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Research paper

Fatigue behavior of TiNi foams processed by the magnesium space holder technique

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ABSTRACT

While the wide range of applications of TiNi alloys makes them highly appealing due to their shape memory and superelasticity properties, the production of TiNi in the porous form further enlarges their application fields. Porous TiNi alloys have been studied extensively for biomedical applications since their elastic modulus is similar to that of bone. Accordingly, TiNi foams have been widely characterized in terms of their various mechanical properties; however, their fatigue properties have not been well studied, even though this is of vital importance in structural applications such as medical implants. In the scope of this study, TiNi foams processed from prealloyed powders by the magnesium space holder technique were mechanically characterized by monotonic and cyclic compression tests. TiNi foams with a porosity range of 49–64 vol.%, which is suitable for bone ingrowth, were determined to have a compressive strength varying in the range 93.27–273.45 MPa. Moreover, the wide range of elastic modulus values obtained (2.93–8.71 GPa) is promising for fulfilling various requirements of different implant applications without causing stress shielding. On the other hand, the endurance limit of TiNi foams was determined to be $0.6\sigma_y$, where σ_y is the yield strength, independent of the porosity content. Fractography studies on the failed foams after fatigue testing revealed that the failure occurs by the coalescence of micro-cracks initiated from pore walls leading to macro-crack formation aligned at 45 ° with respect to the loading axis.

1. Introduction

Porous TiNi alloys (foams) have been studied extensively in terms of their processing and application fields, especially biomedical applications (bone implants), because of their outstanding properties such as superelasticity and shape memory effect. One of the most outstanding properties of porous TiNi alloys as an implant material is that, compared to other implant materials, their elastic modulus is much more similar to that of bone (Geetha et al., 2009); the modulus can further be adjusted by controlling the level of porosity in the structure. Porous TiNi alloys have been widely characterized in terms of their various mechanical properties; however, their fatigue properties have not been well studied, even though they might be considered as one of the most important mechanical properties due to the operation conditions and resulting complications encountered in implant applications. Although there are

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