EXPERIMENTAL RESEARCHES REGARDING THE PROCESSING OF A 3003 ROLLED ALLOYS

Mariana CIURDAŞ[1], Daniela Alina NECSULESCU[2], Nicolae PANAIT[3], Ruxandra DUMITRESCU[4], Robert STEPHAN[5]

It was done a pertinent analysis of the quality of laminates involves both an analysis of the surface of these products and microstructure studies, is well known that surface morphology and roughness of the rolls in cold rolling may influence the surface morphology, formability and drawing properties of sheet metal. Effect of cold deformation on microstructure and texture evolution during rolling of aluminum and its alloys is a primary concern of specialists in this area because it is one of the main factors responsible for the anisotropy of the final products.

Keywords: aluminum alloy, 3003 alloy, slab, SEM, EDS

1. Introduction

Aluminum alloys are widely used in a variety of applications such as automobile, aircraft and food industry. The final mechanical properties of a product are influenced by all thermo-mechanical steps during manufacturing such as casting, homogenization, annealing, rolling and shaping. To meet requirements placed on the final product, manufacturing steps should be carefully studied and understood. It is not heat treatable and develops strengthening from cold working only. AA 3003 is an alloy with very good corrosion resistance and moderate strength. It is not heat treatable and develops strengthening from cold working only. Commonly is used in chemical equipment, ductwork, and in general sheet metal work. AA 3003 is also used in the manufacture of cooking utensils, pressure vessels, builder's hardware, eyelet stock, ice cube trays, garage doors, awning slats, refrigerator panels, gas lines, gasoline tanks, heat exchangers, drawn and spun parts, and storage tanks. AA 3003 alloy is readily machined and is

[1] Lecturer, Dept of Engineering and Management of Metallic Materials, University POLITEHNICA of Bucharest, Romania, e-mail: ciurdasmariana@yahoo.com
[2] Lecturer, PhD eng. Dept of Engineering and Management of Metallic Materials, University POLITEHNICA of Bucharest, Romania, e-mail: alina.necsulescu@upb.ro
[3] Prof., Dept of Engineering and Management of Metallic Materials, University POLITEHNICA of Bucharest, Romania, e-mail: nipanait@hotmail.com
[4] Lecturer, Faculty of Materials Science and Engineering, University POLITEHNICA of Bucharest, Romania, e-mail: ruxandra.paunescu@upb.ro
[5] PhD eng., Dept of Engineering and Management of Metallic Materials, University POLITEHNICA of Bucharest, Romania

considered as having good machinability for the aluminum alloys. This alloy is readily formed by either conventional cold working or hot working [1,2,3].

2. Experimental procedure

The aim of the present work is to investigate the compounds morphology and their distribution in AA 3003 aluminum as-cast slabs [4,5,6].

In the rolling process, five slabs of 3003 cast alloy were used on Pechiney installation and mixed, with chemical compositions shown in table 1.

Table 1

Chemical composition of AA 3003 cast alloys

Charge	Elements, %									
	Cu	Fe	Si	Mn	Mg	Zn	Ni	Cr	Ti	Na
SL6030369	0.1	0.5	0.23	1.05	0.06	0.005	0.004	0.012	0.016	0.0005
SL6030373	0.09	0.44	0.18	1.15	0.01	0.005	0.004	0.004	0.018	0.0003
SL6020248	0.08	0.56	0.33	1.25	0.012	0.006	0.004	0.004	0.011	0.0003
SL6030374	0.08	0.48	0.21	1.07	0.02	0.004	0.004	0.0025	0.017	0.0003
SL6020247	0.07	0.51	0.25	1.38	0.01	0.006	0.004	0.0035	0.0105	0.0004

Fig. 1 shows the compositions (alloying elements and impurities) of five rolled slabs used in experimental research.

