Influence of ripening, molding processes and the addition of mg on the evolution of the main mechanical and structural properties of the binary alloy 42000

Ahmed Hakem Youcef Bouafia
a_hakem1951@yahoo.fr

Abstract

Elaboration and mechanical characterization of a material are of paramount importance because the engineer can not calculate or determine the allowable loads of a room without knowing the mechanical properties of the material he intends to use. In addition, he must know from what part load begins to deform irreversibly (limits of elastic) resulting in a change of its geometry (residual elongation) and from which there is a risk of load failure (tensile strength).

The purpose of mechanical testing is to quantity the values of the characteristics that will be used in the calculation of strength of materials in service, prior to use in a given application, must fulfill their proper functioning in various embodiments in order to rationally exploit and avoid, in some cases, disaster leading to severe consequences.

The mechanical properties are closely related to the microstructure. To understand the behavior of materials in use and able to control their properties, it is necessary to describe and quantify their.

The choice of this material was dictated by the fact that it is widely used in various mechanical applications, while the addition of 7% mass. If (0.20 to 0.60)% Mg and its subsequent heat treatment to various industrial processes of sand casting and metal shell were chosen following the significant improvements in certain desired properties which gives it excellent if skills for casting combined with Mg which is the main agent for improving mechanical properties.

Keywords: - Al-Si, tempering, ripening, income, sand, shell.

1 Introduction

This study aims to determine the influence of chemical composition, specific treatments by precipitation hardening and industrial processes of molding sand and shell metal casting by gravity at room temperature as well as mechanical parts manual metal for the various achievements of the SNVI (Aluminium Smelter Unit of Rouiba) and ENEL (Unit Engines Freha in Tizi-Ouzou) Algeria on the evolution of mechanical behavior to fracture, quasistatic uniaxial tensile, hardness Brinell, resilience quasi-dynamic and microstructure of the cast alloy for chemical designation AlSi7Mg and numeric 42000.

The addition of 7% silicon and magnesium percentage ($\leq$ 1% Mg) to aluminum are the primary agents for improvement of mechanical properties in addition to the specific heat treatments which show precipitates of different genres which hinder the movement of dislocations [1 – 8].

2 Material studied

The material used is provided by the SNVI This is the alloy AlSi7Mg par excellence coveted by manufacturers and smelters because of its remarkable characteristics in general, which governs our study, is a shade containing a little magnesium added in small amounts (0.20 to 0.60)% Mg to the alloy to allow hardening and for efficient use in applications with high mechanical properties to the state T46. This alloy contains 7% silicon which gives very good properties for implementation in foundry (average flowability, low volumetric shrinkage during solidification, reduced shrinkage in both the solid and the expansion coefficient.). It is used for complex shapes, requirements for mechanical resistance and maximum thicknesses which are very low ($\sim$ 10 mm).

AlSi7Mg give the safe results , reproducible and consistent, provided that: the chemical composition of the alloy remains in the allowed range, the use of flow is observed in conjunction with the general rules of merger and the heat treatment is performed properly.

- Chemical composition of the alloy EN AC-42000 according to the NF A57 − 702 The composition below corresponds to the tolerances the composition of castings with sand or shell.

Fe%	Si%	Cu%	Zn%	Mg%	Mn%	Ni%	Pb%	Sn%	Ti%
≤ 0,45	6,5 ÷ 7,5	≤ 0,1	≤ 0,1	0,20 ÷ 0,40	≤ 0,5	≤ 0,05	≤ 0,05	≤ 0,05	0,1 ÷ 0,2

  An alloy entering these tolerances composition, suitably prepared and optionally heat-treated test pieces having gives the mechanical characteristics below.

  The ingots supplied by the Aluminium French help ensure the composition easily imposed in piece.

