EXPERIMENTAL STUDIES ON IMPROVING THE MECHANICAL PROPERTIES OF ALUMINUM ALLOYS

Mihaela SMEADĂ*, **Maria STOICĂNESCU****,

*”Henri Coandă”Air Force Academy, Braşov, Romania
**Transilvania, University, Braşov, Romania

Abstract: *Making modern aircraft is intended primarily to achieve a lightweight structure moving at high speeds without involving excessive costs, so the choice of materials used in the construction of an aircraft is an important factor and is justifying studies on two main directions: finding new materials, and also improving the property of the existing ones. The implementation of both thermal and thermomagnetic treatments of age hardening leaded to the achievement of improved characteristics, the results being confirmed by the XRD, SEM, EDS analyses.*

Keywords: *alloy, aluminum, heat treatment, Brinell hardness*

1. INTRODUCTION

The researches made on the establishment of modern aircraft intended primarily to obtain a lightweight structure moving at high speeds without involving excessive costs. In this sense the choice of materials used in the construction of an aircraft is an important factor and is justifying the studies made on two main directions: finding new materials and improvement of the properties of existing ones.

Through the analyses and the investigations made on the alloy we have determined from the macroscopic point of view the values registered by the studied mechanical properties and from the microscopic point of view the chemical compounds, the network parameters and the crystallite dimension.

2. EXPERIMENTAL RESEARCH

The heat treatments applied to the aluminum alloys includes hardening, recovery and annealing as in the case of steels with the exception that after the recovery treatment, the alloys have a high hardness, a phenomenon known as hardening rebound or aging [2,5]. Natural aging takes a lot of time, modifying the mechanical characteristics very little, so it is replaced by the artificial one. Parts and subassemblies used, that are subject to heat treatments can be classified as: parts and assemblies of simple shapes and small dimensions up to 500 mm, and parts of complex shape and large dimensions as fuselage panels, wings, and different components of the wing and of the construction of the landing gear.

From the aluminum alloys used in technique we have studied the influence of heat treatments on the alloys related to $ATSi_6Cu_4Mn$ [6,7]. The chemical composition of the aluminum alloy samples used in the experimental research period was determined in a physical-chemical and mechanical laboratory using a 8020 Quantometru, and the concentrations of alloying elements (Al, Si, Cu, Mn and Fe) were noted for each sample.

Samples were numbered differently depending on the concentrations determined in the laboratory and on the aging treatment applied; the influence of heat treatment hardening and artificial aging is reflecting on the hardness values, the data present in the tables being the average of three measurements.

The samples were heated in an oven at 520°C for 40 minutes, quenched and then naturally aged for 7 days and artificial at a constant temperature of 170 °C for 0,5 h.

The experimental results recorded (table 1) determines the following average values of Brinell hardness: 66,31HB after quenching and 76,82HB after natural aging.

Table 1 Prints and hardness measured, [3]

	Values after quenching		Values after natural aging	
	Print [mm]	[HB]	Print [mm]	[HB]
1	2,14	66	2,13	66,6
2	2,09	69	2,08	70
3	2,20	62,3	2,12	67,3
4	1, 96	79	1,69	108
5	2,30	56,6	2,04	73
6	2,16	65	2	76

From the results obtained is observing greater values for sample 4 (Si 6,078%, Cu 3,260%, Mn 0,580%, Al 89,46%), sample for which the Brinell hardness presents greater values than the average for each set of measurements.

A further set of samples after heating and direct quenching were kept in a warm environment at a constant temperature of 170 ° C for 0.5 h, the measurements made at the end of the period indicating an increase of the hardness as shown in table 2.

The medium values of the recorded hardness for quenched, natural and artificial aging samples were graphically represented depending on the heat treatments applied, and obtained the diagram in figure 1.

Table .2. Prints and hardness, [3]

Sample	Print [mm]	Hardness [HB]
1	2,14	66
2	2,05	72
3	2,16	65
4	1,99	77
5	2,08	70
6	2,20	63

Graphical representation of average values of hardness tests according to the heat treatments performed (measurements after quenching, after quenching and artificial aging for 30 minutes, and after quenching and natural aging) shows that after artificial aging for a short period of time, the value of average hardness differs very little from the value recorded through natural aging.

