

EFFECT OF SiCp ON COMPRESSIVE BEHAVIOR OF COMPOSITE METAL FOAM

Nilhan ÜRKMEZ TAŞKIN
Trakya University

Vedat TAŞKIN
Trakya University

Metin AYDOĞDU
Trakya University

Pınar Aydan DEMİRHAN
Trakya University

İsmail MUTLU
Trakya University

Abstract

In this study, the effect of size and fraction of SiCp on compressive behavior of composite metal foam were investigated. Compare to the same relative density of composite foam, plateau stress and energy absorption increased with increasing fraction of SiCp.

Keywords: Composite metal foam, SiC, semi-solid, direct foaming

INTRODUCTION

With high porosity metal foam materials for various engineering applications has been a new class of materials, has attracted attention with useful features. The most important features of cellular metallic materials is lightweight, high strength and relatively non-linear deformation behavior [11]. Due to high porosity large amount of energy was damped when they are deformed [2]. Because of the high strength and light weight, composite metal foam was attractive for many industries especially automotive.

Although mechanical properties of metallic foam are proportional with foamed solid metal; it varies depending on several criteria as production method, production parameters, density, cell wall thickness and pore distribution. Many studies of metal foam, the most important factor affecting the mechanical properties of the foam showed that the relative density (ρ/ρ_s) [3, 7, 8] . Using different production methods and/or changing production parameters (temperature, reinforcement ratio and foaming time) metal foam production is possible to perform with desired relative density.

Also elastic modulus, compressive strength and plateau stress is decreased, reduction in the relative density is obtained more lightweight structure. If the metal foam is failed to provide the desired mechanical

properties adding reinforcement in mixture during production can improve mechanical properties. In recent works, comparing with metal and composite foam has same relative density was seen

In recent works; comparing the metal and composite foam with the same relative density, it can be seen that mechanical properties such as the elasticity modulus, compressive stress and plateau stress of composite foam is higher than the metal one [11, 5].

The relation between plateau stress of closed cell composite foam under compressive loading and yield stress of foamed solid metal was described by Gibson summarize as [7]:

$$\frac{\sigma_{pl}}{\sigma_{ys}} = C \left(\frac{\rho}{\rho_s} \right)^{3/2} + C' \left(\frac{\rho}{\rho_s} \right) \quad (1)$$

It is known that foam materials have three deformation stages under compressive loading. First deformation stage was seen on linear elastic region corresponding to Hooke's Law. Second deformation stage is called collapse plateau region. On this region after achieving yield point, was not seen increasing on stress. Last stage of deformation is densification. On this region collapsed cells cause cell wall stacking on each other. Porosity becomes decrease and deformation of foam material likes as a solid.

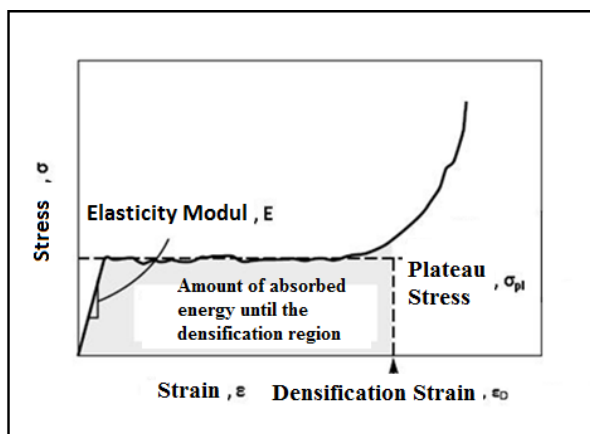


Fig. 1 Stress and strain graph of metal foam [1]

The aim of this study, investigate the effect of SiCp reinforcement size and ratio on compressive behavior of AlMg4.5Mn0.7-SiC composite metal foam which produce by direct foaming at semi-solid temperature.

EXPERIMENTAL PROCEDURE

AlMg4.5Mn0.7 aluminum alloy is reinforced with different rates of SiCp and 0.5 % ratio TiH₂ used as blowing agent is produced by direct foaming at semi-solid temperature. [3].

TiH₂ (98 wt% fine powders, about 44μ in size, supplied from Merck, Germany) were used as blowing agent without any treatment.

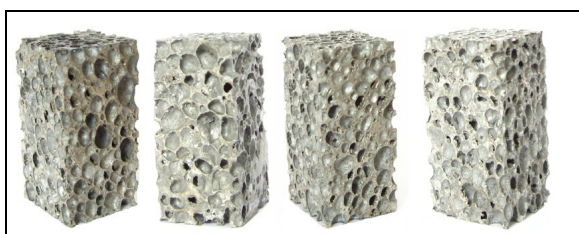


Fig.2. Compressive test specimens

Archimedes principle was used for measuring density. Foams was coated with a thin film layer, the weights was measured in the air and water by using a precision weighing with 1 / 1000 g accuracy.

Compressive test specimens with dimensions of 15x15x30 mm were prepared with Metkon Micracut 200 as precision cutting machine. Compressive test were performed with Instron 8501 universal testing machine at 5 mm/min as constant crosshead speed until deformation ratio of 70%.

