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THE SOLIDITY OF VESSELS FOR CONTAINING PROPANE-BUTANE OF AlMg4,5

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ABSTRACT
In this work described defined construction solution and technologies producing containers for storage and transport of liquid petroleum propane-butane gas, nominal charging of 10 kg from alloy AlMg4,5. With regard to use of aluminum alloys, results which are experimentally obtained hydraulic tests, are confirming high quality of this technical solutions. Hydraulic tests showed that the bottle meets the requirements concerning the maximum working pressure (16 bar on 50 °C for pure propane) and a test pressure (26 bar) according to the Regulation on technical standards for mobile welded containers for liquid and compressed under the pressure, melted gases.
Keywords: hydraulic tests, solidity, welded wessel, mechanical characteristics

1. INTRODUCTION
From the point of aluminium alloy application, there are two technological solutions. For the first solution we use Al-Mg-Si alloys that are thermally workable. The necessary technical characteristics of a final product are achieved by final thermal processing. For the second technological solution we use Al-Mg alloys that are not thermally workable. The necessary technical characteristics of a final product are achieved by deformational strengthening which occurs during the technological operation of production (deep drawing, extrusion etc.).

2. CONSTRUCTION SOLUTION AND TANK FABRICATION TECHNOLOGY
Construction solution of a welded tank, with its capacity of 10 kg, used for storage and transport of liquefied petroleum gas (propane-butane), made of Al-Mg4,5 alloy is shown on Figure 1. Tank volume (JUS M.Z2.401/94) is 24,70 ℓ, i.e. 2,47 ℓ, of the tank volume per each kg of propane or propane-butane mixture. Tank mass is 7,8 kg. Maximum working pressure of the tank in the extreme situation, when the tank is filled 100% with propane and external temperature 40 ºC is 15 bar. Test pressure of the tank through hydraulic test is 25 bar.
Apart from the typical solution with square butt joint between the halves, there is the construction solution of inserting the lower half into the upper one. Welded joint between the helves is made and approximately corresponds to square butt joint with backing. This joint is easier to perform, especially when it comes to automatic welding process. In that case, the technological operation of narrowing of the lower half has to be performed (Figure 2). Technological scheme of the tank fabrication with square butt joint between the halves is shown on Figure 3.
There are four welded joints on the tank, which are performed in the following sequence: shank and the upper half welding; welding of the sheet metal protection and the upper half; welding of the stand and the lower half and welding of the two halves in order to form the whole of tank. Welding is performed with MIG-procedure. In order to perform the welded joint between the halves we can use pulsed transfer of additional material (MIGp). For the performance of other welded joints we can use Spray Arc i.e. MIGs procedure.

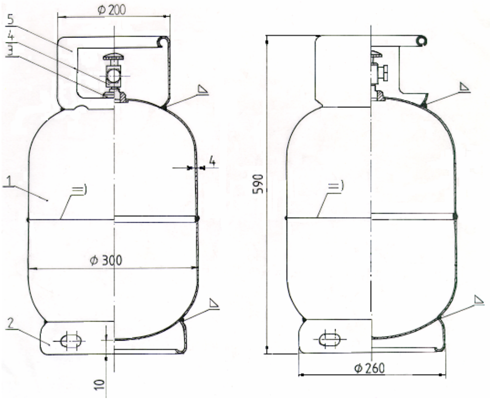

Figure 1. Welded tank (AlMg 4,5 alloy), capacity 10 kg

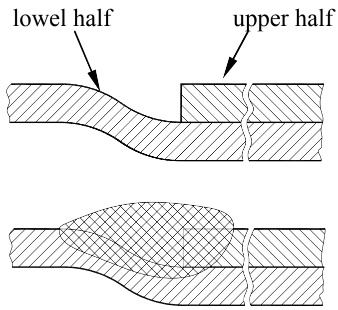

Figure 2. Demonstration of the welded joint between the halves with the lower half narrowed and inserted into the upper one

