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ANALYSIS OF METALLOGRAPHIC STRUCTURE AND HARDNESS OF ALUMINUM ALLOY 3L59 FROM THE STRUCTURE OF VULCANIZATION EQUIPMENT

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The use of aluminum and special alloys of aluminum in the construction of large installations as is the case of vulcanization equipment, cause a substantial reduction in their weight, while increasing the useful capacity used in the joint process. Metallic structure of vulcanization equipment is made of aluminum alloy 3L59, and after a period of use it was found a deterioration of the quality of joints caused by the modification of the properties of the metallic structure from 3L59. The modification of the properties of the metallic structure is determined by the presence of heat in the vulcanization process and in this regard it has been made an analyze of modifications of metallographic structure and hardness which occur in aluminum alloy 3L59.

Key words: aluminium alloy, metallographic structure, analysis of hardness

INTRODUCTION

Pieces made of aluminum alloys must have a high resistance to corrosion and / or wear and entirely corespond to the functional role in the assembly which they belong [1].

Special properties of aluminum and aluminum alloys (low specific weight, high plasticity, good mechanical properties for alloys, high electrical and thermal conductivity, good corrosion resistance, particularly pleasant appearance of products) determined the construction of installation of joint by vulcanization of conveyor belts.

The use of aluminum and special alloys of aluminum in the construction of large dimensions installations such as installation of joint by vulcanization led to a substantial reduce in weight, while increasing the usable capacity used in the joint processw [2].

Due to the aluminum can be easily manufactured, pieces can be made much faster and in a more accurate way and the thermal conductivity of aluminum positively influences the joint process by vulcanization of conveyor belts, is indicated its use in building the vulcanization installations.

The mechanical characteristics of the main special aluminum alloy, high mechanical resistance, used in the top domains of techniques, vary depending on several factors of which the most important are the chemical composition and structural state, the degree of deformation and the flow direction of the metallic material in the plastic deformation process and heat treatment applied.

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The process of vulcanizing of conveyor belts is the main technology for rawlplugged joints and due to their degree of reliability demonstrated in exploitation, it must be applied in all circumstances where conditions allow. The durability of the joint vulcanized at heat of conveyor belts depends on the adhesion between the joint surfaces. Conditions for obtaining resistance values in the joint portion which is closer to the nominal resistance of conveyor belt itself, refers to how the joint technology is made and to the technological equipment used [3].

The joint of these types of conveyor belts, the individual steel wires, corresponding to the two ends of the conveyor belt, are inserted one in another (by a joint system) into a rubber core and it is vulcanized [4, 5].

In the joining area of the ends of the two conveyor belts is required to obtain a structure as similar to the original conveyor belt. Due to the metal insertion provide mechanical strength of the section which is being formed, layout of the cable in the joint area shows the great importance [6]. Knowledge and respecting the operations, the execution mode of the joint are absolutely necessary conditions to obtain the proper joints for conveyor belts [7].

MATERIALS AND METHODS

For joining the conveyor belts, it is used a machine of DSLQ type, which is a machine that works by electrical heating, triphased. The metal structure of this machine is made largely of aluminum alloy with symbolization 3L59. General scheme of the installation of vulcanization of a conveyor belt is shown in Figure 1.

The aluminum alloy 3L59 in accordance with British Standard with the following features:

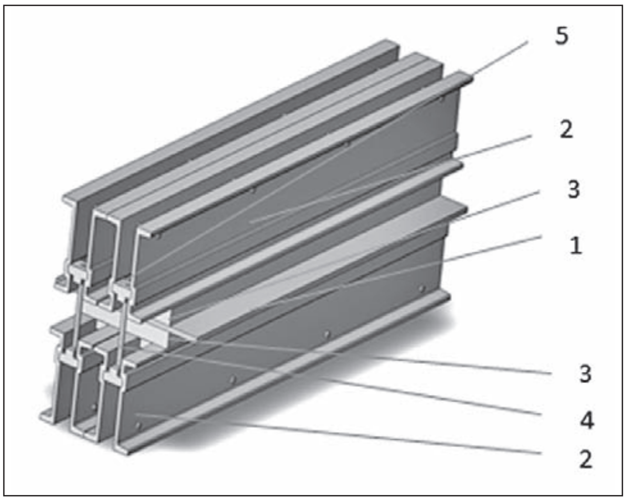


Figure 1 General scheme of joint installation: 1 - conveyor belt; 2 - traverse; 3 - heating plate; 4 - system for fixation of traverse package; 5 - hydraulic pistons for maintain the pressing pressure

