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Comparison on Porosity Percent, Microstructure and Compression Behavior of Steel Foams Containing 2 wt. % Cu and 2 wt. % P

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1. Introduction

Metallic foams or cellular metals are a new class of engineering materials. The low density, the production of lightweight structures, unique chemical, physical, and mechanical properties, and exclusive thermal and acoustical behavior of the steel foams have made them suitable for many structural and non-structural applications.

Common fabrication methods for steel foam include powder metallurgy, hollow spheres, and lotus methods. In powder metallurgy methods, the leachable space holder technique is an interesting method. Although there have been many studies on how to fabricate the steel foams using space holder technique, there are few studies on the influences of alloying elements on the properties of steel foams. In this work, steel foams were fabricated by powder metallurgy using urea grains as a leachable space holder. And the influences of adding 2 wt. % copper and phosphorus on porosity percentage, compressive properties and microstructure were studied.

2. Materials and Experiments

To fabricate the steel foams, the leachable space holder-powder metallurgy technique consists of (a) coating of urea granules by powder mixes, (b) compacting, (c) leaching, and (d) sintering. At first, powder mixtures were coated on the surfaces of urea granules. In order to fabricate green steel foam specimens, coated urea granules were compacted using a stainless steel mold through a hydraulic press (200 MPa). Then, the leaching of the urea granules by water was carried out. Finally, the green steel foam specimens were sintered at 1120 °C for one hour. To investigate the microstructural and mechanical properties, the optical and scanning electron microscopes and compression tests were conducted on the steel foam specimens.

3. Results and Discussion

In the steel foams, the distribution of cells is virtually uniform, and the thickness of the cell walls is a constant value. Figure 1 shows the surface fraction of cell and thickness of cell walls. It is noteworthy that the thickness of the cell walls was measured only in the middle and the thickness of the walls was not measured at the junction of several cells. Sample A had the lowest surface fraction of cells and sample C had the highest surface fraction of cells. It was observed that the thickness of cell walls is also lower in the samples containing copper and phosphorus.

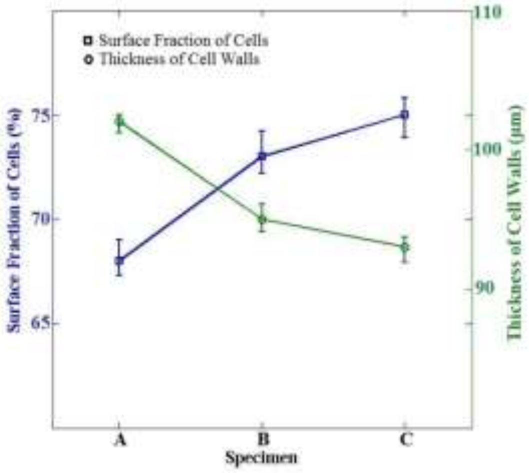

Fig. 1. Surface fraction of cells and thickness of cell walls of steel foam specimens

The surface fraction of pores formed in the cell wall is shown in Figure 6. As it can be seen, the largest amount of pores is observed in the walls of sample A. Foams containing 2 wt. % of copper and phosphorus have relatively similar pores. The reduction of pores in the walls of samples B and C is probably related to the improved bonding of the powdered particles due to liquid phase sintering.

SEM image and EDS results of C sample are shown in Figure 3. As it can be seen, a new phase is formed in the microstructure. The formed phase is probably iron phosphide that melts under sintering conditions. EDS results show that the formed phase has a higher amount of phosphorus and thus, the formation of iron phosphide at the iron particle boundary is confirmed.

The mechanical properties of metallic materials and cellular metals are influenced by the metal or alloy forming the walls, microstructures, heat treatment, cell morphology, and wall thickness. In Figure 4, the engineering stress-strain curves are presented. It is observed that the curves of steel foams shift upwards by adding the copper and phosphorus.

