A Synthesis of Aluminium Foam from Ingot by Compressing Method

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Abstract: - The purpose of this research was to synthesis of the open cell aluminum foams under the compressing process. The materials of this research were aluminium powder ingots (99.8%) and NaCl powder (99.0%) on the size of 30-50 mesh. The experiment was conducted between aluminum powder and NaCl which were mixed in ratio of 2:1 passing the compression molding force of 30kN into the cylindrical shape on $\varnothing$ 25 $\times$ 40mm. then heat treatment at 720 ^{o}C for 1hr. After that, the cylindrical was milled into the specimens of compression and microstructure test, then cleaning up the hot salt out. The results revealed that the aluminium foam can be synthesized through compressing process having a density of 1.1-1.2 g/cm3, porosity of 50-52% and compression of 16-17 MPa.

Key-Words: - Alumnium foam, Pure aluminium, Metallic foam, Compressing process

1 Introduction

Metallic foam materials have been developed in many different ways at the present due to their properties in a wide variety of applications such as the energy absorption properties, sound absorption or even in thermal insulation [1] with low density, lightweight. Therefore, they are better choice among present materials development. Metallic foam, frequently aluminium which can be synthesized for producing many metallic foams that come in two varieties, closed-cell foam and open-cell foam. There are many methods in synthetic process of aluminium foam, such as alloying element (TiH_2), casting process, gas bubbling and metal extrusion [2-4]. When considering the synthesis of aluminium foam, it is the most selected way to economize expenses with less complexity and suitable for the raw material in Thailand. Thus, the researcher would like to study a synthesis of aluminium foam from compressing process by aluminum powders and NaCl. In additional, to study the possible synthesis including the physical properties and mechanical property of aluminium foam from synthesis process.

2 Equipments and Experiment Method

In this study used purity aluminium powders from the ingot chips (Fig. 1) passing an ingestion through the sieve machine with mesh size 30 mesh (Fig. 2), and used NaCl 30 and 50 mesh (Fig. 3).

When getting the purity aluminium powders and NaCl, then mix them in the ratio 2:1 with the two components; aluminium powders 30 mesh and NaCl 30 mesh. The other components were aluminium powders 30 mesh and NaCl 50 mesh. Mixing them together through the mixing machine for 1 hour and compression molding was used to produce the cylinder-shaped specimens of $\varnothing$ 25 mm and 40 mm length with pressure 40kN.

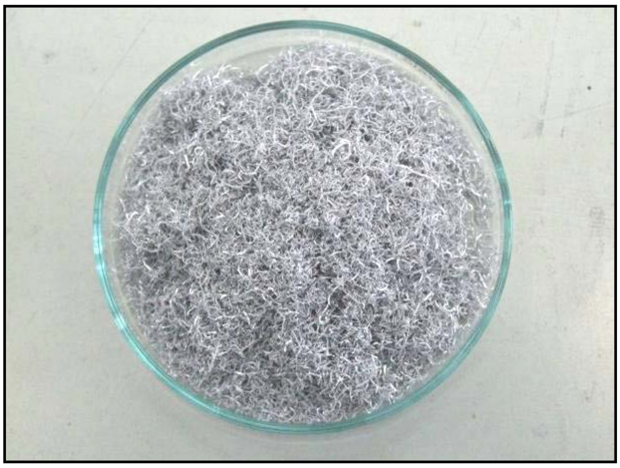

Figure 1 Chips of aluminium from turning

Figure 2 Aluminium powder (30 meshes)

Figure 3 NaCl powder (30 meshes)

When getting the cylinder-shaped specimens made from two components of aluminium (three specimens per one component), the specimens were heated in an oven for 1 hour at 720^{o}C and leaving them to cool down in the oven. The specimens were turned on the lathe for making compression test and micro structure. After that, the oven-dried specimens were turned to the cylinder-shaped of ∅ 25 mm and 40 mm length. NaCl on the specimens were cleaned by using a hot water (Fig. 4).