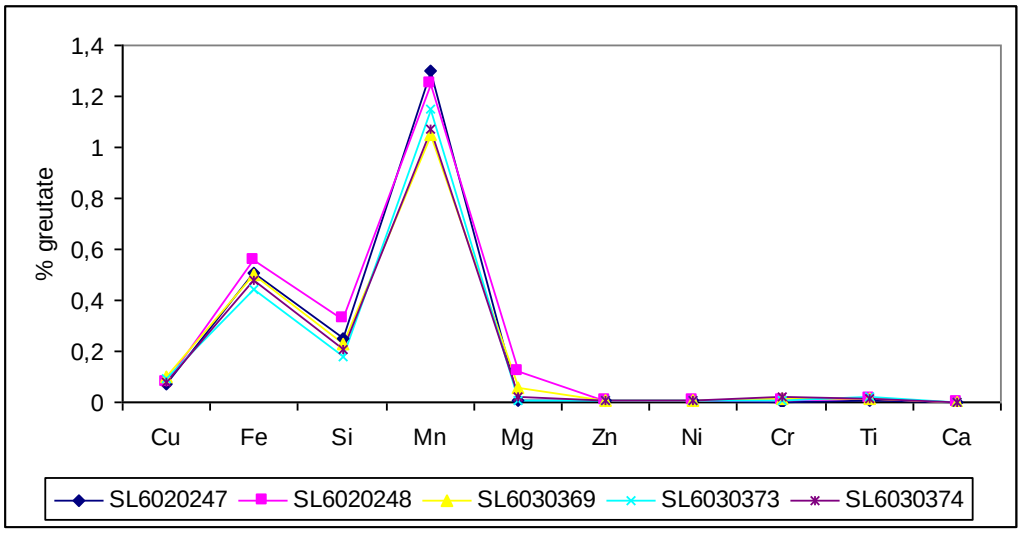


Fig.1. Composition of the alloying elements and impurities of the five cast slabs

2.1 Technique used

Were obtained five slabs by casting:

A. Slab SL6030369, with dimensions 1640x500x6200 mm was laminated and plates were obtained with thickness of 80 mm.
B. Slab SL6030373, with dimensions 1640x500x6200 mm was laminated and plates were obtained with thickness of 80 mm.
C. Slab SL6020248, size 1340x500x6200 was molding and thin plates were obtained with thickness of 5, 3.17 and 1.6 mm.
D. Slab SL6030374, size 1340x500x6200 was molding and thin plates were obtained with thicknesses of 3.17 and 1.6 mm.
E. Slab SL6020247, size 1340x500x6200 was molding and thin plates were obtained with thicknesses of 2.032 and 1.06 mm.

Macro and microstructure of obtained plates were determined by the following methods:

1. Qualitative optical microscopy using an Olympus microscope BX51M
2. Microstructural analysis by scanning electronic microscopy, the FEI Quanta SEM Microcopy Inspect F, field emission and equipped with the energy dispersive analysis system (EDS).

Considering the chemical composition of the alloy studied, were used backscattering electron images in which the light contrast of micro areas contain heavy elements (with large atomic number) and the dark contrast area is occupied with light elements. Areas of interest were analyzed by micro-compositional quality X-ray spectrometry, to identify constituents notice.

Some samples were cut in longitudinal section, defined as the direction of rolling (DL) other by normal section, defined as the normal direction which makes an angle of 90^0 to laminations direction (DN), Fig. 2.