- Composition of ingots AlSi7Mg supplied by the Aluminium French

Fe%	Si%	Cu%	Zn%	Mg%	Mn%	Ni%	Pb%	Sn %	Ti %
≤ 0,35	6,5 ÷ 7,5	≤ 0,1	≤ 0,1	0,25 ÷ 0,40	≤ 0,3	≤ 0,05	≤ 0,05	≤ 0,05	0,10 ÷ 0,20

- Chemical composition of cast test in sand and shell

Elements	Fe	Si	Cu	Mg	Mn
% SNVI	≤ 0,2	6,5 ÷ 7,5	≤ 0,1	0,45÷0,6	≤ 0,1

3 Elaboration of alloy studied

3.1 Casting

The melting of the metal takes place in a gas oven production, to tilting of the front to back, comprising a graphite crucible with a load capacity 350Kg is composed of approximately ≈ 40% in ingots new AlSi7Mg of standard dimensions, composition and specified characteristics., delivered by the French company Pechiney and a mixture of jet casting ≈ 60% return (appendages supply, drainage, control, defective parts and scrap). Once the melt has become liquid full at about 700° C, we proceed to the first scrub and skimming with a ladle and poteye appropriate and removing a first test of immediate spectrometry for chemical analysis. Results of this analysis, the first correction is performed if necessary. The liquid mass is then subjected to a degassing treatment followed by a second cover and slagging in the oven.

Then the metal is poured, or in a pocket of warm-50Kg prepared for this purpose for sand casting and in series or in a holding furnace of 150kg set correctly for the unit mold preheated shell and that we proceed carefully prepared operations of refinements and dcrassages. We make a second test to verify the correction effect. If the analytical results of this second test are consistent, the parts can be cast respectively in the single metal shell or sand molds prepared for it, and the reference specimens are known as cast noting: F. To seek to increase over the characteristics of resistance to state F and obtain substantially large elastic stresses, the stiffness of large modules with small deformations, the material of 42, 000 numerical designation is subject to specific treatments T46.

3.2 Molding

a. **Sand**: This mold has two halves by the footprints in the sand packed model.
b. **Shell**: In this mode of molding, the mold consists of two steel yokes (5% chromium), which is responsible for maintaining the tracks. These caps, separated by a parting line, possibly to be prepared and heated to a temperature (200÷300)° C. After analysis, the samples cast in sand and metal shell by gravitation have the following chemical composition:

Chemical elements	Si	Mg	Fe
% according to analysis	6,75	0,51	0,19

Results of chemical analysis after control samples cast in sand and shell. This alloy is prepared by two different methods: sand casting and shell casting, considering 03 states, crude of casting noted: F, hardened noted: T and aging noted: T46.

4 Experimental procedure

The physical characterization, chemical and mechanical in general especially crucial importance for the design of various metal parts subjected to external forces varied constituents various mechanisms in motion a mechanical component. The designer can therefore neither calculate nor size these parts without identifying and quantifying their characteristics. To determine them, we reproduce these loads using static or dynamic tests, usually performed on standard specimens. Four techniques are used, namely traction to identify the various constraints, the Brinell hardness HB for the stress field, Kcv resilience tells us about the mode of fracture, brittleness and impact resistance and metallography shows the structures.

The specimens are divided into 03 identical batches each consisting of 05 tensile specimens, 05 specimens of resilience and 02 samples for each mode and casting (sand noted: S and shell noted: K). - The 1st batch noted: F - crude of casting, - the 2nd lot is designated: T - hardened condition, - the 3rd batch is rated: T46 - aging. After the heat treatments are performed, the material will be tested in quasi-static uniaxial tensile loads and low speeds, Brinell hardness and resilience of quasi-dynamic to encrypt different characteristics, resistance and ductility, needed for different calculations we need the design engineer at the consulting firm. The microstructure complement the study to fully identify the material. We will describe in more detail and present in the main mechanical characteristics obtained from the chemical composition of material being AlSi7Mg purpose of this study.

5 Results obtained and discussion

The mean values of tensile mechanical properties, toughness and hardness of the alloy AlSi7Mg are those given by averaging five identical specimens for each of the respective cases and are represented in Figures 1 to 3 below.