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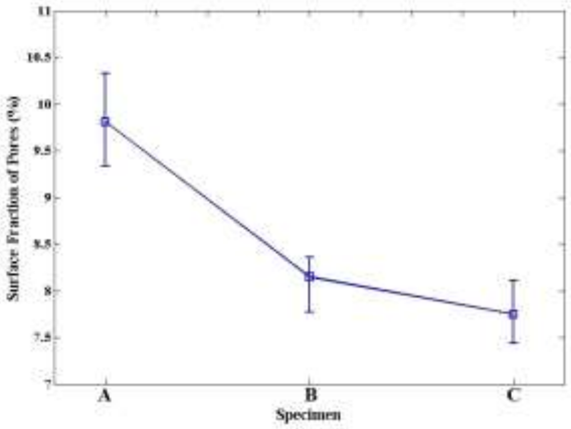

Fig. 2. Surface fraction of pores formed between the cell walls

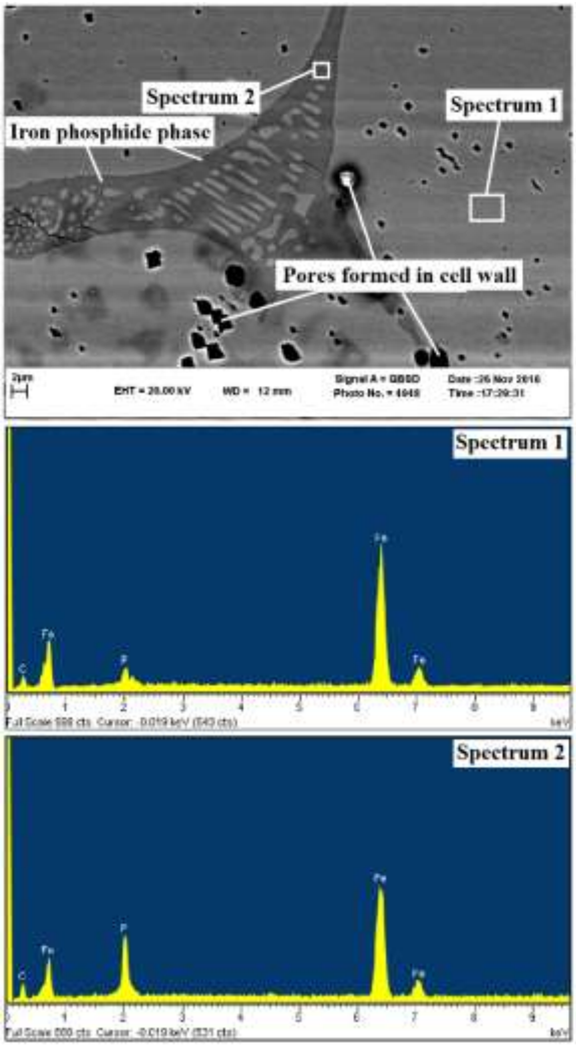

Fig. 3. SEM image and EDS results of B sample

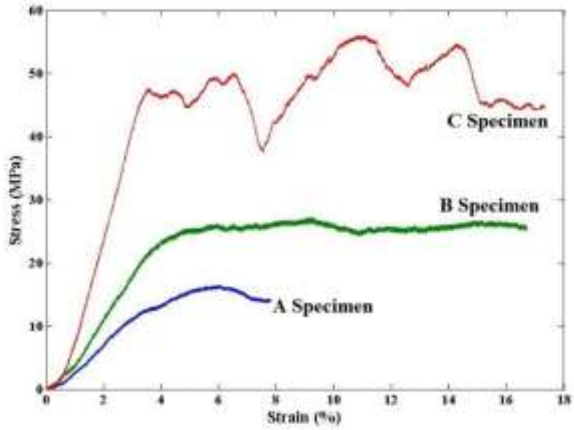

Fig. 4. Stress-strain curves of steel foam specimens

4. Conclusion

In this study, steel foam containing carbon, copper and phosphorus was produced by leachable space holder-powder metallurgy technique and the followings are the main conclusions:

1. The amount of porosity in the foam produced depends on the amount of leached urea granules and pores formed in the cell wall.
2. Adding 2 wt. % copper and phosphorus affects the porosity of the foam produced.
3. Adding copper and phosphorus improve the bonding of iron particles.
4. Steel foams containing phosphorus exhibit the best compressive behavior while steel foams containing copper are in the second position.
5. Plateau region is very long in the steel foam containing copper and phosphorus.