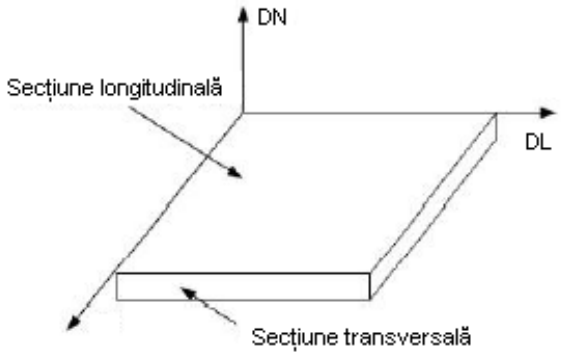


Fig.2. Introducing the two types of sections used for microstructures analysis

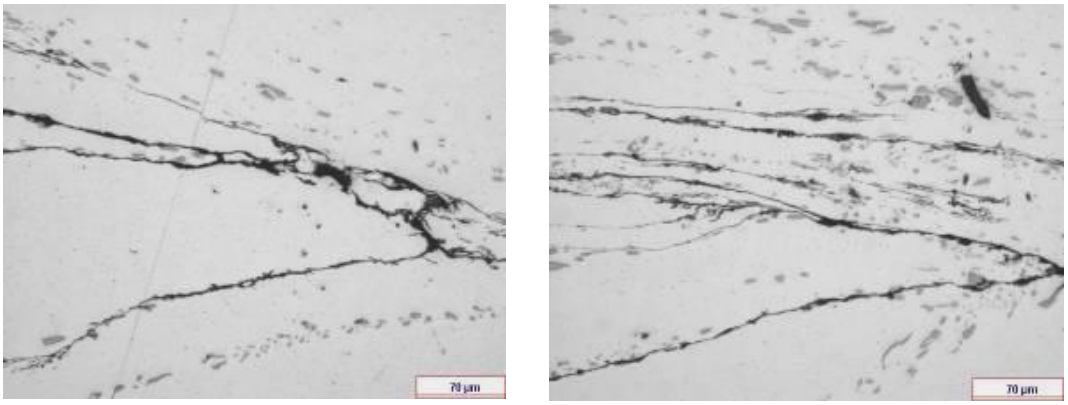
3. Experimental results

3.1. A sample analysis - sheet with thickness of 80 mm derived from SL6030369 charge

During the rolling process plate SL6030369 / 3 1640x500x6200mm format, thickness 80 mm it was broken. The rift was having a width of about 30 cm and a length of about 20 cm.

For micro analysis the samples were prepared near the crack both in longitudinal section and cross section. Other samples were prepared in an area without defect, the same depth as those which were prepared from defect area.

In the samples which were prepared from the nearest crack were found oxide films (Figs. 3.a. and b).



a) b)

Fig.3. Areas near the crack that traces of oxides a – x 250, b- x 200

Samples prepared from an area near the crack had segregation of fine particles and areas with grains of different sizes (Fig. 4). They were also founded different sizes of primary phase $(Mn,Fe)Al_6$ (Fig. 5). Fig. 5 shows a fine microstructure with uniform grains of samples from the area without defect.

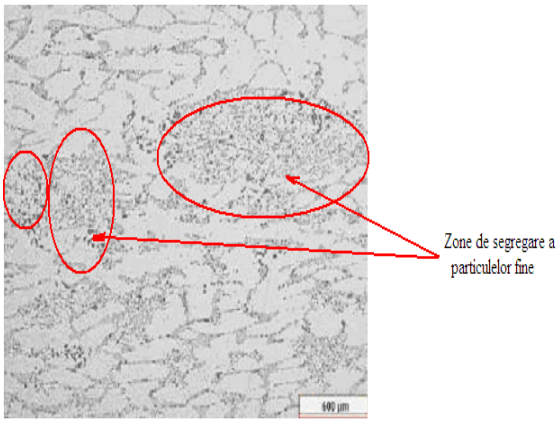


Fig. 4. Zone near to the crack that with segregation , x 25

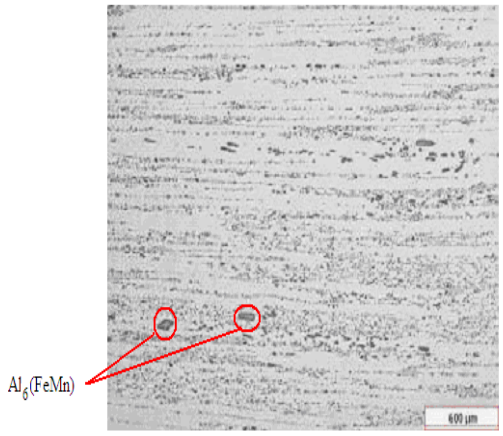


Fig. 5. Primary phases (Mn, Fe) Al_6 , x25

3.2. B sample analysis – from sheet with thickness of 80 mm derived from SL6030373 charge

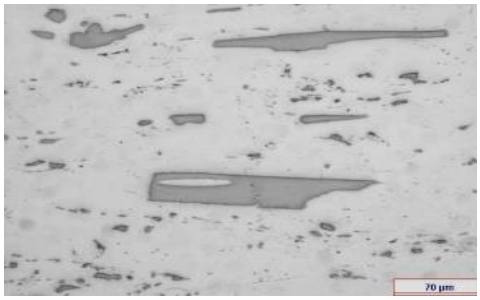
During rolling of SL6030373 slab, thickness of 400mm, all slabs were broken highlighting the discontinuities of hardware. They were continued rolling until the thickness of 80 mm. Cracks have appeared only at ends of first two metal plates, and in the case of the third plate, they appeared all over the plate (Fig. 6 a, b).