- inspection and testing procedure: section 1 and 8 of the British Standard L100;
- quality of the material: materials must be made of aluminum and alloy components, with or without approved additions that remain at the discretion of the manufacturer.
- the chemical composition of the material is shown in Table 1:

Table 1 **The chemical composition of the alloy 3L59 / %**

Chemical element	min.	max.
Copper	-	0,1
Magneziu*	-	0,1
Siliciu	-	0,6
Fier	-	0,7
Mangan	0,8	1,5
Nichel*	-	0,2
Zinc*	-	0,2
Plumb*	-	0,05
Staniu*	-	0,05
Titan şi Zirconiu*	-	0,2
Crom*	-	0,05
Aluminum	-	Residue

* The verifying and the identification of these items need to be done on a small part of the analyzed samples.

Metallurgical processes used to obtain aluminum alloys follow especially finishing the grain size and obtain much improved resistance characteristics compared to common alloys. Development of new alloys mainly aims intensive exploitation of systems likely to suffer modifications in solid, in terms of structural hardening. Technical conditions which must be respected by the material used in the construction of vulcanization installations are:

- the material was supplied as cold lamna elements in partially annealed condition.
- heat treatment - none.

Mechanical characteristics - tensile testing - for the selected pieces, tested and prepared in accordance with British Standard L100 are presented in Table 2:

Table 2 **The mechanical characteristics of aluminum alloy**

Nominal thickness	Tensile strength		Stretching over a length of 50 mm
	min.	max.	min.
mm	N/mm^2	N/mm^2	%
From 0,4 to 0,8 inclusively	160	195	2
Over 0,8 to 1,3 inclusively	160	195	3
Over 1,3	160	195	4

RESULTS AND DISCUSSIONS

Structural analysis of samples taken from the three areas, Figure 2, was performed using metallographic microscope type Omnimet-Buehler.

For the examination of metallographic structure there were considered the following steps:

- cutting operation was performed on automatic cutting machine ISOMET 4000;
- recording and notation of samples that were taken from pieces of aluminum alloys. It should be noted that they were cut without causing them additional heat
- operation of embedding of specimens. It was used the embedded machine with interchangeable resin IPA 40;

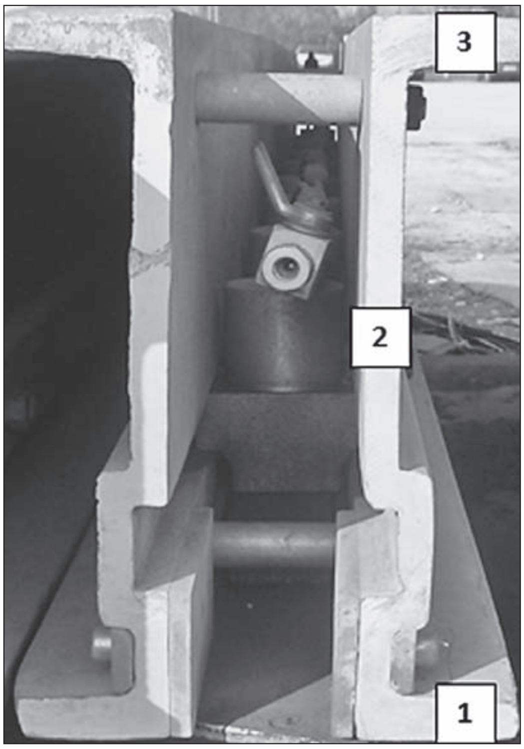
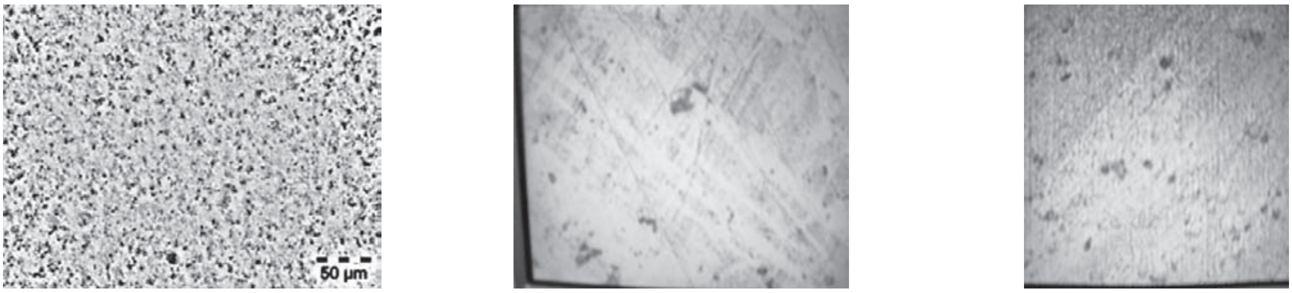


