v. 3, n. 23, 2023

Journal of
Engineering
Research

CHARACTERIZATION OF A-319 ALUMINUM THROUGH THE ADDITION OF MASTER ALLOY AL-MG-CE APPLYING MECHANICAL AGITATION

J. S. Luna Alvarez
Faculty of Engineering, Autonomous University of Coahuila, Edificio D Unidad-Campo Redondo, Saltillo, Coahuila, Mexico.

J. A. Villarreal Sanchez
Faculty of Engineering, Autonomous University of Coahuila, Edificio D Unidad-Campo Redondo, Saltillo, Coahuila, Mexico.

G. D .Olvera Romero
Faculty of Engineering, Autonomous University of Coahuila, Edificio D Unidad-Campo Redondo, Saltillo, Coahuila, Mexico.

F. Garcia Vazquez
Faculty of Engineering, Autonomous University of Coahuila, Edificio D Unidad-Campo Redondo, Saltillo, Coahuila, Mexico.

A. Flores
Cinvestav Unidad Saltillo, Carretera Saltillo-Monterrey Km. 13.5;

Abstract: The influence of cerium (Ce) on the as-cast microstructure and mechanical properties of the A-319 alloy were investigated. The A-319 experimental alloys were prepared. The aluminum,magnesium, cerium master alloy was added into the molten bath The cerium content increased 0 to 0.12 wt.% after 15 min of treatment. To obtain kinetic information and metallographic, samples were analyzed by using Scanning Electron Microscope (SEM) respectively. Dross samples were taken and analyzed by X-ray diffraction (XRD) for the qualitative identification of the crystalline compounds. The tensile properties, including ultimate tensile strength, yield strength. Elongation and creep properties of the as-cast experimental alloys were established. This result indicate that the incorporation of Ce to the A-319 alloy cause change in the morphology and distribution of the phase. Nevertheless, the grain size tended to be effectively refined. Furthermore, adding 0.12 wt.% Ce to the A-319 alloy improves the tensile properties at room temperature.
Keywords: Al-Ce-Mg master alloy; Modification; Mechanical properties.

INTRODUCTION

Al-Si alloys are mainly used in automotive and aerospace industries. The demands on the mechanical properties require a strict control on the additions of refinements and modificants in the melt bath.[1] The wide variety of alloys that are produced has led to the manufacture master alloys which are of great importance in the industry of aluminum smelting. [2] The use of rare earth has been the led the attention of researchers because aluminum alloys with rare earths such as cerium change the morphology of the eutectic silicon in Al-Si alloys resulting in better physical and mechanical properties. [3] This study proposes to addition master alloys Al-Mg-Ce based on the reduction of CeO_2 powder for subsequent conversion to Ce by aluminothermic reduction using scrap aluminum (beverage cans) and magnesium. [4]

EXPERIMENTAL PROCEDURE

The experiments were carried out using an *inductotherm* brand 70 kW *PowerTrack 75-30* electromagnetic induction oven in a silicon carbide crucible with a capacity for 10 kg of liquid aluminium. In the furnace, 500 grams of a-319 aluminum was melted, later the generated slag was removed, followed by the addition of 500 grams of master alloy Al-Mg-Ce this alloy containing 3.40% cerium and 2.5% magnesium. Immediately, mechanical agitation was given for 15 minutes and immediately samples were taken for chemical and metallographic analysis and tensile test.

Throughout the experiments, the following conditions were kept constant:

- amount of aluminium A-319: 5,000 g.
- Added amount of master alloy: 500 g.
- Stirring rate: 80 rpm
- Treatment time: 15 min.
- Temperature 750°C

CHARACTERISATION

The Ce and Mg contents in the aluminium alloy were analyzed chemically by means of atomic absorption spectroscopy and spark emission spectroscopy, respectively. Phases were identified by X-ray diffraction (XRD).

The samples were also analyzed in a SEM using energy dispersive spectroscopy (EDS).

RESULTS AND DISCUSSION

CHEMICAL ANALYSES

Figure 1 shows the results of the chemical analysis of samples obtained by means of metallothermic reduction, with the Al-Mg-Ce master alloy.The figure demonstrates the incorporation of Ce was of 0.12 %e.p and temperature of the liquid bath was 750°C. The treatment time was 15 minutes.

