Scientific
Research

Influence of Thermomecaniques Treatments on the Proprietes of Al-5.8%Zn-2.7%Mg Alloy

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ABSTRACT

The aim of this work is the demonstration of the effect of thermomechanical treatments on the properties of the alloy Al-5.8%Zn-2.7%Mg by thermal analysis techniques and calorimetry, which are methods of test widely used for research purposes and quality control. The effects of thermomechanical treatments on the two variables namely the coefficient of thermal expansion and heat capacity, we can provide further information for better understanding of the phenomena responsible for the thermodynamic behavior of the alloy. The results showed the one hand, there is great similarity between the linear coefficient of thermal expansion and heat capacity, and secondly the effect of plastic deformation is evidenced by changes in the shape of the curves from the rough. Similarly the kinetics of precipitation of η phase is accelerated in the case of samples homogenized and homogenized + distorted and accompanied by a shift in the temperature range to lower temperatures than those recorded in the case of the material state Gross.

1. Introduction

Despite the importance of work in this area, aluminum alloys continue to be the center of interest of several research projects in materials science. Their use in the automotive and aerospace industries depends heavily on their mechanical and thermal characteristics. By using different types of heat treatment and thermomechanical can get a wide spectrum of mechanical properties. For conditions of employment data, the thermomechanical treatment of alloys requires a perfect knowledge of changes in thermodynamic properties it entails.

The continuing development of modern techniques, the complication and expansion of requirements to be met by metal alloys have different properties and qualities that are even today the study of thermomechanical processing is experiencing continued growth. New modes of heat treatment, thermomechanical and thermochemical alloys should be designed to meet the requirements of modern industry. In this work, we propose to study the behavior dilatometry and calorimetry (DSC) of the alloy Al-5.8%Zn-2.7%Mg in different thermomechanical states.

2. Experimental Methods

The alloy Al-5.8%Zn-2.7%Mg was prepared by the con-

ventional method of casting ingots by melting in an induction furnace from Leybold. The fusion is performed in refractory crucibles (Al_2O_3). Its chemical composition is shown in **Table 1**.

The temperatures and durations of heat treatments are shown in **Table 2**.

The analytical techniques used in this regard are the dilatometer and the DCS. It should be noted that all heat treatments were performed in a furnace summers type Adamel or the temperature gradient is about +/− 2˚C.

- The first sample is in the rough cast of [B] (**Figure 1(a)**).
- The second underwent a homogenization annealing [H] at $T = 465$˚C and held for 20 hours, then quenched in water (20˚C) (**Figure 1(b)**).
- The third sample, in addition to the homogenization treatment, the alloy was cold rolled ($E = 20\%$) [H + D] (**Figure 1(c)**).

3. Results and Discussion

3.1. Dilatometric Study of the Sample in the Rough

The **Figure 2** shows the variation of the linear coefficient of thermal expansion α of the alloy Al-5.8%Zn-2.7%Mg in the raw state as a function of temperature in the

Table 1. Chemical composition of the alloy Al-5.8%Zn-2.7%Mg.

Elément	Al	Zn	Mg	Cu	Zr	Fe	Si
%en poids	91.45	5.8	2.7	0.01	0.01	0.01	0.01

Table 2. Temperature and duration of heat treatments.

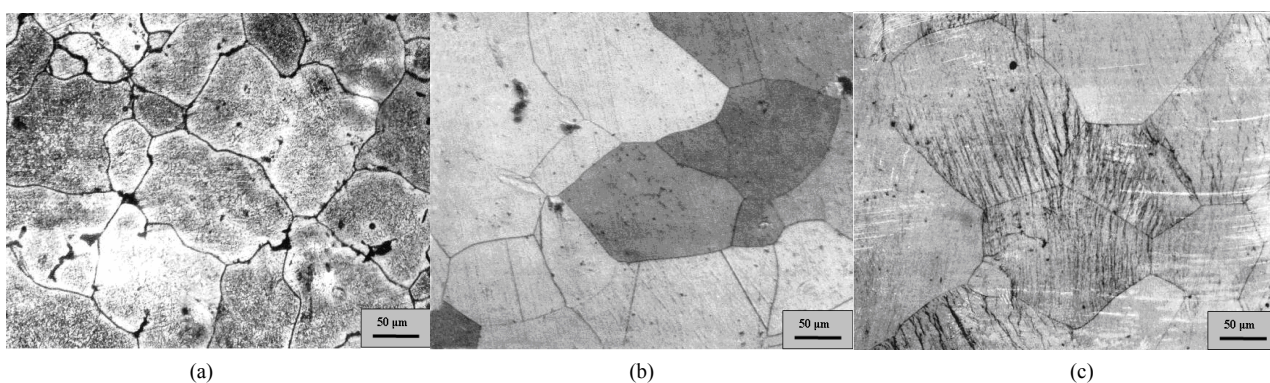| Alliage	Type des traitements thermiques	Température (˚C)	Temps de maintien (h)
	Homogénéisation	465	20
Al-5.8%Zn-2.7%Mg	Trempe	20	
	Revenu	25 - 425	Variable

(a)   (b)   (c)

Figure 1. Microstructure of samples of the alloy Al-5.8%Zn-2.7%Mg: (a) Gross State (B); (b) State Homogenized (H) and (c) Deformed State + Homogenized (H + D).