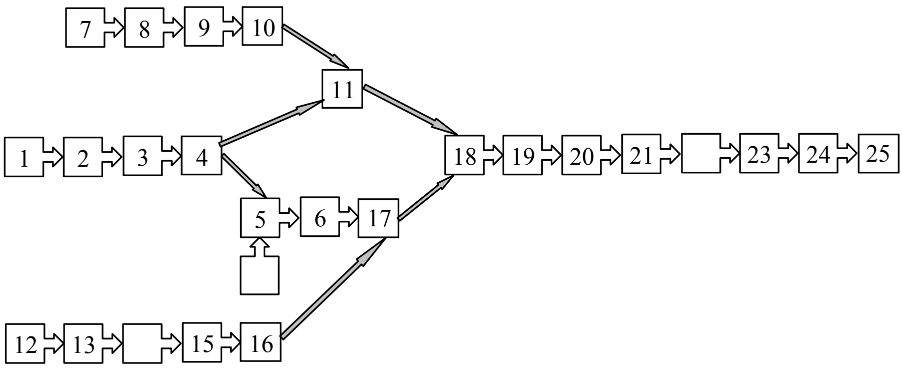

Figure 3. Tank fabrication technological scheme

LEGEND:

1 – Sheet metal cutting
2 – Cutting through the roundel
3 – Deep drawing of the halves
4 – Halves trimming
5 – Making a hole for the shank
6a – Shank preparation
6 – Shank and the upper half welding
7 – Sheet metal cutting
8 – Cutting through the stand (foot)
9 – Bending of the stand (foot)
10 – Final shaping of the stand (foot)
11 – Stand (foot) and the lower half welding
12 – Sheet metal cutting
13 – Cutting through the sheet metal
14 – Extrusion
15 – Bending of the sheet metal
16 – Final shaping of the sheet metal protection
17 – Welding of the sheet metal protection and the upper half
18 – Welding of the two halves
19 – Etching
20 – Neutralisation
21 – Hydraulic testing
22 – Weighing
23 – Vent placing
24 – Air testing
25 – Storage

Additional material is S-AlMg5 with diameter of 1,6 mm (welded joint between the halves) and 1,2 mm (other welded joints). Parameters of the welding regime are given in Table 1.

Table 1. Parameters of welding regime

Parameter	Werd		
	Between halfs	Between the sheet metal and half	Between the stand and half
Diameter wire electrode, mm	Ø1,6	Ø1,2	Ø1,2
Welding current, A	≈ 290	≈ 200	≈ 190
Welding voltage, V	24	25	25
Speed the introduction of wire electrode, m/min	≈ 6	≈ 8,5	≈ 7
Speed Welding, m/min	≈ 1,2	≈ 0,9	≈ 1
Number of passages in the Welding	1	1	1

3. TANK STRENGTH TESTING

Testing pressure is 25 bar. The tank is filled with water and subjected to hydraulic testing with an appropriate pump. Testing pressure lasted for five minutes (minimum one minute according to JUS M.Z2.401/94 standard). Under these testing conditions, the tank did not show any sign of pressure loss, visible deformations, leakage or any other problems.

4. DEFINING THE PRESSURE UNDER WHICH PERMANENT PLASTIC DEFORMATIONS ON THE TANK WILL OCCUR

According to the standard, minimum allowed pressure that can create permanent plastic deformations is 40 bar. The tank was evenly pressure-loaded until the value of 40 bar. Measured deformations are in the field of elastic behaviour of the tank material under the influence of internal hydrostatic pressure.
In order to measure deformation, and at the same time stress notation on the gas tank, we used measuring ribbon 6/120 RY 11 and rosettes 10/120 RY 11, while the compensation of temperature changes was performed with one measuring ribbon 10/120 LY 11 made by Hottinger Baldwin Messtechnik. The measurement results were read on the multipoint measuring device UPM-40 from the same manufacturer.
On Figure 4 we can see that the distribution of the measuring ribbons is such that it can monitor the condition of the base material (rosettes #1, #2, #3) and welded joints material (measuring ribbons 7 and 8; 12 and 13).