For microstructure analysis the samples were cut near the cracked zone, and from a certain distance from the rupture, at the same depth of the surface of lamination. The three samples prepared near the crack put in evidence the presence of segregation. These two different structures appear if these areas are mostly porous.

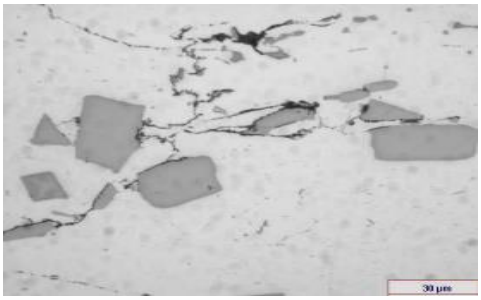
a) b)

Fig. 6. Cracks appeared on the first two laminate

For these plates, chemical composition (Mn+Fe) was 1.85%. In this case, particles larger than 100 μm (Fig. 7), which were demonstrated in samples prepared near the crack, represent a primary particles (Mn, Fe)Al6, which was formed when exist a relatively slow cooling (they can also occur if chemical composition (Mn+Fe) exceed more than 1.85%).



x 200



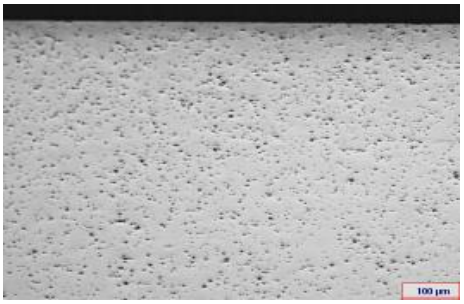
x 500

Fig.7. Primary particles (Mn, Fe)Al6

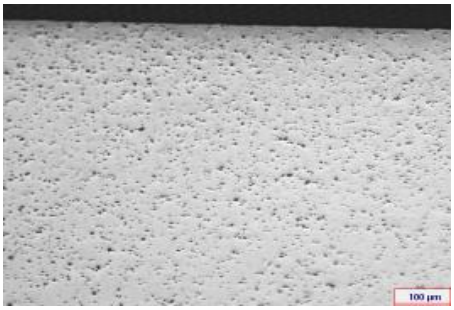
3.3 C sample analysis - thin plates of 5 mm thickness, 3.17 mm and 1.6 mm from SL6020248 charge

SL6020248 slab, with sizes 1340x500x6200 was rolled and there were obtained thin plates with 5mm, 3.17 mm and 1.6 mm thicknesses. All three types of plates obtained had a surface texture corresponding to rolling.

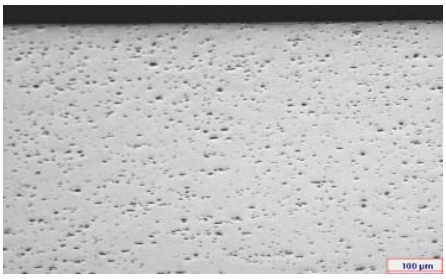
Samples were prepared in longitudinal section, from tables with all three thicknesses. Macro analysis of these plates showed a uniform distribution of phases: $MnAl_6$ and αAlMnSi (Figs. 8 a, b and c).



(a)



(b)



(c)

Fig.8. Rolled sheet with thickness of 5 mm (a) 3.17 mm (b) and 1.6 mm (c) x 100 magnification

Two samples were analyzed in longitudinal sections and a sample from a cross-section. Samples were prepared by grinding, polishing and chemical attack with Keller's reagent. BSE images (Fig. 9) present the general appearance of the microstructure and morphology of brittle compounds, disposed on the direction of deformation. Majority phase is solid solution based on aluminum, consistent with grains elongated in the direction of deformation. Images put in evidence dark contrast particles, located on the direction of deformation; the dark contrast suggests the presence of light metals, probably oxygen, so we suspect that these particles are oxides.