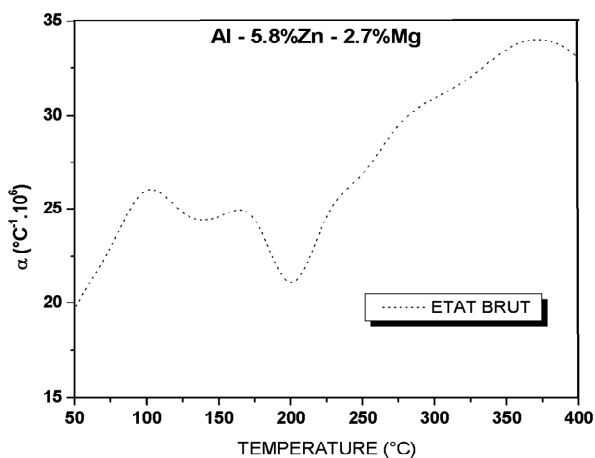| Transformations	Domaine de température ˚C
Expansion	90 - 125
Contraction	175 - 225
Expansion	270 - 300
Expansion	350 - 400

Figure 2. Variation of α as a function of T ˚C of the alloy Al-5.8%Zn-2.7%Mg in the rough.

interval [50˚C - 400˚C]. It is observed that occurs four (04) transformations corresponding to different temperature ranges and is characterized by the peaks.

3.2. Calorimetric Study of the Sample in the Rough

The **Figure 3** shows the change in the DSC curve of the alloy Al-5.8%Zn-2.7%Mg in the raw state as a function of temperature and in the interval [50˚C - 400˚C].

It is observed that occurs three (03) transformations corresponding to peaks:

One might think at first approach as the first three transformations, there is a similarity between the results found by both experimental techniques. There is a gap of about twenty degrees C for there to be a perfect overlap of the results found by the techniques of dilatometry and calorimetry. The work of Deschamps *et al.* [1] and Benabdoun [2] suggest that this discrepancy is certainly due to poor calibration of the DSC. By cons for the fourth processing corresponding to the third expansion observed in the temperature range 350˚C - 400˚C, we find no confirmation by a peak in this temperature range.

- The first peak, endothermic, is the first expansion observed on the dilatometric curves and can be attributed to the dissolution of Guinier and Preston zones
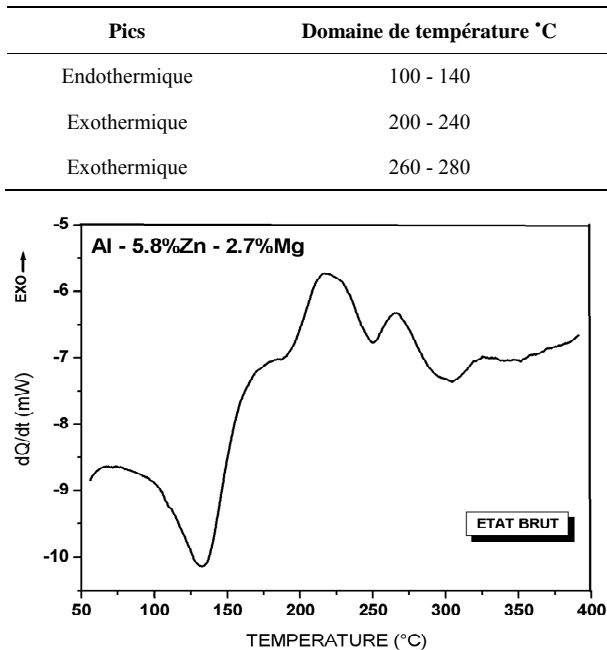
         MSA

Pics	Domaine de température ˙C
Endothermique	100 - 140
Exothermique	200 - 240
Exothermique	260 - 280

Figure 3. Variation of the DCS as a function of *T* ˙C of the alloy Al-5.8%Zn-2.7%Mg in the rough.

[3-7].

- The second peak, exothermic, one corresponding to the contraction during the heating of the alloy in question, in the field [50˚C - 400˚C], is probably due to the appearance of the metastable phase η' quoted by Mondolfo *et al.* [8].

- The third exothermic peak recorded on the DSC curve during heating of the alloy, corresponds perfectly to the second expansion observed by dilatometry. This is certainly related to the formation of the stable phase η (MgZn) [9-11].

3.3. Influence of Thermomechanical Treatments on the Expansion Curves Heat of the Alloy Al-5.8%Zn-2.7%Mg

The **Figure 4** shows the variation of the linear coefficient of thermal expansion α of the alloy Al-5.8%Zn-2.7%Mg as a function of temperature in the interval [50˚C - 400˚C] for the three structural states studied (Gross, homogenized and Homogenized + Garbled).

