# A Comparative Study of Mechanical Property in Al-8Fe-2Mo-2V-1Zr Bulk Alloys Fabricated from an Atomized Powder and a Melt Spun Ribbon

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**Abstract**

*Al-8Fe-2Mo-2V-1Zr alloys were prepared by the gas atomization/hot extrusion and the melt spinning/hot extrusion. For the gas atomized and extruded alloy, equiaxed grains with the average size of 400 nm and finely distributed dispersoids with their particle sizes ranging from 50nm to 200nm were observed. For the melt spun and hot extrusion processed alloy, refined microstructural feature consisting of equiaxed grains with the average size of 200nm and fine dispersoids with their particle sizes under 50nm appeared to exhibit a difference in microstructure. Strength of the latter alloy was higher than that for the former alloy up to elevated temperatures.*

**Keywords : Al-Fe-TM alloy, gas atomization, melt spinning, microstructure, mechanical property**

## 1. Introduction

Al-Fe-TM (TM: Transition Metals) alloys have been expected to use as a high temperature structural material for automobile engine parts because of their good strength at high temperature, specific elastic modulus and lightweight. The origin of high temperature strength of these alloys was known to be due to the thermally stable dispersoids such as Al-Fe, Al-Fe-TM and Al-TM based intermetallic compounds [1]. However, the difficulty in controlling microstructural features, such as refinement of grain size and dispersoids, is main obstacle to practical application of the Al-Fe-TM alloys. One way to refine the microstructure would be a specific processing technique in terms of a rapid solidification.

The gas atomization and melt spinning processes have been well known as rapid solidification techniques, both processes would be effective method in displaying a microstructure to be refined because their fast cooling rates, more than $10^3$K/s, are enough to make significant nucleation sites during solidification than conventional manufacturing process such as sand or permanent casting. Moreover, the additions of high melting point transition metals, which have narrow solid solubility and low diffusivity in aluminum, could accelerate to form an extremely fine microstructure not only during solidification process but also by subsequent hot extrusion, rolling and forging. In our prior study, we reported that the chemistry of matrix phase is mainly dependent upon alloying elements and cooling rates from liquid phase resulting in different microstructures and mechanical properties. Under these backgrounds, in this study, we have tried to produce a bulk Al-Fe-TM alloy fabricated by a powder metallurgy process and subsequent hot extrusion. In order to vary the microstructure by cooling rates the alloy powders were prepared by a gas atomization (>$10^3$K/s) and a melt spinning (>$10^6$K/s)/milling, respectively [2, 3]. Mechanical properties of the present alloys will be correlated to microstructures developed in both gas atomization and melting spinning processes.

## 2. Experimental and Results

The raw materials with the chemical composition of Al-8Fe-2Mo-2V-1Zr (wt.%) were prepared using a gas atomization and a melt spinning method. The atomized powders under 75㎛ were supplied from Sumitomo Light Metal Ind., Ltd. Melt spun powders were prepared by the single roll melt spinning with a copper roll speed of 42 m/sec under argon atmosphere and pulverizing using a speed rotor mill. Two kinds of alloy powder were pre-compacted in aluminum can and then hot extruded at 693K in the extrusion ratio of 25 to 1. Hereafter, we denoted the specimen prepared by atomization and subsequent hot extrusion as AE specimen and melt spinning and hot extrusion as ME specimen. Microstructural observation was performed using a transmission electron microscopy (TEM) Compressive test was carried out using an Instron testing machine in air from room temperature to 783K and at an initial strain rate of $1x10^{-3}s^{-1}$.