Figure 2 Areas of sampling of samples of material from the traverse of vulcanization installation: 1 - area corresponding to the lower part that is in direct contact with the heating plate, 2 - the center of the traverse, 3 - the upper part of traverse



a b c

Figure 3 Metallographic structure of material of traverse of joint installation, 3L 59: a - for the sampling area 3; b - for the sampling area 2; c - for the sampling area 1; zoom 200 x; attack Nital 2%

- grinding operation was performed on automatic grinding machine Vector;

Operation of chemical attack was performed with reagents 1, 2, 3, whose chemical composition is shown in Table 3:

Table 3 **Reagents chemical composition**

Reactive	Composition	Utilization instructions
1	1 / g NaOH 100 / ml water	- 10 seconds dabbering for general structure making evidence; - 10 - 20 / sec. imersion; - 10 / min. washing in water for film formation that varies with grain orientation;
2	2 / ml HF 3 / ml HCl 5 / ml HNO_3 150 / ml water	- Immersion for 10 - 20 / sec. Washing in current of hot water current. General structure evidentiation; - dillution with Diluarea cu 4 water portions. Constituents colouring.
3	25 / ml HNO_3 75 / ml water	- Immersion for 40 secunde, 70 / ^{0}C temperature. Cold water rinsing.

Analysis of metallographic structure of the material from the three sampling areas of the traverse made of aluminum alloy 3L59 are shown in Figure 3. Choice of the three areas was made considering that the area 1 is in direct contact with the heating plate and so is the most strongly influenced by the heat, and the other two areas are becoming less influenced by heat.

It notes from the metallographic analysis that nonuniform heat of the material from traverse cause spectacular structural modifications in the way that metallographic structure corresponding to sampling area 3 is a structure with uniform grains, and with the emrgence of higher temperatures in the material of structure, namely the sampling area 2, occur series of segregation in material, and metallographic structure of the material is one with unevenness.

Metallographic structure of the material from sampling area 1 (where temperature-has the highest values) is one uneven and segregation occur in material, consisting of material grains of large dimensions.

Presence of metallographic structures both in the sampling area 2, especially in sampling area 1 cause structural heterogeneity of material of traverse which has negative effects on the behavior in exploitation of the joint installation. Metallographic structure modificated very much from sampling area 1 is explained by higher temperature values in the area that is in direct contact with the heating plate from the structure of vulcanization installation.

This structural modification also cause a modification in material properties from these areas, and this causes the traverse to have more improper behavior in exploitation, where is noticeable growing deformations in the center of traverse, which cause after a certain number of uses of the joint installation an accentuation of the defect which appear in the joint area of conveyor belt.