5.1 Influence of molding processes in the sand and in the shell for alloy AlSi7Mg on the characteristics in

5.1.1 resistances

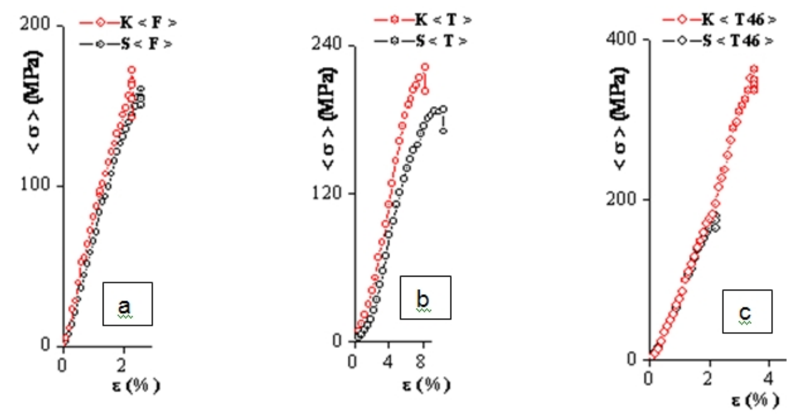

Figure 1: Grouping of the mean curves of comparison (mean stress - deformation) of the AlSi7Mg alloy casted in sand and in shell: a – K < F > / S < F >, b – K < T > / S < T > and c – K < T46 > / S < T46 >.

Discussion It is seen that all curves and all the graphs of the shell casting are above those of the sand casting whatever of the states considered. In addition to the increase in mean values of the characteristics of resistance is the state F to the T state, reaching its maximum value to the state T46 whatever the two modes of elaboration at the expense of ductility; This is probably due on the one hand, the mode for cooling the molds, on the other hand the addition of alloying elements combined with structural hardening treatment by precipitation.

5.1.2 Ductility

Notation $< \sigma^m >$ (MPa) - mean maximum stress (Mega Pascal) ,$< \sigma^e >$ (MPa) - mean elastic stress (Mega Pascal), $< \sigma^r >$ (MPa) - mean breaking stress (Mega Pascal), < HB > - mean hardness Brinell HB, < E > (GPa) - mean Young's modulus (Giga Pascal), < A%> - mean elongation (%), < Z% > - mean coefficient of necking, < Zu% > - mean elongation of necking, F - crude of casting, T - hadened T, T46 вЂ“ aging, S вЂ“ Sand and K вЂ“ shell.

Discussion We see that all curves of sand casting are above those of the shell casting whatever of the states considered. In addition to the increase in mean values of ductility characteristics is the state T46 that of T to reach its maximum value at state F regardless of the two modes of elaboration to the detriment of the characteristics of resistance.

5.2 Influence of hardening on the evolution of mechanical properties of the alloy AlSi7Mg mode casting

5.2.1 Sand noted: S

Discussion The mean curve of the sand casting S < T46 > state is above the other curves that is to say, those S < T > and S < F > states. The means constraints, the < HB