Fig. 1 shows TEM images (a, c) and TEM-EDX mapping results (b, d) for both the AE (a, b) and ME specimens (c, d). Apparently, it is noted that both specimens have a similar microstructural feature displaying equiaxed grain structure and fine dispersoids distributed uniformly within grains and at grain boundaries. However, a finer microstructure for both the grain size and particle size appeared to exhibit the effect of faster cooling rate in the ME specimen compared to the AE specimen. For the AE specimen, the average grain size is measured to about 400 nm, and the size distribution of dispersoids is ranged from 50 nm to 200 nm. On the basis of chemical composition, size distribution, TEM mapping and XRD result the dispersoids could be classified into three groups. The results can be summarized as follows: (1) dispersoid containing Al and Fe with the particle size of less than 200 nm, (2) dispersoid containing Al, Fe, V and Mo with the particle size of less than 200 nm, (3) very fine dispersoid containing Al and Zr with the average particle size of 50 nm. In contrast, for the ME specimen, the grain size was measured to about 200nm, and the average particle size was measured to less than 50nm. From TEM-EDX results, the kinds of dispersoids for the ME specimen are similar to AE specimen, as shown in Fig. 3(d).

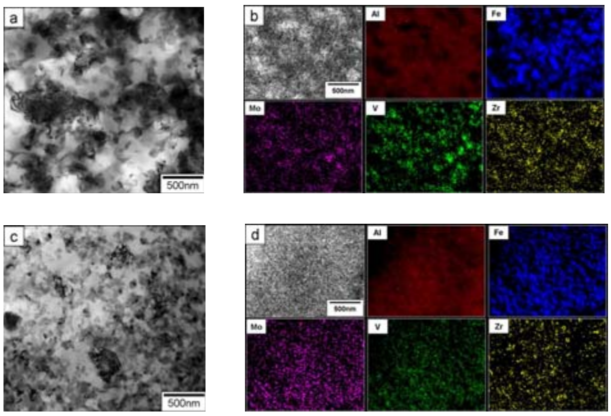


**Fig. 1. TEM images (a, c) and EDX-mapping results (b, d) for the AE specimen (a, b) and the ME specimen (c, d)**

Fig. 2 shows the yield strength values for both specimens tested in compression at temperatures ranging from RT to 773K and at an initial strain rate of $1\times10^{-3}$/s. Over whole temperature range, the ME specimens showed higher compressive yield strength than those of the AE specimen. The higher strength of the ME specimen may originate from a finer microstructure compared to the AE specimen. The yield strength of the ME specimen was estimated to 792MPa at room temperature, which value is about 1.5 times higher than that obtained in the AE specimen. Even in the high temperature region, the ME specimen exhibited higher strength than the AE specimen. The difference in yield strength between two specimens becomes smaller with increasing test temperature.

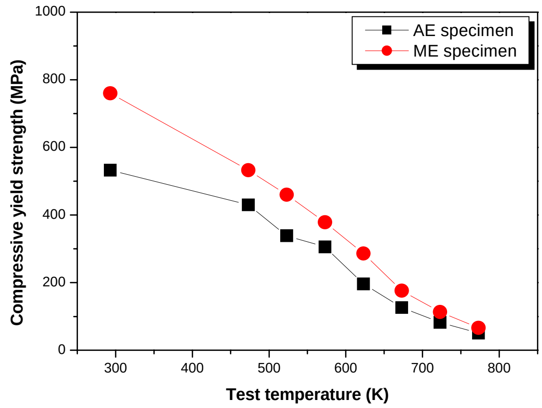


**Fig. 2. Yield strength values as a function of temperature**

## 3. Summary

We have successfully produced Al-8Fe-2Mo-2V-1Zr bulk alloys without any processing defects such as micro pore or cracks in terms of gas atomization and subsequent extrusion (AE) or melt spinning and subsequent extrusion (ME). Equiaxed grain structures and extremely fine dispersoids were characterized over the whole microstructure for both specimens. The ME specimen showed a finer microstructure for both grain size and particle size than those obtained in the AE specimen. The yield strength of the ME specimen was estimated to 792 MPa at room temperature, which value is about 1.5 times higher than that of the AE one. In the high temperature region, the ME specimen even showed higher strength than the AE specimen. From these results, it is suggested that microstructural refinement of Al-8Fe-2Mo-2V-1Zr alloy is effective to improve mechanical property not only at room temperature but also at high temperatures.

## 4. Acknowledgement

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## 5. References

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