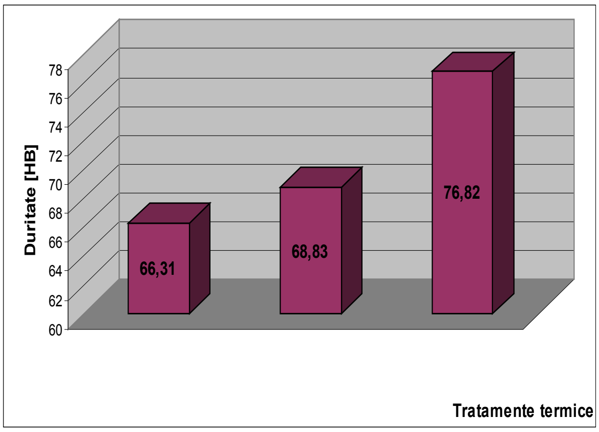

Fig.1. Brinell hardness depending on the heat treatment, [3]

X-ray diffraction performed on samples naturally aged, highlights the elements that have the largest share in the structure (figures 2, 3), compounds that appear and preferred orientation on certain crystallographic directions.

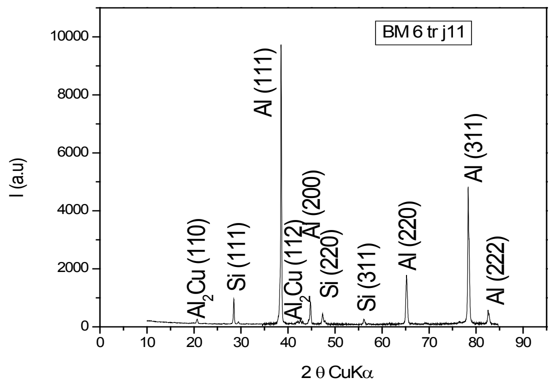

Fig. 2. X-ray diffractogram of the alloy ATSi$_6$Cu$_4$Mn naturally aged (Si 5.995%, Cu 3.249%, Mn 0.494%, Al 89.70%), [3]

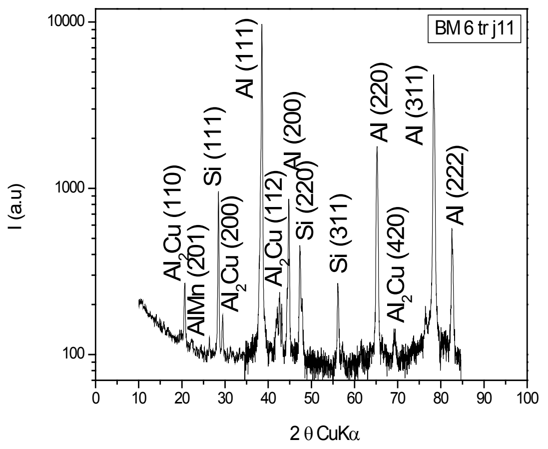

Fig. 3. X-ray diffractogram in logarithmic scale of the alloy $ATSi_6Cu_4Mn$ naturally aged (Si 5.995%, Cu 3.249%, Mn 0.494%, Al 89.70%), [3]

The main features obtained from X-ray diffraction are [1, 3]:

- main phase has cubic structure, space group Fm-3m (225) aluminum (JCPDS 04-0787, network parameter a= 4.0494 Å);
- the main phase diffraction peaks were Miller indexed according to the spatial group;
- network constant calculated is 4.046 Å;
- the Sample appear as textured (preferred orientation on some crystallographic ways) on directions (111) and (311);
- crystallite size calculated by Scherrer formula is 74 nm.

The existence of AlMn compound is highlighted while the diffractogram is done in logarithmic scale (Figure 3).

Following the completion of recorded images with secondary electron detectors on natural aging samples, selected a small area of the sample 6.11 (Si 5.995%, Cu 3.249%, Mn 0.494%, Al 89.70%), the area shown in figure 4. (a and b).

