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Mechanical properties with thixo-extrusion of the semi-solid 7075 Aluminum alloy

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This study investigated on the mechanical properties with thixo-extrusion of semi-solid casted 7075 Aluminum alloy. The semi-solid alloys used for the experiments were prepared by cooling plate casting, and semi-solid cast alloy showed fine and globular microstructure more than permanent cast alloy. Difference of microstructures with extrusion direction showed that thixo-extrusion had equiaxed grain while hot extrusion had elongated grain along with extrusion direction. As a result, ΔHv value along with extrusion direction at thixo-extrusion is smaller than hot extrusion. Tensile test result of each extruded alloy showed that thixo-extrusion had low yield strength, low ultimate tensile strength and high elongation more than hot extrusion.

Keywords: *7075 Aluminum alloy, semi-solid casting, thixo-extrusion*

1. Introduction

Al-Zn-Mg alloys have been used in the aerospace, the railroad cars and sporting goods which is required the specific strength. It is categorized for 2 groups according to Cu addition. A7075 that is typical alloy adding Cu have been used in structural materials requiring high strength, but when it was extruded or forged, due to high load, it has taken limitation on shape design and effectiveness reduction on life of mold [1-2].

Thixo-extrusion has been known for the alternative to solve the problem on the plastic forming of high strength Aluminum alloys. Because of rheological advantage of between cast and plastic forming taken by reheating process, the thixo-extrusion can decrease the extrusion pressure and reduce the problem on crystal grain anisotropy of the extruded alloys [3]. But some alloys that has solid-liquid coexistence state of small region is hard the application of thixo-extrusion, and it has difference of extrusion properties and mechanical properties of extruded alloys on reheating temperature at solid-liquid coexistence region [4-5].

In this study, to search reheating temperature of giving moderate liquid rate used for previous research result [6], and the microstructure and mechanical properties of the billets made by semi-solid casting method and permanent mold casting method was investigated.

2. Experiment

2.1 Semi-solid casting using slope cooling method

The composition of A7075 alloy used in this study is given in Table 1. The alloy melted at 740ºC was treated by degassing process, then, when it was at 650ºC, it was poured at mold of 570ºC. And after it had a holding time during 60sec, it was quenched by water. When semi-solid casted alloys was poured at mold, slope cooling method was used.

2.2 Thixo-extrusion of reheated billet

The reheating of billet for thixo-extrusion was performed at 595ºC, and The reheated billet was extruded for diameter 10mm at extrusion rate of 27:1, Ram speed of 1mm/s and heated extrusion container for 450ºC.

The microstructure analysis of A7075 prepared at each conditions was observed by optical microscope, its mechanical properties measurement was performed by universal testing machine using tensile specimen made on ASTM E 8M.

Table 1. Chemical compositions of A7075 alloys (mass%).

Zn	Mg	Cu	Si	Fe	Mn	Zr	Al
6.07	2.50	0.41	0.03	0.12	0.28	0.09	Bal.

3. Result and Discussion

In Fig. 1(a) observed the microstructure of dendrite structure, but In Fig. 1(b) generally observed the microstructrue of spherical structure. Because the primary crystal nuclear made by slope cooling method provided heterogeneous nucleation site, the microstructure of semi-solid cast materials was more refined.

Fig. 2 showed the microstructure on reheating temperature of semi-solid cast materials. As reheating temperature was increased, the partially melted grain boundary was observed, because the melting point was decreased by alloying elemnet around grain boundary.

Table 2 showed maximum extrusion pressure and conditions of each extrusion. Partially melted result by reheating process showed significant decraese of extrusion pressure.

Table 3 showed tensile properties of hot-extruded materials and thixo-extruded materials. At both conditions, Tensile strength was not many difference, but fracture elongation showed significant difference.

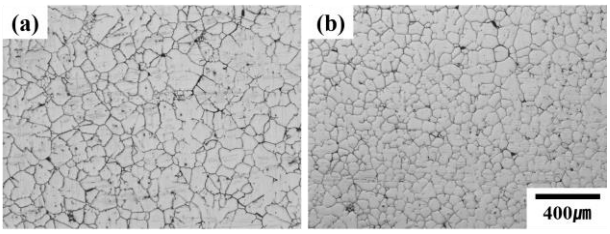

Fig. 1. The microstructures of (a) permanent mold casting, (b) semi-solid casting

Table 2. Extrusion conditions and maximum pressure

Extrusion Method	Rehearting Temp. (°C)	Extrusion Speed (mm/s)	E.P.$_{max}$ (MPa)
Hot-extrusion	-	1	816
Thixo-extrusion	595	1	597

Table 3. Mechanical properties of each extrusded materials

Extusion Method	Yield Stress (MPa)	Tensile Stress (MPa)	Elongation (%)
Hot-extrusion	263	375	15.7
Thxio-extrusion	227	368	25.2

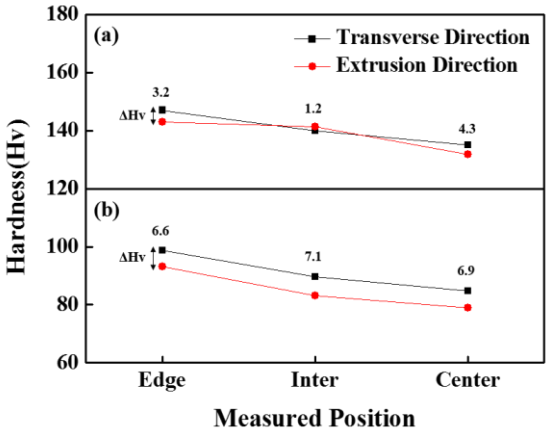

Fig. 2. Vicher`s hardness of (a) thixo-extrusded and (b) hot-extrusded materials; ∗ **ΔHv = TD - ED**

Fig. 3 showed vicher`s hardness measurement results on extrusion direction and transverse direction of hot-extruded materials and thixo-extruded materials. The hardness of thixo-extruded materials was higher than hot-extruded materials. and ΔH_V value on hardness difference of between extrusion direction and transverse direction was smaller at thixo-extruded materials. As a result, the microstructure on extrusion direction at thixo-extrusion was spherical, and it means that microstructure had isotropy characteristic.

4. Conclusions

The following conclusions can be obtained from this investigation.

(1) The microstructure was mostly spherical by thixo-extrusion, the result showed decrease of hardness difference between center position and edge position of extrusion materials.

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