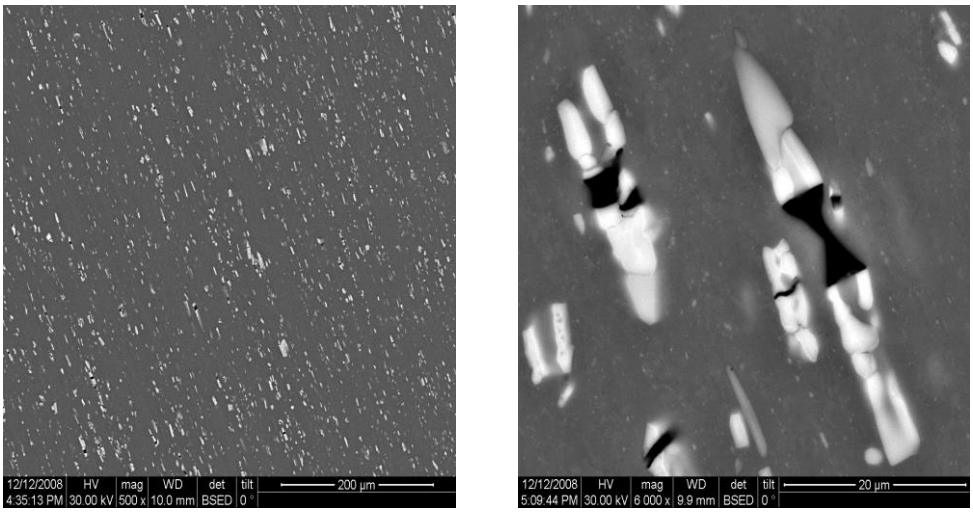


Fig.9. BSE images put in evidence the microstructure and morphology of brittle compounds, disposed on the direction of deformation (x500, x6000) with the presence of dark particle of oxides

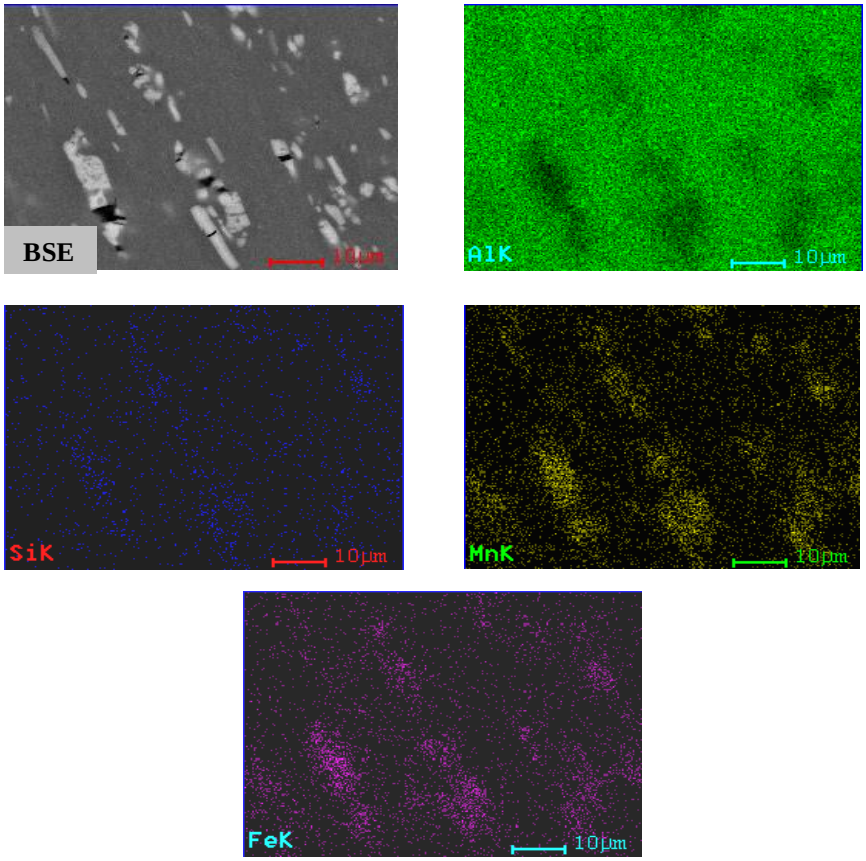


Fig.10. BSE image of distribution in surface of relative intensity X-rays of AlKα, SiKα, MnKα and FeKα on micro zone from Fig. 9