X-RAY DIFFRACTION

Figure 2 represents a PDRX obtained from the Al-Mg-Ce alloy used as an addition to an A-319 aluminum alloy. The peaks recorded in the PDRX identify the main compounds. Al_3Ce and Al, the presence of the oxides MgO and $MgAl_2O_4$ is not registered.

SCANNING ELECTRON MICROSCOPY (SEM)

Figure 4 shows the morphology of the intermetallic Al_3Ce precipitated in the samples with high cerium content, and it is observed that the intermetallic presents a two-dimensional planar growth in the form of needles of considerable thickness, in a A-319 aluminum.

MODIFICATION DEGREE OF EUTECTIC SILICON IN AN A-319 ALLOY BY ADDING AL-MG-CE MASTER ALLOY

Figure 5. Shows a comparison of the samples before the treatment and after the modification treatment, the conditions were as follows: temperature 750°C, stirring time 15 minutes. In the micrographs obtained, the morphology of the eutectic silicon can be observed. Before starting the treatment, the silicon presented a needle morphology, and once the Al-Mg-Ce alloy was incorporated, it shows a eutectic silicon structure in an acicular shape, presenting degree 3 of modification, being a typical structure in Al-Mg-Ce alloys. If modified, which provide good mechanical properties.

TENSILE TEST, A-319 ALLOY ADDING AL-MG-CE MASTER ALLOY

The values obtained in the tensile tests carried out on the unmodified A-319 alloy and on the same already modified A-319 alloy are shown , With the master alloy Al-Mg-Ce, the results obtained for the unmodified A-319 alloy were: Maximum stress 145 Mpa with a hardness of 52HB and for the modified A-319 alloy were: Maximum stress 199 Mpa with a hardness of 74 HB.

For this study, an increase of 37% was achieved with respect to the maximum stress of aluminum A-319 and with respect to hardness it was 42% with respect to the original sample, this being significant since this aluminum is used for manufacturing of engine heads and monoblocks in the automotive industry.

CONCLUSIONS

- The cerium content in the Aluminium A-.319 was increased to 0.12 wt% after 15 min o treatment.
- Change in the morphology and distribution of the phase, the grain size tended to be effectively refined.
- The tensile properties and hardness were satisfactory.
- The parameters of temperature and amount of aluminum and master alloy were satisfactory.

Elements	Al	Fe	Cu	Mn	Si	Mg	Zn	Ti	Ce
Alloy A-319	87.93	0.52	3.30	0.30	7.32	0.28	0.25	0.10	0
Modified Alloy	87.62	0.53	3.31	0.32	7.28	0.47	0.25	0.10	0.12

Figure 1. Chemical analysis of aluminium A-319 and modified aluminium.

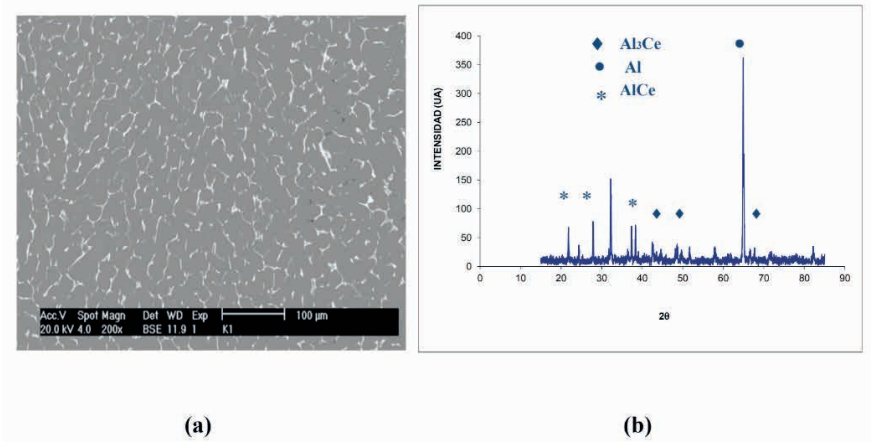

Figure 3. (a) Micrograph of the Al-Mg-Ce master alloy analyzed by X-ray diffraction. (b) X-ray diffraction pattern of the Al-Mg-Ce alloy.