Figure 4 Specimens were cleaned by using a hot water

After the process, the cleaned specimens were tested on Apparent porosity; P as in equation 1, finding the Bulk Density as in equation 2 by the standard method of ASTM C373 [8]

Apparent porosity Calculation

$$P = \left[\frac{(M-D)}{V}\right] \times 100 \ (\%) \qquad (1)$$

When P = Apparent porosity
M = Wet Weight
D = Dry weight
V = Total Volume

Bulk Density Calculation

$$B = \frac{D}{V} \qquad (2)$$

When B = Bulk Density
D = Dry weight
V = Total Volume

The specimens were used for the preparation of compressive strength test with the shape of of ∅ 20 mm and 20 mm length by the standard method of ASTM E9 [9] including the considering of testing on high compressive strength before specimens was failure.

3 Results and discussion

3.1 Physical properties

From the results, it was found that the extrusion process could synthesis of aluminium foam, their physical characteristics were open-cell foam with cavity structure which both of components were also being open-cell foam. On the other hand, the cell size of the specimens on aluminium powders 30 mesh and NaCl 30 mesh had larger pores than the specimens on NaCl 50 mesh (Fig. 5 and Fig. 6)

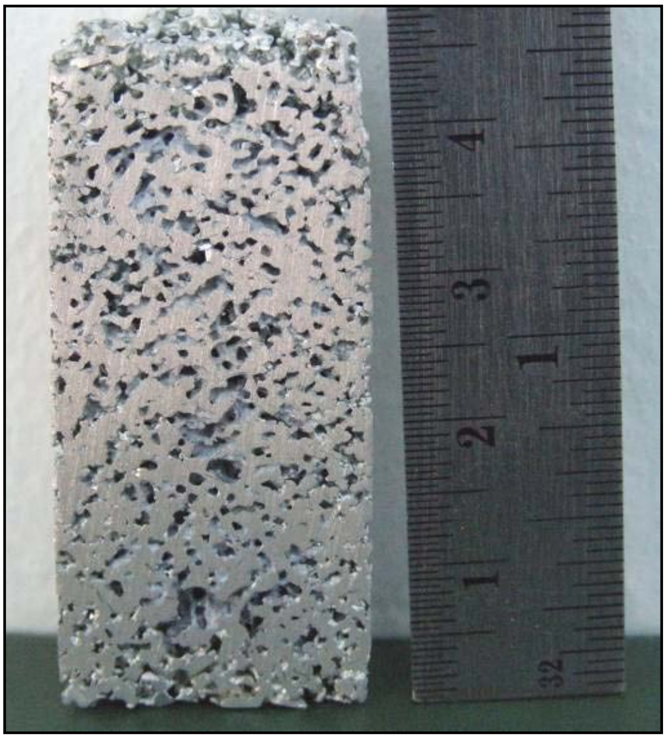

Figure 6 Aluminium foam from aluminium powder 30 mesh

The microstructure examination of aluminium powders 30 mesh and NaCl 50 mesh by the scanning electron microscope (SEM), it was found that both of components had the within structure of foam cavity with sphere characteristic, similar smooth including the cavity distribution with non-direction but it would be different on the cavity size. The specimens with NaCl 50 mesh had smaller cavity. (Fig. 7 and Fig. 8)