Fig. 11 presents the energy spectrum (EDS) from micro zone and the results of quantitative X-ray microanalysis performed punctually, on the bright contrast compound and the matrix.

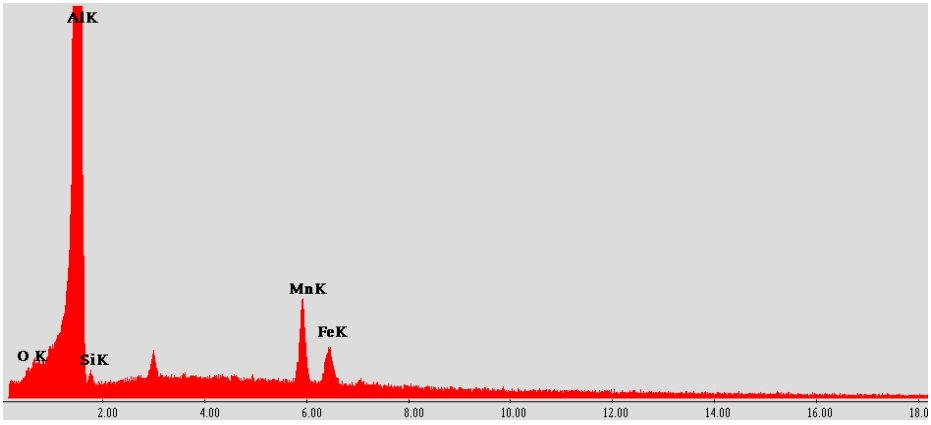


Fig.11. Energy spectrum (EDS) from the micro zone present in Fig. 9

The main homogeneous phase is aluminum solid solution, with grains elongated in the direction of deformation. Intra-granularity bright contrast compounds were observed, brittle, fragmented and arranged in parallel array to the direction of deformation.

In detail we can observe rows of massive rectangular compounds and compounds strongly broken in the deformation direction. Also, we can observe oxide particles (dark contrast) in the solid solution based on Al matrix (Fig.12)

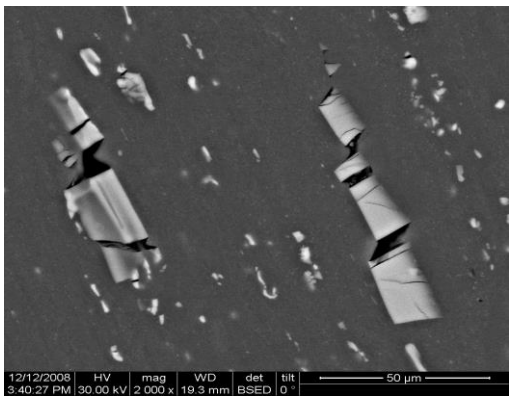


Fig.12. Compounds morphology details (x2000)

4. Conclusions

1. It was analyzed and studied five different composition and dimensions rolled slabs with different thicknesses.
2. Optical, EDS and SEM analysis confirm the presence of high number of primary phase (Mn,Al)Al_6 particles in plates of thickness 80 mm.
3. In the rolling process the studied plate was cracked at different thicknesses. Near to the cracked zone it was observed the segregation of fine primary phases and also zone with large size of particles.
4. The chemical composition and technological parameters of plates (Mn+Fe >1.85 %) influenced the dimensions of primary phase particles.
5. Phases and compounds like: $MnAl_6$ and αAlMnSi were observed at thicker slabs, in longitudinal and cross-section.
6. The surface morphology of cold rolled slabs reveals a uniform distribution of phases and the presence of brittle compounds with elongated grains in the direction of deformation.

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