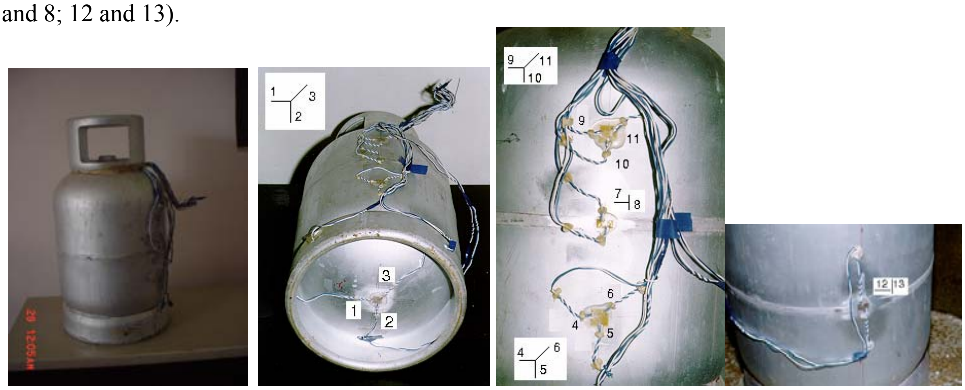

Figure 4. Distribution of the measuring ribbons on the tank

On the basis of measured values of deformations regarding girth (ε_t) and meridian (ε_z) direction [1], we obtained values of stresses in girth and meridian direction (σ_t and σ_z) [2] and [3]. Value of comparative stress (σ_i), is calculated on the basis of calculated stress values σ_t and σ_z [3]. The values of the calculated stresses are shown in Table 2.

Table 2. Naponi dobijenih numeričkim putem, na osnovu izmjerenih deformacija

Measuring place	Stress MPa	Pressure, bar								
		0	10	15	20	25	30	35	40	0
Basic Material rosett #1	σ_{1d}	0	53	69	86	106	125	144	163	0
	σ_{2d}	0	52	67	85	104	122	141	160	0
	σ_i	0	53	68	86	105	123	143	161	0
Basic Material rosett #2	σ_t	0	57	76	94	116	135	158	184	7
	σ_z	0	40	53	67	83	95	111	131	6
	σ_i	0	51	67	84	104	120	141	164	7
Weld MS 7 i 8	σ_t	0	52	68	84	103	120	140	199	48
	σ_z	0	32	42	51	62	73	86	155	**65**
	σ_i	0	45	59	73	89	104	122	181	58

Basic Material rosett #3	σ_t	0	53	71	89	109	127	147	169	4
	σ_z	0	32	42	53	65	74	86	98	2
	σ_i	0	46	62	78	95	111	128	147	3
Weld MS 12 i 13	σ_t	0	32	43	55	69	81	102	162	**54**
	σ_z	0	11	14	18	24	28	34	67	29
	σ_i	0	29	38	48	61	71	90	141	**47**

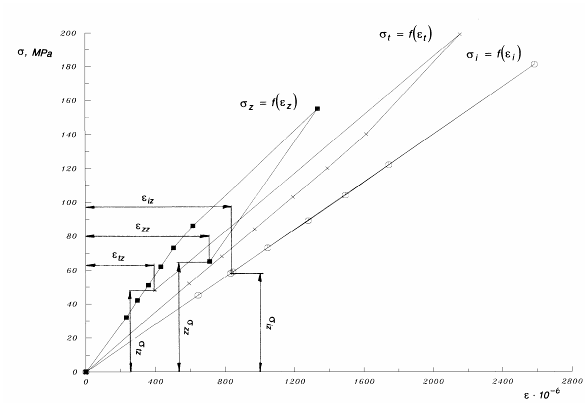

Figure 5. Diagram stress-deformation for measuring spot 7 and 8 (square butt joint of the tank halves)

5. CONCLUSION

From Table 1 and Diagram (Figure 5), show us that after the tank is unloaded we can see occurrence of delayed stresses. This can be perceived on the measuring spots which monitor the behaviour of the tank halves welded joints (measuring spot 7, 8, 12 and 13) the highest stress value in the girth direction (measuring spot 12) is σ_{tz}= 54 MPa, and in the meridian direction (measuring spot 8) is σ_{zz}= 65 MPa. The highest value of the comparative stress (σ_i) is on the measuring spots 7 and 8, and is σ_i = 58 MPa. Testing of the tank with hydrostatic pressure that is ≈ 2,5 times higher than the maximum working pressure (15 bar), showed that the tank has high usage safety.

6. REFERENCES

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