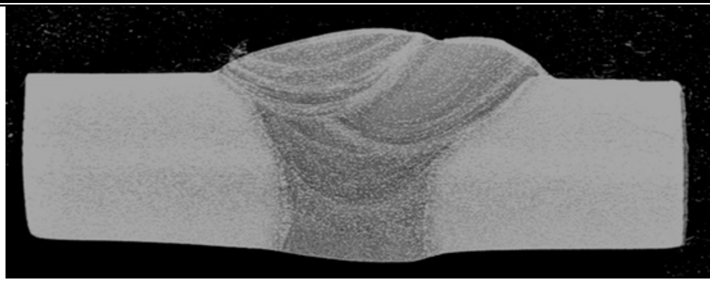
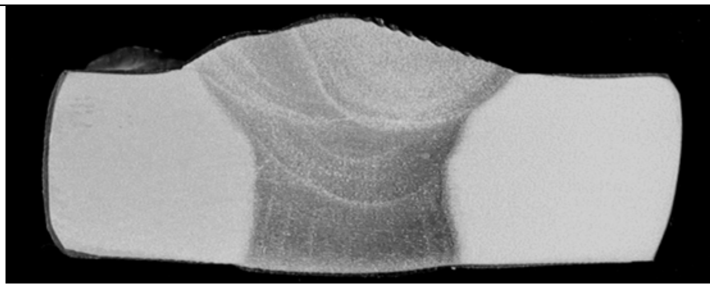
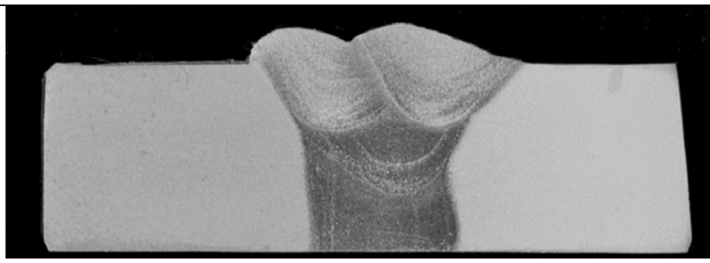
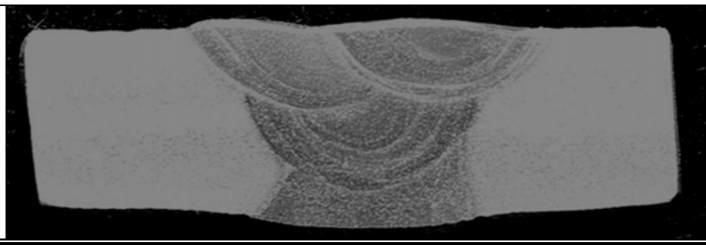
Table 1 clearly shows that during welding in the protective atmosphere of the mixture of gases, the increase of the quantity of helium affects the increase of arc voltage at the same strength of the current. (plates1,5), since helium has a greater ionization potential than argon. The voltage increase directly affects the welding speed increase, which is also shown in Table 1. The amount of heat used during welding was 17-26kJ/cm in all cases except the last (plate 5), where it was 13-17 kJ/cm, which is explained by the increase in welding speed.

3. MACROSTRUCTURAL INVESTIGATION

Specimens for macrostructural investigations were cut from all welded plates, polished and prepared by etching, which is shown in Table 2.

Table 2. shows that during welding in the protective atmosphere of pure argon (plate 4) the weld width is smaller, as well as that the spilling of the filler material is less adequate. By adding nitrogen to pure argon the weld width grows somewhat, and the spilling of the filler material is a little better, since N increases the heat power of the arc (plate 2).

Table 2. Macrophotographs of welded joints

Shelding gas	Plate No	Macrophotographs of welded joints
Ar	4	
Ar+0.015%N_2	2	
Ar+15%He+0.015% N_2	1	
Ar+50%He+0.015% N_2	5	

The addition of 15%He to the protective gas of argon with N results in the weld appearance similar to the weld obtained by welding in the protective atmosphere of pure argon (plate 1), the spilling of the filler material being unsatisfactory. With greater quantities of He in the protective gas, the weld width increases, and the spilling of the filler material is better. The best weld appearance (without undercuts, good spilling, no high reinforcement) is obtained by welding in the Ar+50%He+0.015%N_2 protective atmosphere, which is clearly shown in Table 2 (plate 2).

4. ESTIMATION OF WELD METAL TOUGHNESS

Impact testing is performed at room temperature and at -196°C, according to EN 10045-1, i.e ASTM E23-95, with Charpy specimens, V notched in weld metal on the instrumented machine SCHENCK TREBEL 150 J and results are shown in Table 3. The testing temperature of -196°C was chosen on the basis of empirical data on the exploatation temperature of a plant, that has been made of this alloy. Table 3 clearly shows that the best toughness at room temperature is shown by the weld metal produced by welding in the protective atmosphere of gas containing the highest percentage of helium

(50%). This toughness corresponds to the toughness of the metal plates. In all cases the energy of the crack initiation is lower than the energy of the crack growth.

Table 3. Toughness testing results at room temperature and at -196°C

Shelding gas	Plate No	Specimen No	Room Temperature			-196^0C
			E_u,J	E_{in},J	E_{lom},J	E_u,J
Ar	4	1	32	11	21	7,5
		2	31	11	20	7
		3	31	11	20	7
Ar+0,015%N_2	2	1	25	10	15	6
		2	24	9	15	6,5
		3	24	10	14	6
Ar+15%He+0,015%N_2	1	1	24	10	14	6,5
		2	26	11	15	8,5
		3	24	10	14	6,5
Ar+50%He+0,015%N_2	5	1	36	12	24	8
		2	32	11	21	7
		3	35	11	24	9

As regards weld metal toughness at -196°C, it is similar in all the cases. Since the toughness values involved are small and do not significantly differ from one another, it may be concluded, with certain qualifications, that the best metal toughness is that of plate 5. Also, in this particular case Table 3 shows only the total energy of impact, which, in fact, corresponds to the energy of the crack initiation. As aluminum and its alloys do not have transitional temperature, since they belong to the group of metals with superficially centered cubic resetka, the technical literature does not contain any data relating to the acceptability of these metals as regards their toughness. It was shown during the testing that in these alloys toughness decreases with the decrease of temperature (which is not the case with carbonic steels), therefore this problem area should be dealt with in more detail in the future.

4. CONCLUSION

1. The process of welding of alloy AlMg4,5Mn sheet metal should involve preheating at above 100°C. Preheating decreases weld metal porosity.
2. The addition of nitrogen to argon ensures somewhat better spilling of the filler material, since N increases the heat power of the arc.
3. The increase in the content of helium causes better spilling of the filler material, lower reinforcement and better weld width. The best protective atmosphere proved to be Ar+50%He+0.015%N_2, displaying the smallest tendency towards porosity.
4. The welded joint produced in the Ar+50%He+0.015%N_2 protective atmosphere showed the best combination of hardness, plasticity, and toughness.

5. REFERENCES

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