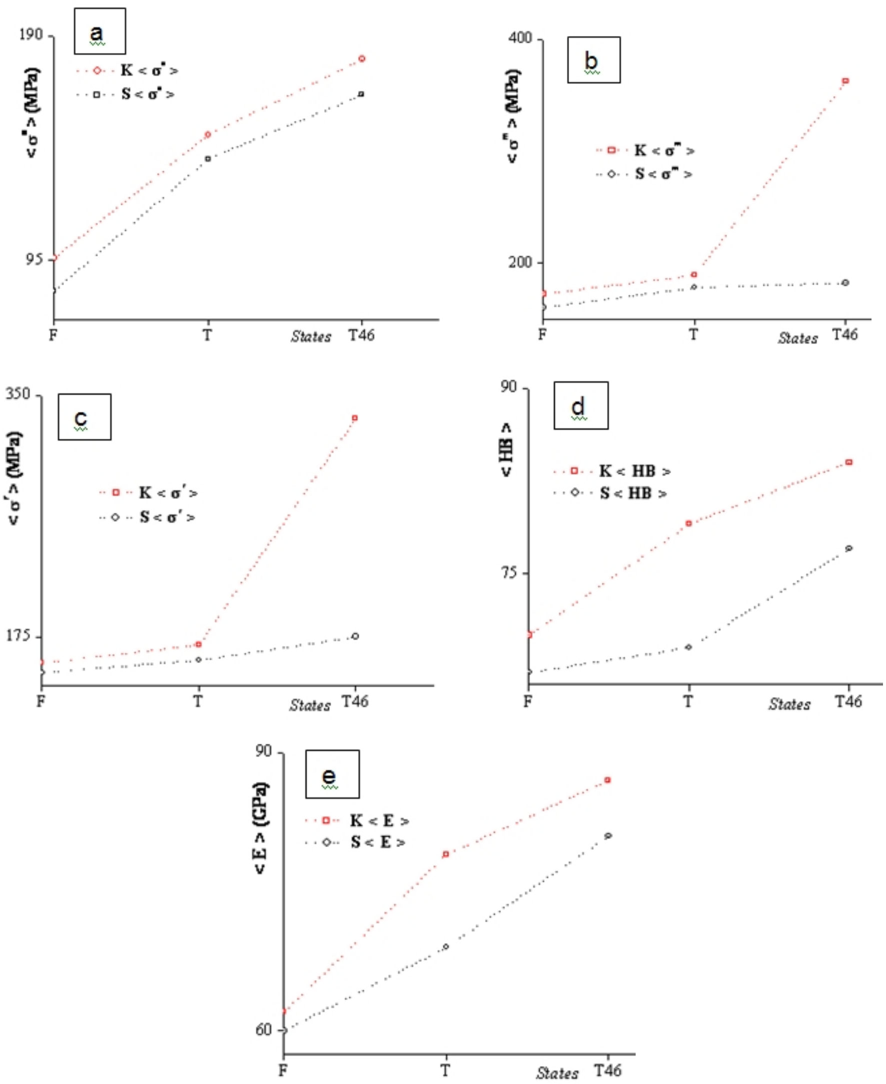

Figure 2: Grouping of the mean Graphs of comparison (mean stress, mean hardness and mean Young's modulus - states)of the AlSi7Mg alloy casted in sand and in shell: a – K $< \sigma^e >$ / S $< \sigma^e >$, b – K$< \sigma^m >$ / S $< \sigma^m >$, c – K $< \sigma^r >$ / S$< \sigma^r >$, d – K < HB > / S < HB >, e – K < E > / S < E >.

> hardness and the YoungвЂ™s modulus increase with an average improvement of the S < F > state to the state S < T > reaching maximum values in the state S <T46 > to the detriment of ductility which decreases for the opposite direction. By against the Poisson's ratios and the consolidation coefficient remains almost invariant for sand casting.

5.2.2 Shell noted: K

Discussion Similarly the mean curve of the shell. casting KT46Moy state is above the other curves that is to say, those KTMoy and KFMoy states; and the mean resistance characteristics increase with an average improvement of the KF state to the state KT reaching maximum values in the state KT46 to the detriment of ductility Characteristics which decreases for the opposite direction. By against the Poisson's ratios and the consolidation coefficient remains almost constant for the shell casting.