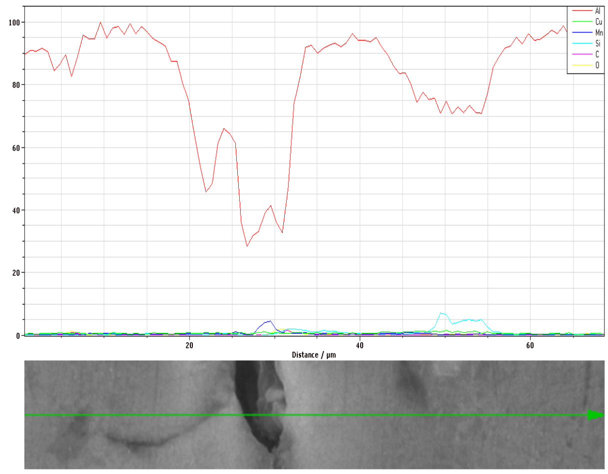

Fig.4.a) Linear scanning, [3,]

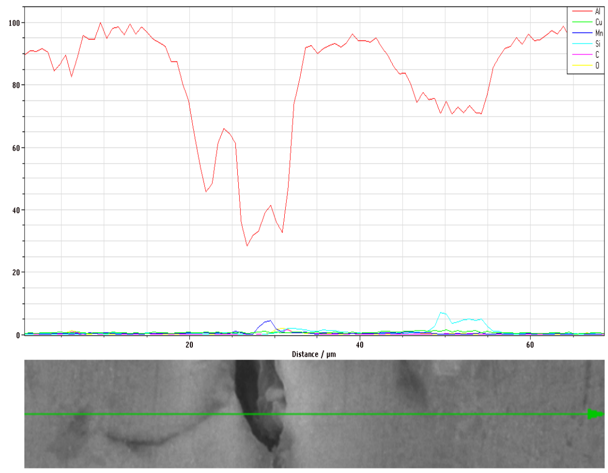

Fig.4.b) Linear scanning, [3]

The analysis of samples naturally aged using the SEM-EDX system, VEGA II LSH TESCAN model, shows that on short distance, in the selected region, the concentration of alloying elements is changing as represented in linear scanning system shown in figure 4. (a and b).

It is observed the presence of a high concentration of aluminum over the analyzed surface and also the decrease in the levels of concentration of aluminum in the darker color area, area in which is increasing the concentration of manganese.

3. CONCLUSIONS

Experimental research allowed the study of the mechanical properties of the alloy $ATSi_6Cu_4Mn$, of the heat treatments applied in improving the performance, the influence of time on the results and also obtaining further information about the resulting microstructures from heat treatments applied.

The aluminum alloy studied, $ATSi_6Cu_4Mn$ type, subject to artificial aging heat treatments on different time periods, presents superior mechanical characteristics, which requires further researches on it.

BIBLIOGRAPHY

1. BENȚA, M., MIHAI, C., PEARSICĂ, M., STRÂMBU, C., VASILACHE, V.,(2011), *Ways of Working the Data Obtaind through Atomic Force Microscopy Tehnology,* Review of the Air Force Academy;

2. GIACOMELLI, I., STOICĂNESCU, M., MOISA, S., NABUTOVSKY, O., (2003), *Modificări structurale în aliajele Al-Si-Cu prin tratamente termice neconvenționale*, Conferința Internațională de Ştiința şi Ingineria Materialelor, BRAMAT 2003, vol. 2

3. SMEADĂ, M., (2011), *Studii şi cercetări privind îmbunătățirea proprietăților fizico-mecanice ale materialelor utilizate în tehnica aerospațială,* teză de doctorat, Universitatea Transilvania din Braşov

4. STOICĂNESCU M., GIACOMELLI, I., (2005), *Mechanical properties of aluminum alloys obtained as a result of unconventional heat treatment,* Conferința Internațională de Ştiința şi Ingineria Materialelor, BRAMAT

5. STOICĂNESCU, M., GIACOMELLI, I., LUCA, M., (2004), *Studii şi cercetări experimentale privind îmbunătățirea performanțelor tratamentelor termice ale aliajelor de aluminiu*, Conferința Internațională ROMAT, Bucureşti,

6. STOICĂNESCU, M., SMEADĂ, M., (2009), *Experimental Research Regarding the Thermal Treatments Applied to Aluminium Alloys That Are Used in the Aviation Technique,* Metalurgia International, Editura Ştiințifică F.M.R., NO.3

7. STOICĂNESCU, M., SMEADĂ, M., GEAMĂN, V., (2009), *Unconventional heat treatmens applied to alluminum alloys used in airforce technique,* Proceedings of the1 st International Conference on Advances in Manufacturing Engineering Quality Production System*s* (MEQAPS 09),volume II, Braşov, , pag. 440-444