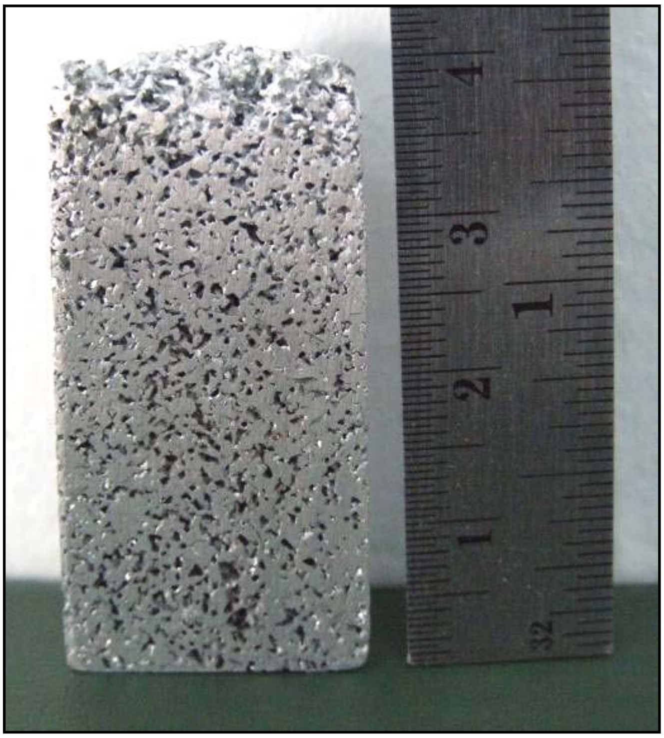

Figure 6 Aluminium foam from aluminium powder 50 mesh

Table 1 Bulk Density

Specimens	Dry weight(g)	Volume (g/cm^3)	Bulk Density (g/cm^3)
1	13.9395	11.7355	1.187
2	13.6535	11.1775	1.221

1 : Al 30 mesh and NaCl 30 mash,
2 : Al 30 mesh and NaCl 50 mash

Table 2 Apparent porosity

Specimens	Wet weight (g)	Dry weight(g)	Volume (g/cm^3)	Apparent porosity (%)
1	19.9645	13.9395	11.7355	51.37
2	19.394	13.6535	11.1775	51.35

1 : Al 30 mesh and NaCl 30 mash,
2 : Al 30 mesh and NaCl 50 mash

The mean of bulk density of aluminium powders 30 mesh and NaCl 30 mesh was at 1.187 g/cm^3. The mean of bulk density of aluminium powders 30 mesh and NaCl 50 mesh was at 1.221 g/cm^3 (Table 1). Due to the cell size of NaCl was smaller, it would have affected to the space of aluminium foam and also increasing bulk density because those specimens had more quantity when compared with volumes.

The mean of apparent porosity within aluminium foam of aluminium powders 30 mesh and NaCl 30 mesh were at 51.37 %. The mean of apparent porosity within aluminium foam of aluminium powders 30 mesh and NaCl of 50 mesh were at 51.35 % (Table 2). When considering of the apparent porosity of the specimens with different NaCl of 30 and 50 mesh, there was not different value. It might be affected by the compression molding in preheating process. According to high compression molding, some NaCl broke and had smaller size [5]. Thus, it affected the apparent porosity of aluminium foam with NaCl 30 mesh which was not different from the specimens of NaCl of 50 mesh.

