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The Effect of Rare Earth Elements Holmium, Gadolinium and Zinc on Microstructure of Aluminium LM30 Alloy

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Abstract

This study explores the practical applications of aluminum alloys in various manufacturing sectors, focusing specifically on the advantages of incorporating rare earth elements to enhance corrosion resistance and improve the microstructure of these alloys.

1. Introduction

Aluminum, a lightweight, versatile metal, has become a cornerstone in various industries due to its unique properties and wide range of applications [1]. Its usage spans from everyday household items to critical components in high-tech industries. Aluminum is prized for its low density, high strength-to-weight ratio, excellent corrosion resistance, and ease of fabrication [2]. It can be alloyed with other elements to enhance its properties, making it suitable for specific applications [3]. Aluminum alloys are often chosen for their ability to be recycled without losing quality, contributing to environmental sustainability efforts.

In the automotive sector, aluminum has gained significant traction due to its contribution to vehicle lightweighting [4]. Reducing the weight of vehicles is crucial for improving fuel efficiency and reducing greenhouse gas emissions. Aluminum alloys are used to manufacture engine components, wheels, and body parts [5]. For example, the 2015 Ford F-150 used an aluminum body, which resulted in a weight reduction of 700 pounds compared to its steel predecessor. This weight reduction not only enhances fuel economy but also improves vehicle handling and performance.

2. Methodology

The primary material used for manufacturing the sample is aluminum LM30 alloy, with its chemical composition expressed in weight percent (wt.%). The LM30 alloy is melted in a crucible furnace, and holmium (Ho), gadolinium (Gd), and zinc (Zn) additives are introduced at a temperature of approximately 730°C. During the melting process, the mixture is stirred to ensure homogeneity of the composition. The molten alloys are then poured into preheated steel molds. Table 1 below displays the chemical composition of the aluminum LM30 used in this study. Microstructural analysis of the as-cast samples was conducted to determine the modification effects of the Ho, Gd, and Zn additions. The samples for microstructural analysis were ground and polished before being inspected under an optical microscope at various magnifications to observe changes in the compounds with and without the addition of the REE.

Element	Cu	Si	Mg	Fe	Mn	Ni	Zn	Pb	Sn	Ti
Percentage, %	4.0-5.0	16.0-18.0	0.4-0.7	1.1	0.3	0.1	0.2	0.1	0.1	0.2

Fig. 1 *The Chemical composition of LM30 Aluminium Alloy*

The samples will be categorize as below:

Table 1:*Sample Categorization*

Sample	Ho(wt%)	Gd(wt%)	Zn(wt%)
A	0	0	0
B	0.1	0.4	0.1
C	0.4	0.1	0.8
D	0.1	0.4	0.8
E	0.4	0.1	0.1

3. Results

The results that will be presented and discussed includes the Optical Microscope observations, observations obtained from SEM/EDM coupling, and the XRD data.

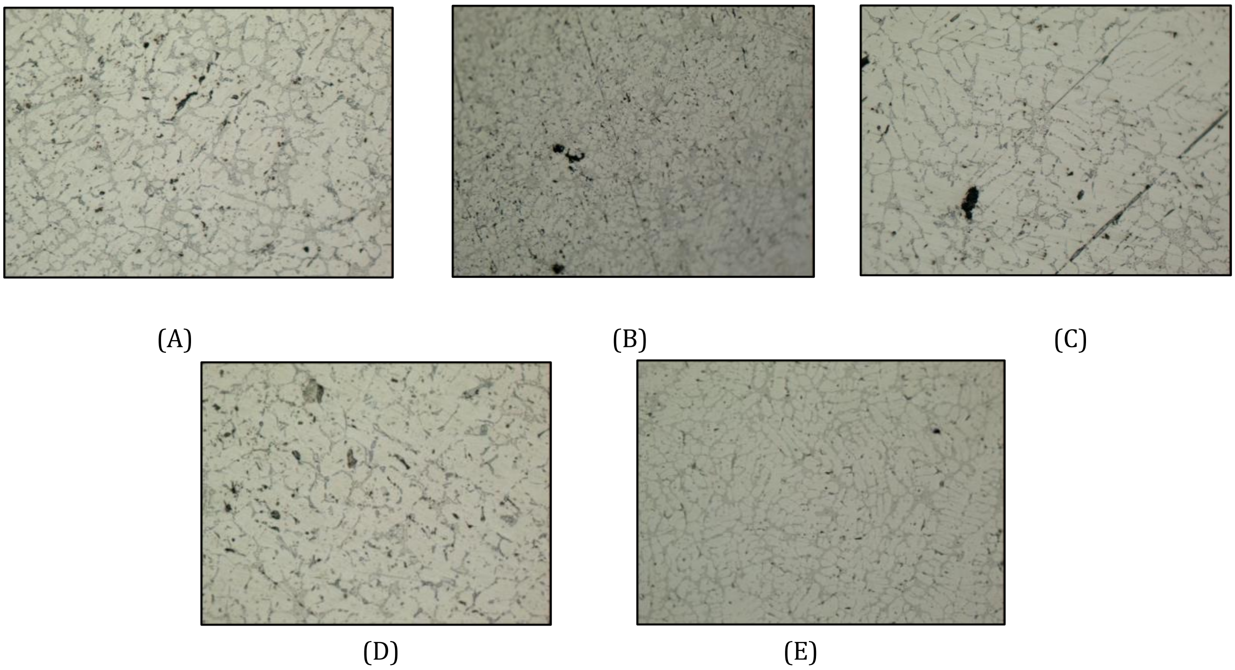

Fig. 2 *The Scanning Electron Microscopy (SEM) of LM30 Aluminium Alloy*

The EDX analysis indicates that aluminum is the predominant element in the mixture. Figure A illustrates the highest percentage of aluminum in the composition. Additionally, the introduction of Ho, Gd, and Zn into the sample is reflected in the EDX results. Observing the optical microscopy results reveals that the presence of these elements alters the microstructure of the aluminum alloy itself.

4. Conclusion

This study investigated the impact of rare earth elements (REE) on the microstructure and corrosion resistance of aluminum alloys. The following key findings were derived:

- The addition of REEs such as Holmium (Ho) and Gadolinium (Gd) to aluminum alloys resulted in significant alterations in the microstructure. These changes were observable through optical microscopy, where variations in grain structure were noted.
- X-ray diffraction (XRD) analysis confirmed the presence of distinct crystallographic phases corresponding to the added REEs. The intensity peaks indicated the formation of new compounds within the aluminum matrix.

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