It also notes that there is a slight shift in the temperature ranges corresponding to these phase transformations. The latter depend on the history of the material before income and this confirms the work of Deschamps [5] and Benabdoun [6].

3.4. Influence of Thermomechanical Treatments on the DSC Curves Alloy Al-5.8%Zn-2.7%Mg

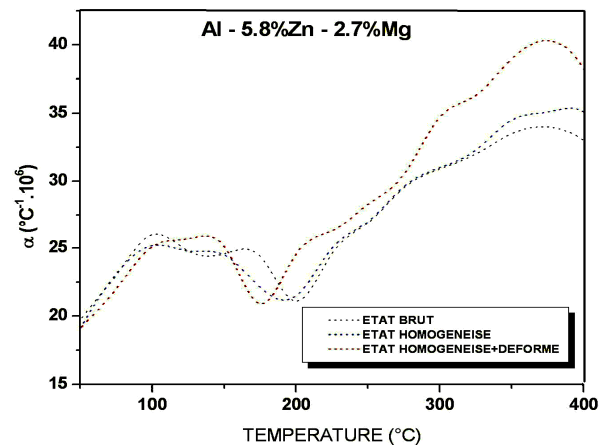Examination of the DSC thermograms (**Figure 5**) con-

Figure 4. Variation of *α* as a function of *T* ˙C of the alloy Al-5.8%Zn-2.7%Mg for the three structural states.
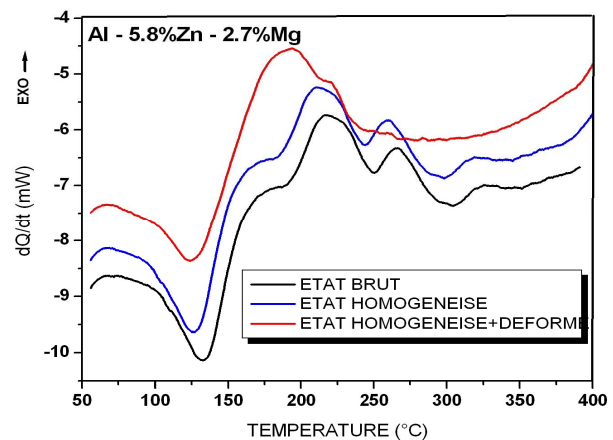

Figure 5. Variation of the DCS as a function of *T* ˙C of the Al-5.8%Zn-2.7%Mg alloy for the three structural states.

firms, quite clearly, the existence of at least three (03) of these changes occurred during the tempering, the appearance of three different peaks, while giving us additional information on their intensity and nature of precipitation or dissolution. It is found that these treatments have no significant effect on the dissolution of GP zones (endothermic peak corresponding to the first expansion) and the precipitation of equilibrium phase η (MgZn) corresponding to the second exothermic peak corresponding to the second expansion recorded dilatometric curves. For cons, the effects of heat treatment and homogenization in particular those associated with plastic deformation are visible by a shift to higher temperatures low precipitation of the metastable phase η'. This is mainly due to defects introduced during plastic deformation that significantly enhance decomposition of the supersaturated solid solution. The increase in the number of gaps facilitates the diffusion of atoms of magnesium and zinc, and the high density of dislocations stimulates diffusion along the channels of dislocations. Thus the activation energy of

the reaction of precipitation of deformed samples is much lower than that of samples with little or no distortion. Therefore the process of germination and growth of new phases are favored.

On the other hand, the plastic deformation introduced a supersaturated solid solution already containing an excess of defects due to the rapid quenching, further increasing their density, and therefore encourages a greater degree than the different phase transformations may occur during heating of the material. This explains why the phenomena related to the dissolution of the zones, and precipitation of two phases η' and η occur earlier, at lower temperatures than for the case of the raw material and/homogenized or that generally observed in various aluminum alloys 7000 series.

4. Conclusions

The great diversity of phases present in alloys Al-Zn-Mg makes this system very complex. They are likely to improve physical properties by hardening or otherwise alter significantly.

- Both technical analysis of thermodynamic properties namely dilatometry and calorimetry may give us additional information on the nature and sequence of the various phenomena of precipitation or dissolution of phases present during the tempering of the alloy studied in the temperature range [50°C - 400°C].
- There is a great similarity between the curves of thermal expansion and calorimetric study of the alloy.
- The first three transformations observed by the dilatometer technique namely the first two expansions and the only contraction are directly related to the appearance of different peaks recorded on the DSC curves.
- The first expansion is directly related to one endothermic peak appears on the DSC curves, it is certainly due to the dissolution of GP zones.
- The only contraction experienced by the material during tempering is represented by the first exothermic peak, the latter is due to the appearance of the metastable phase η'.
- The second expansion corresponding to the second exothermic peak may be due to the appearance of the stable phase η (MgZn).
- The effects of heat treatment and homogenization in particular those associated with plastic deformation are highlighted by a shift toward lower temperatures of the precipitation of metastable phase η'.

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