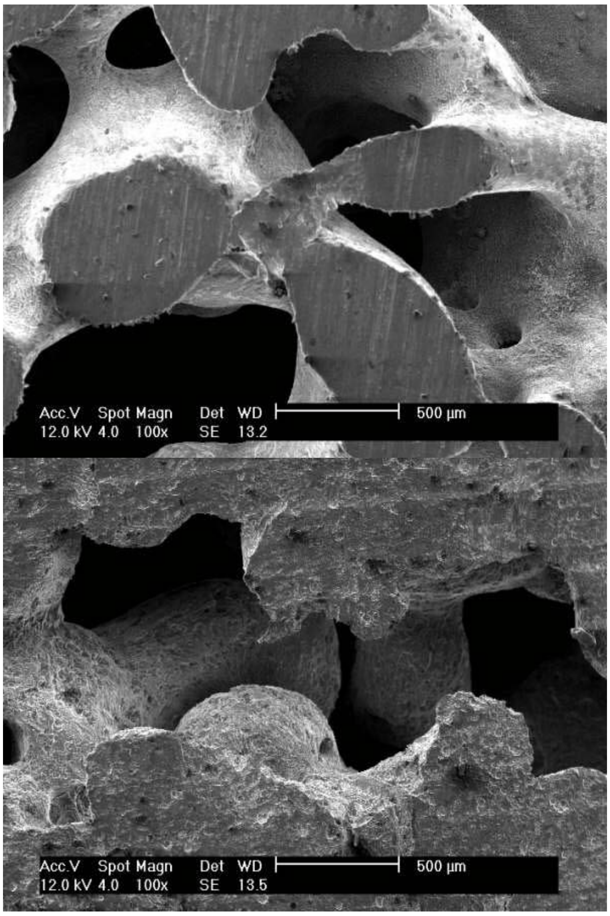

Figure 7 SEM micrograph of aluminium foam 30 mesh

Table 3 Compressive Strength

No.	Cross Section (m^2)	Total load(N)	$\sigma = \frac{P}{A}$ (MPa)
1	394.00	6,530.91	16.58
2	390.50	6,745.10	17.27

1 : Al 30 mesh and NaCl 30 mash,
2: Al 30 mesh and NaCl 50 mash

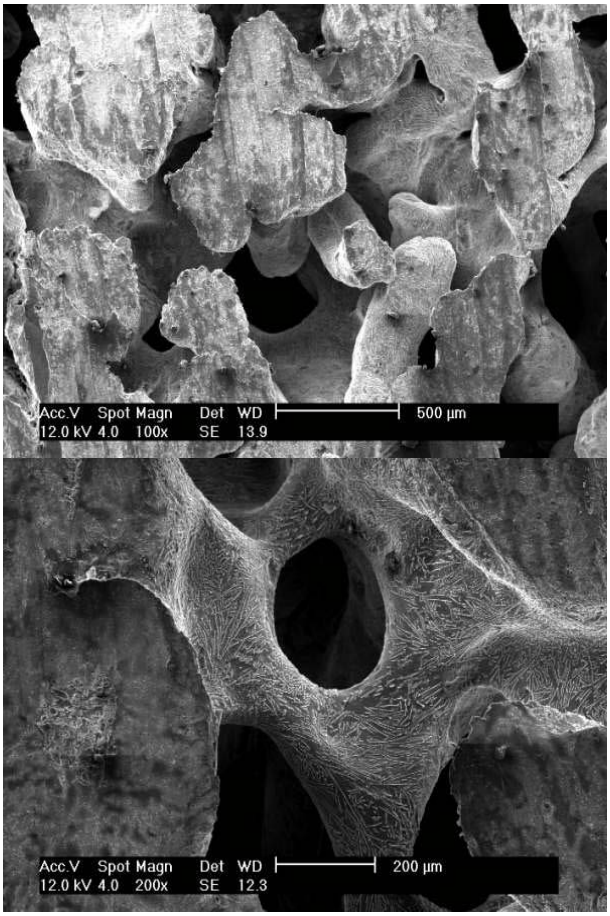

Figure 8 SEM micrograph of aluminium foam 50 mesh

3.2 Mechanical Properties

The results of compressive strength on two components of aluminium foam, it was found that the mean for specimens of aluminium powders 30 mesh and NaCl 30 mesh was at 16.57 MPa. the mean for specimens of aluminium powders 30 mesh and NaCl 50 mesh was at 17.05 MPa (Table 3).

When considering the above experiment, it was found that when increasing the bulk density, it would have affected the compressive strength. Due to the specimens with NaCl 50 mesh had a few higher compressive strength than specimens with NaCl 50 mesh following to NaCl had smaller size, thus aluminium would also have high quantity including the specimens of aluminium foam had more strength space which was affected the high compressive strength [6-7].

4 Conclusion

As the results of synthesis of aluminium foam from purity aluminium powders and NaCl, it could be summarized as the following:

1. A synthesis of aluminium foam could be done by compressing process of purity aluminium powders and NaCl.
2. The size of NaCl 30 and 50 mesh had an effect on the shape and size of aluminium foam cavity. If NaCl had larger size, it would have affected the aluminium foam cavity also had larger size.
3. Bulk density and apparent porosity of the specimens of NaCl 30 and 50 mesh had similar value by the bulk density of specimens of NaCl 50 mesh had a few higher and the apparent porosity of both components had no different.
4. The compressive strength of the specimens of NaCl 30 and 50 mesh had similar value by the the compressive strength of specimens of NaCl 50 mesh had a few higher.

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