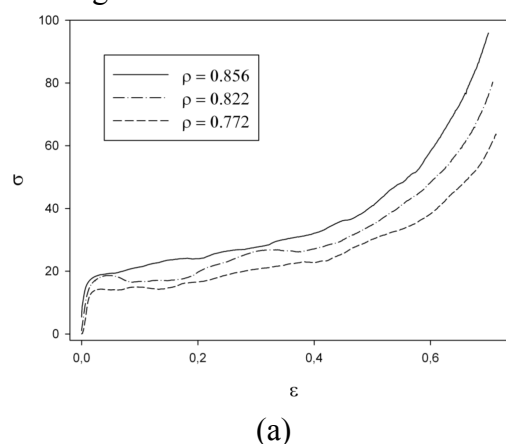
Table.1. Experiment chart

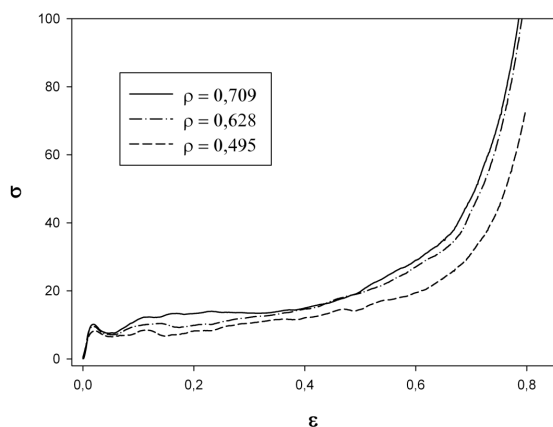
Experiment No	Material	% wt. TiH ₂	Size of SiCp	% wt. SiCp reinforcement ratio
1	5083	0,5	-	0
2	5083	0,5	12μ	5
3	5083	0,5	12μ	10
4	5083	0,5	12μ	15
5	5083	0,5	12μ	20
6	5083	0,5	1μ	5
7	5083	0,5	1μ	10
8	5083	0,5	1μ	15
9	5083	0,5	1μ	20

RESULTS AND DISCUSSION

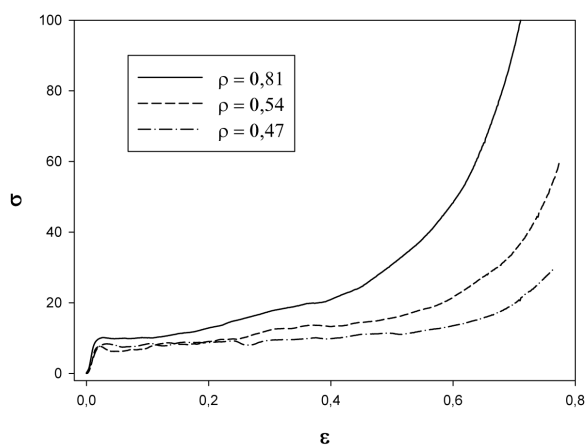
In this study effect of SiCp on compressive behavior of composite foam were investigated. Compressive test were performed on AlMg4.5Mn0.7 aluminum alloy which produced by direct foaming at semi-solid temperature. On compressive test results of composite metal foam, the characteristic stress - strain diagram were obtained. The three regions that represent the compressive properties of foam were appeared clearly.

It was realized that compressive properties of composite foam depends on relative density of foam. With decreasing relative density mechanical properties was decreased. Decreasing density with high reinforcement ratio causes plateau stress and compressive stress become smaller was found. On composite foam with same relative density, improvement of compressive properties was seen with increasing reinforcement ratio. The reduction of plateau stress was observed with decreasing reinforcement size.



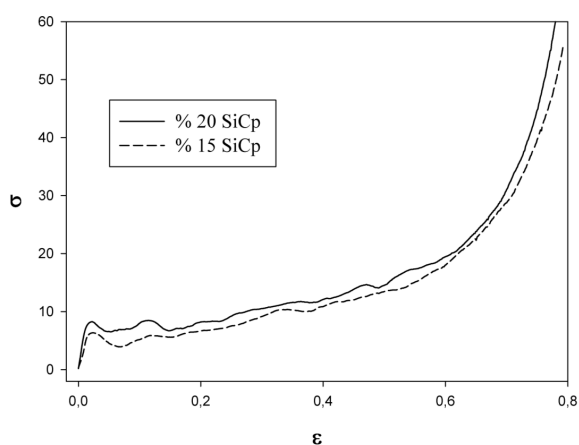


(b)

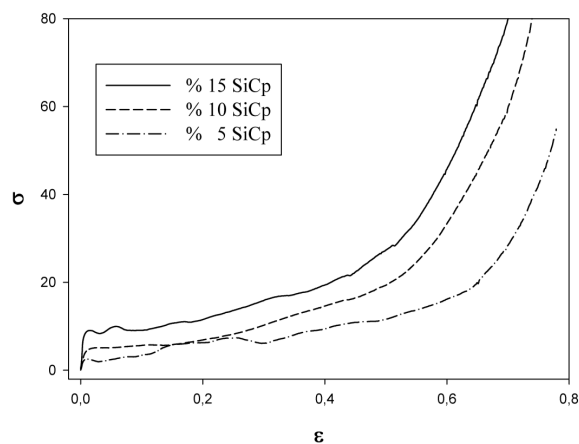


(c)

