Comparison Between Mo Addition to ZA22 Grain Refined by Ti and Ti-B Regarding its Metallurgical and Mechanical Characteristics

Adnan I. O. Zaid and Safwan M. A. Al-qawabah

Abstract—Zinc and its alloys are widely used materials in manufacturing several industrial and engineering parts especially in the automobile and aircraft industries due to their good mechanical strength and hardness in addition to their inherent corrosion resistance. However, they have the disadvantage of solidifying in large grains which reduces their mechanical strength, therefore they are normally grain refined by addition of titanium or titanium plus boron to their melts prior to solidification. In this paper, comparison between molybdenum addition to ZA22 grain refined by Ti and Ti-B on its grain size and mechanical characteristics in the cast condition is investigated and the obtained results are presented and discussed.

Index Terms—Cast condition, Comparison, Grain refinement, Mechanical characteristics, Metallurgical, Molybdenum, Titanium, Titanium-boron

1 INTRODUCTION

Zinc aluminum alloys in general and ZA 22 in particular are widely used due to their useful and attractive properties. They form substitutes for cast iron and copper alloys in many structural and pressure tight applications especially whenever strength, hardness, wear and corrosion resistances or good pressure tightness are required. Since they have good wear and bearing characteristics they are used for bearing bushings and flanges replacing bronze. Other applications in which they have been successfully replaced cast iron and copper alloys include fuel-handling components, pulleys, electrical fitting and hardware articles. Zinc aluminum are easy in machining, high machinability rating and their inherent corrosion resistance give them advantages over cast iron and because the price of zinc is much less than copper give them a distinct cost advantage over copper base alloys, [1-4].

Zinc gravity casting alloys are versatile materials which are widely used in industrial applications due to their low melting and casting points, around 450 degrees Centigrade, their energy requirements are low and virtually pollution free and the gravity casting of these alloys have attractive foundry properties in addition, they can be used for manufacturing components in a wide range of sizes and weights, e.g. from 1.5 mm to 5 mm in size and from few grams up to 50 kg in weight in sand and graphite casting molds, [5]. Against these favorable advantages, they have the disadvantage of solidification in dendritic structure of large grains which tends to reduce their mechanical strength and surface quality. To overcome these describences their structures are grain refined by either Ti or Ti-B, which are normally used for this purpose in aluminum and zinc alloys foundries.

2 EXPERIMENTAL PROCEDURES

The experimental work started by preparing the binary Al-Mo and the Al-Ti master alloys. The ternary Al-Ti-B was commercially available and supplied by ARAL, Arab Company of producing different aluminum article. These master alloys were used for manufacturing the different micro alloys which are used in this paper. The master and micro alloys were prepared in graphite crucibles and graphite rod was used for stirring one using graphite rods. Melting was carried out in an electrical furnace and poured to solidify in hollow thick brass rods in air. Details of the preparation of the master alloys and micro alloys are given in [8, 9]. Their chemical compositions were determined using the scanning electron microscope, (SEM) as shown in Table 1.

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3 RESULTS AND DISCUSSION

3.1 Comparison between Mo Addition to Al Grain Refined by Ti and Ti-B

Figures 1 to 4 inclusive show comparison between addition of molybdenum to ZA22 grain refined by Ti and ZA22 grain refined by Ti-B in the cast condition: the ZA22 general microstructure solidify in dendritic type with large grains which collect in cluster shape. Addition of Ti or Ti-B to ZA22 resulted in refining of its structure. Ti-B is found to be better refiner.
than Ti although the Ti percentage in Ti-B addition is smaller than percentage in case of Ti addition, although boron is not a refiner itself. However, in the case of Mo addition the structure in completely different from the ZA22 or ZA22-Ti or the ZA22-Ti-B micro alloys as the grains collected in a columnar type structure with little or no distance between the grains. Addition of Mo to ZA22 grain refined by Ti resulted in further refinement with small distance between the grains. However in case of Mo addition to the ZA22, it changed the Metallurgical structure into petal-like type.

Addition of Mo to either ZA22 grain refined by Ti or Ti+B resulted in enhancement of its hardness giving better enhance-

**Fig. 1.** Photomicrographs of ZA22 and its Micro Alloys: (a) ZA22, (b) ZA22-Ti, (c) ZA22-Ti-B, (d) ZA22-Mo, (e) ZA22-Ti-Mo, (f) ZA22-Ti-B-Mo, cast condition X 500.
ment in case of ZA22 grain refined by Ti-B and Ti-B-Mo, as shown in the histogram of figure 2.

It can be seen from the summary of the resultants of the mechanical behavior and the mechanical characteristic of ZA22 and its five micro alloys in the as cast condition and after the pressing by the ECAP process presented in Table 8 that the mechanical behavior is decreased by the addition of all grain refiners except Ti addition in as cast condition where the strength coefficient, K, in the as cast condition is increased by addition of Ti by (37.6%) followed by Ti-Mo addition being (14%) and by Ti-B-Mo addition, but it is decreased by Ti-B and Mo addition. However, the only parameter which was increased by all the additions is the work hardening index, n, as clearly demonstrated in Table 2.

### Conclusion

From the previous investigation the following points are concluded:

i) Addition of molybdenum, Mo, to the ZA22 alloy, resulted in reduction of its grains i.e. refining them.

ii) Addition of Mo to ZA22 grain refined by Ti or Ti-B resulted in increase of its micro hardness in the cast condition.

iii) Addition of Mo to ZA22 grain refined by Ti and Ti-B in as cast condition resulted in deterioration of its mechanical behavior i.e. its reduced the true stress-true strain (σ-ε) curve, flow stress where decreased by 22.6% at 20% strain was achieved in Mo addition, whereas it improved its work hardening index, n, and its ductility, i.e. improves formability and hence reduces the number of stages required for forming the alloy at large process strains in excess of the plastic instability strain.

iv) Addition of Ti to ZA22 resulted in improvement of its mechanical behavior i.e. its true stress-true strain (σ-ε) curve, increase of flow stress by 22.4% at 20% strain was achieved, increase of work hardening index, n, by 18.75%.

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REFERENCES