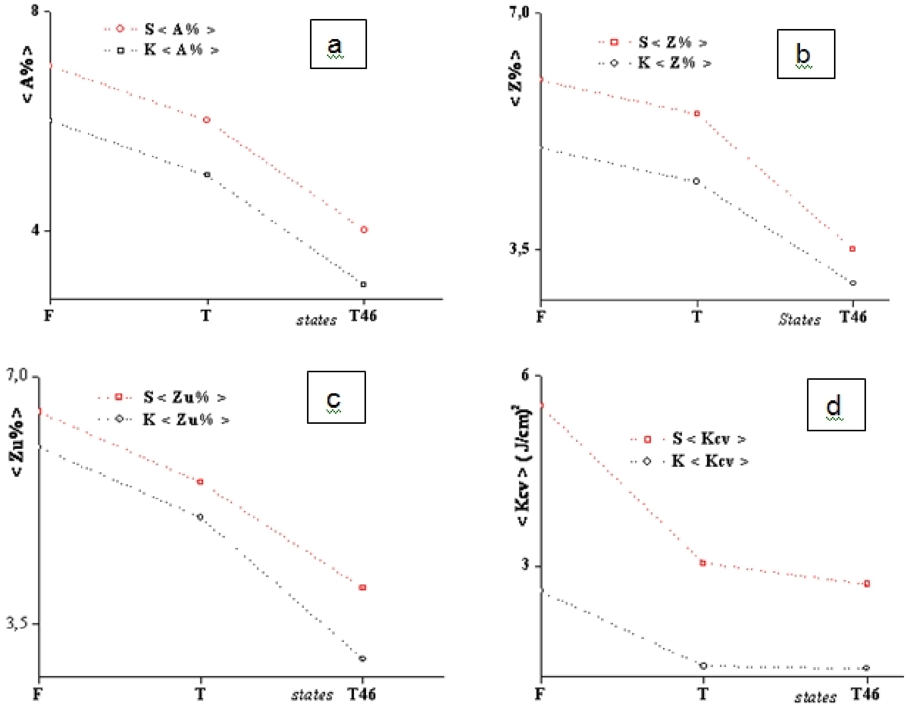

Figure 3: Grouping of the mean Graphs of comparison(elongation, coefficient of necking, elongation of necking and resilience – states) of the AlSi7Mg alloy casted in sand and in shell: a – K < A%> / S < A%>, b – K < Z%> / S < Z% >, c – K < Zu% > / S < Zu% >, d – K < Kcv > / S < Kcv >.

6 Interpretation of results

6.1 Effect of elaboration mode

During casting of metal, heat escapes through the walls of the mold which are the coldest parts of the whole, this is where the solidification begins. The mode of growth of germs and the size of the grains formed depend on the rate of solidification. This solidification time is depending on the type of mold used. In metal molds, solidification occurs much faster than in sand molds, resulting in a finer structure (interdendritic distance, size of intermetallic compounds). The grain size of metal exerts an important action on its mechanical properties. These properties, especially ductility and plasticity, are more pronounced when the grain is small.

During the analysis of microstructures obtained by optical microscopy, we found that the grain size obtained by shell casting are thinner compared to that obtained by sand casting, which explains the results of the characteristics of resistance the **shell casting** metal are significantly improved compared to those figures by the method of sand casting regardless of the conditions considered at the expense of ductility characteristics.

6.2 Effects of treatment made T46

The mechanical behavior of the alloy studied in the crude of casting condition may be due to heterogeneities of concentration (Si), ie non-uniform distribution of the element solute (Si) in the mother matrix. In fact the primary dendrites contain less than (Si) because of the non-uniform cooling during solidification of the material. In addition to these heterogeneities, shape and size of the dendrites have a large influence on the mechanical behavior of materials. The presence of internal defects of metal components and intermetallic inclusions, non-uniform distribution of alloying elements, the shape and size of dendrites make irregular stress distribution by conditioning concentration. This irregular distribution constraints for obstacles to the movement of dislocations and cause a notch effect favoring the failure initiation.

To improve the mechanical properties of the alloy studied in state F, we must impede the movement of dislocations throughout the bulk of the material causing the formation of different kinds of finely dispersed precipitates (Mg_2 Si, Si). For this we subjected to specific treatment T46 alloy which gave a significant improvement in mechanical and structural properties for both modes of molding whatever the conditions considered. Addition of Mg is needed to make the alloy sensitive to this treatment.

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Ahmed Hakem, Laboratory LaMoMS, Mouloud MAMMERI university of Tizi-Ouzou, 15000 Algeria