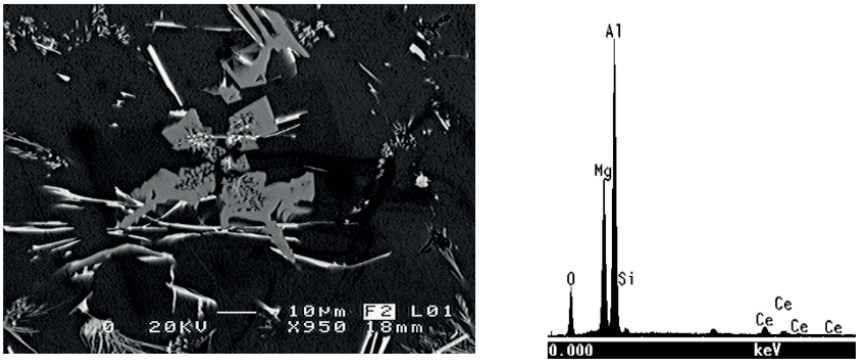

Figure 4. The microstructures of the alloys were observed by (SEM) analysis, the cerium content in the A-319 Alloy was increased to 0.12 wt% after 10 min of treatment. The cerium content benefits the morphology of the eutectic silicon in Al-Si alloys. [5]

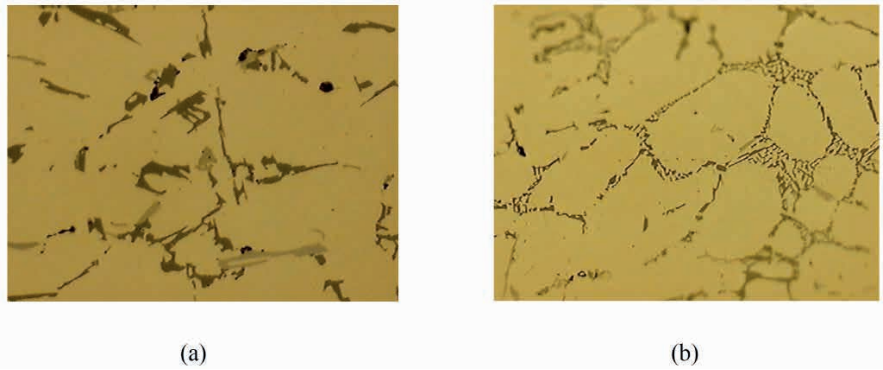

Figure 5. Shows the micrographs (a) before the modification test 500X (b) after the modification test, 500X.

REFERENCES

[1].- LUNA J. FLORES A, MUÑIZ R, FUENTES A, TORRES J, RODRIGUEZ N, ORTIZ J, OROZCO P. Cerium extraction by metallothermic reduction using cerium oxide powder injection [J]. Journal of Rare Earths, 2011, 29 (1): 74-79.

[2].- YANG M B, HOU M D, ZHANG J, PAN F S. Effects of Ce, Y and Gd additions on as-cast microstructure and mechanical properties of Mg-3Sn-2Sr magnesium alloy [J]. Transactions of Nonferrous Metals Society of china, 2014, 24: 2497-2506.

[3].- DUAN R, BAI P, YANG J, ZHANG W, DING H. Influence of Rare Earth Modification and Homogenization on the Microstructure and Mechanical Properties of Recycled Can 3004 Aluminum [J]. The Journal of Wuhan University of Technology-Materials Sciense, 2014, 29(2): 264-268.

[4].- ESCOBEDO J, HERNANDEZ J, FLORES A. Estudio Cinético de la Eliminación de Mg en las Aleaciones de Aluminio Mediante la Inyección de Polvos de Sílice [J]. Revista de Metalurgia (Madrid), 2003, 9:171-182.

[5].- FLORES A, MARTINEZ C, ESCOBEDO J, TOSCANO J.A Kinetic of Demagging of Molten Aluminium by the Use of SiO2 Submerged Powder Injection [C]. Light Metals, 1999. Aluminum Committee at the 128th Tms Annual Meeting.