Fig. 3. Stress-strain graph of composite foam and with different density a) AlMg4.5Mn0.7 metal foam b) 20 %wt. SiCp (12μm) reinforced AlMg4.5Mn0.7 composite foam c) 15 %wt. SiCp (1μm) reinforced AlMg4.5Mn0.7 composite foam



(a)



(b)

Fig. 4. Stress-strain graph of composite foam and with same relative density a) ($\rho/\rho_s = 0,49$) 20 %wt. and 15 %wt. SiCp (12 μm) reinforced AlMg4.5Mn0.7 composite foam b) ($\rho/\rho_s = 0,58$) 15 %wt. , 10 %wt. and 5 %wt. SiCp (12 μm) reinforced AlMg4.5Mn0.7 composite foam

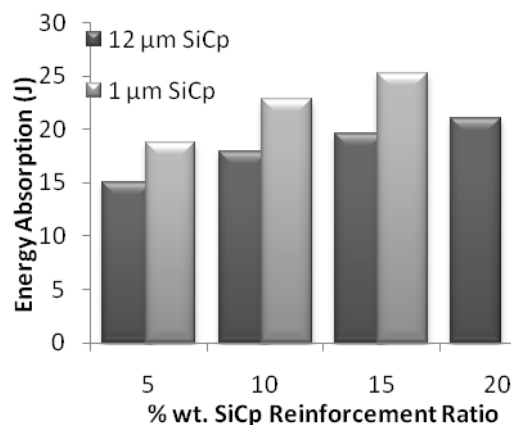


Fig. 5. Energy absorption until deformation ratio of % 40

On investigation of energy absorption was found that energy absorption capability increase with increasing reinforcement ratio and decreasing reinforcement size. It was realized that composite foam with produced by smaller size of reinforcement is more capable to absorption of energy.

As in other mechanical properties of foam, energy absorption capability is still closely related with the foam structure. It was known that mainly to the relative density, energy absorption capability is affected on many factors as distribution of cell size, cell wall thickness, cell shape and porosity [7, 8, 10, 11].

ACKNOWLEDGEMENT

This study supported by TUBITAK Scientific Research Projects Support Programs within project numbers of 108M325.

REFERENCES

- [1] Ashby, M.F., Evans, A.G., Fleck, N.A., Gibson, L.J., Hutchinson, J.W., Wadley, H.N.G., 2000, "Metal Foams: A Design Guide", Butterworth-Heinemann
- [2] Banhart, J., 2003, "Aluminium Foams: On The Road to Real Applications", Mrs Bulletin, April, 290-295
- [3] Demirhan, P.A., 2010, Investigation of Mechanical Properties of Composite Metal Foam, Master of Science Thesis, Trakya University, Turkey
- [4] Deqing, W., Xiangjun, M., Weiwei, X., Ziyuan, S., 2006, "Effect of Processing Parameters on Cell Structure of an Aluminum Foam", Materials Science and Engineering, A420, 235–239
- [5] Elbir, S., Yılmaz, S., Toksoy, A.K., Güden, M., 2003, "SiC-Particulate Aluminum Composite Foams Produced by Powder Compacts: Foaming and Compression Behavior", Journal Of Materials Science, 38, 4745 – 4755
- [6] Esmaealzadeh, S., Simchi, A., 2008, "Foamability and Compressive Properties of AlSi7 - 3 Vol.% SiC- 0.5 Wt.% TiH₂ Powder Compact", Materials Letters, 62, 1561–1564
- [7] Gibson, L.J., 2000, "Mechanical Behavior of Metallic Foams", Annual Review Of Materials Science, 30, 191–227
- [8] Jeon, Y.P., Kang, C.G., Lee, S.M., 2009, "Effects of Cell Size on Compression and Bending Strength of Aluminum-Foamed Material by Complex Stirring in Induction Heating", Journal of Materials Processing Technology, 209, 435–444
- [9] Haesche, M., Weise, J., Garcia-Moreno, F., Banhart, J., 2007, "Influence of Particle Additions on The Foaming Behaviour of AlSi11/TiH₂ Composites Made by Semi-Solid Processing", Materials Science And Engineering, 480, 283–288
- [10] Luo, Y., Yu, S., Li, W., Liu, J., Wei, M., 2008, "Compressive Behavior of SiCp/AlSi9Mg Composite Foams", Journal of Alloys and Compounds, 460, 294–298
- [11] Yu, S., Luo, Y., Liu, J., 2008, "Effects of Strain Rate and SiC Particle on the Compressive Property of SiCp/AlSi9Mg Composite Foams", Materials Science and Engineering, 487, 394-399