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MECHANICAL BEHAVIOR OF ADDITIVE MANUFACTURED METALLIC MICRO-LATTICE STRUCTURE

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ABSTRACT

This work investigates the uniaxial compressive behavior of additive manufactured metallic micro-lattice materials. Different temperatures and loading velocities are taken into consideration for analysis. The mechanical tests provide some useful information about the mechanical properties and optimal design of the micro-lattice materials used in structural protection.

Keywords: solid mechanics, additive manufacturing, micro-lattice, energy absorption.

INTRODUCTION

The rapid development of the aerospace and automobile industry requires that the material has the characteristics such as lightweight and multifunctional integration. Cellular materials have been proved to with excellent properties combining light weight, outstanding mechanical behavior and low thermal conductivity (Gibson, 1999). With the emerging of newly manufacture methods such as additive manufacturing technology, periodic lattice structures have attracted much attention due to their better properties than stochastic foams. It had been demonstrated that the mechanical properties of metallic lattice materials additive manufactured were affected by manufacturing routes, parameters and post-manufacture treatments (Hasan, 2013). Loading velocity is also an important factor which can change the energy absorption of the lattice structures (Ozdemir, 2016).

A series of quasi-static and dynamic tests were performed. All the samples were cubic and the sample length was 15 mm (±0.3 mm). The quasi-static tests were performed at slow displacement rate (0.9 mm/min) and at four different temperatures (25º C, 200º C, 400º C and 600º C). The dynamic tests were conducted by split Hopkinson pressure bar (SHPB). The samples were loaded with three velocities (13m/s, 18m/s and 23m/s) at room temperature (≈25º C). From the compressive test, the collapse strength and plateau stress of the lattice materials were calculated. The energy absorption capacities were also evaluated.

RESULTS AND CONCLUSIONS

Fig.1 shows the collapse strength and plateau stress of Ti-6Al-4V lattice structure at different temperatures. The initial collapse strength obtained from the quasi-static and dynamic tests are shown in Fig. 2.

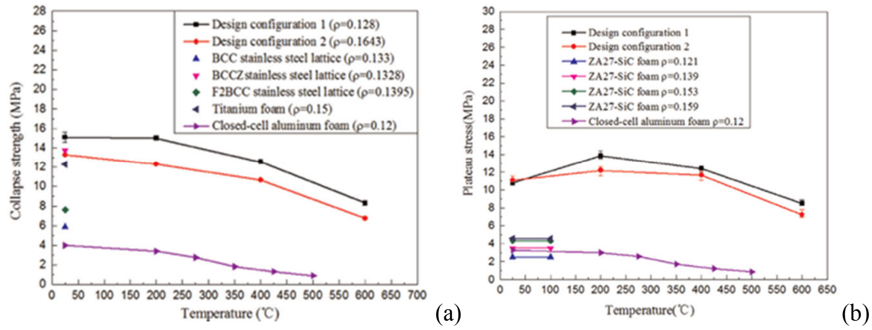

Fig. 1 - Quasi-static compressive test results: (a) Collapse strength; (b) plateau stress

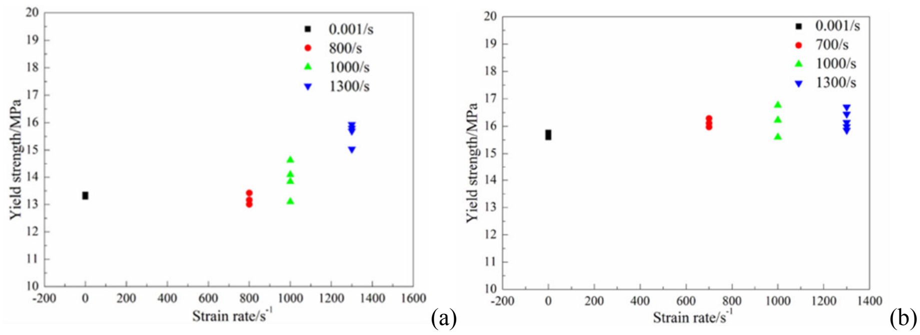

Fig. 2 - Yield strength of Ti-6Al-4V lattice structure: (a) with 5 cells along each direction; (b) with 3 cells along each direction at different strain rates

The results show that the temperature and strain rate influence the mechanical properties of Ti-6Al-4V lattice structure. Compared with other porous materials existed, Ti-6Al-4V lattice structure fabricated by EBM exhibit more excellent crush resistance at high temperatures.

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