A property that is required to be considered, considering the modifications in metallographic structure, is the hardness of the material and the determination of the causes that determine modifications of hardness. For the achievement of micro-hardness measurements, it was used a microhardness tester type FM 700. All measurements were conducted under the following conditions:

- press force: 50 / gr ≈ 0,4903 / N;
- keeping time of force 15 / seconds;
- loupe for zoom used: 40 x;
- distance between fingerprints: 2,5 / mm.
- numbering the fingerprints start with area 1 of traverse which is in direct contact with the heat source, Figure 4.

After hardness measurements performed, on the entire height of the traverse, by Vickers method were obtained values shown in Table 4.

Table 4 **Hardness values measured / HV**

No.	1	2	3	4	5	6	7	8
Hardness	60,3	59,2	58,7	58,1	57,6	56,2	55,1	54,3
No.	9	10	11	12	13	14	15	16
Hardness	54,1	54,0	53,7	53,1	52,8	52,6	50,7	49,8
No.	17	18	19	20	21	22	23	24
Hardness	49,6	49,3	48,9	48,6	48,4	48,3	48,2	48,1

The average value of hardness of the base material that has not been affected by the temperature, during the joint process, was 48 / HV. Also it was found that the presence of temperature in joining process causes a progressive increase of hardness and hardness difference between measuring points is 12 / HV. This modification of hardness is supported by the appearance of modifications of metallographic structure and also a large in-

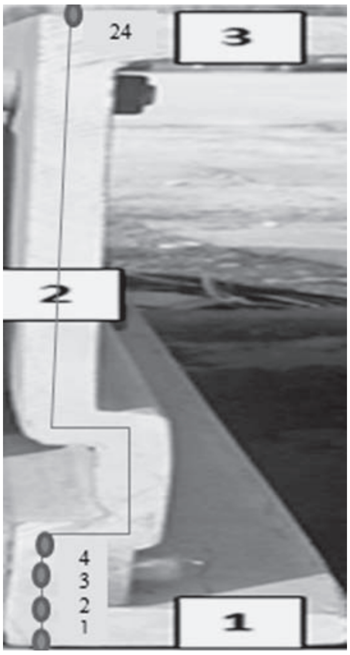


Figure 4 The arrangement of fingerprints for measuring hardness

crease of hardness can cause an increase of susceptibility to cracking of the traverse and and accidentally eject of its use.

CONCLUSIONS

Research on structural modifications in the metallic structure of joint installation made of aluminum alloy 3L59 enabled issuing the following conclusions:

- presence of heat in the joint process, determine structural modifications in the material of traverse and especially in the area where they come into direct contact with the heating plate;
- after long-term use of installation of joint by vulcanization reveals a modification of hardness of aluminum alloy 3L59 meaning as in point 1 of zone 1 are recorded the biggest growth registering a 60,3 / HV hardness, and in point 24 corresponding to zone 3 is recorded a 48,1 / HV hardness;
- structural modifications cause a decrease of the mechanical properties of the material of metallic structure which has the effect of emphasizing the defects that may occur in the joint area;
- to reduce the effects of heat transfer that accompanies the joint process by vulcanization is advisable to adopt a technical solution which enable thermal isolation of the heating plate from the rest of the steel structure of vulcanization installation.

REFRENCES

[1] B. Karpe, A. Nagode, B. Kosec, A. Stoić, M. Dolenec, M. Bizjak, Metalurgija, 52 (2013) 2, 305-308.
[2] B. Chang et al., Journal of Materials Processing Technology 108 (2001) 3, 307-313.
[3] E. Bayraktar et al., Journal of Materials Processing Technology 145 (2004) 1, 27-39.
[4] D. Dobrota, C. Iancu, Metalurgija, 52 (2013) 2, 247-250.
[5] J. Matthias, Polymer Testing, 28 (2009) 8, 901-906.
[6] D. Dobrotă, Journal of Adhesion Science and Technology, 27 (2013) 2, 125-135.
[7] L. Yu-Rong L., Micromolecular rapid communications, 26 (2005) 11, pp. 926-931.

Note: The responsible translator for English language is S.C. PURTRAD S.R.L., Targu Jiu, Romania