RESEARCH & TECHNOLOGY

A COMPARATIVE STUDY ON MICROSTRUCTURE AND COMPRESSIVE PROPERTIES OF NiTi ALLOYS SINTERED FROM Ni/Ti AND Ni/TiH_2 MIXTURES

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This work reports a comparative study using nickel powder and two different titanium powder sources to synthesize porous NiTi alloys via a conventional press-and-sinter powder metallurgy process. Two batches of powder mixture (i.e., Ni/Ti and Ni/TiH_2) were prepared in a ball mill, pressed under five different compaction pressures, and subsequently sintered in vacuum at 1,100 °C for 2 h. The results of microstructural observations reveal porosity ranging from 5.1 ± 0.6% to 31.2 ± 0.3%, and density varying from 4.38 ± 0.02 g/cm^3 to 5.74 ± 0.04 g/cm^3 in the sintered samples. The predominant phase identified in all the NiTi alloys produced is B2-NiTi, with the presence of minor Ni_3Ti and $NiTi_2$ phases. The sinter shrinkage is not uniform, with axial shrinkage (A) being larger than radial shrinkage (R). The A:R ratio increases with increasing compaction pressure.
The cyclic compressive behaviors of the porous NiTi alloys made from Ni/Ti and Ni/TiH_2 mixtures were also investigated.
In comparison with the sintered Ni/Ti samples, the sintered Ni/TiH_2 samples exhibit more porosity, a larger pore size, lower fracture strength, and lower secant modulus.

INTRODUCTION

The equiatomic NiTi alloy was first found accidentally by Buehler et al.[1] and immediately attracted extensive research interest because of its unique properties, such as shape-memory effect (SME), pseudoelastic properties, low stiffness, large energy absorption, and excellent biocompatibility.[2] Although ingot-wrought processing is the mainstream manufacturing technique for solid NiTi products, powder metallurgy (PM) offers an alternative approach. In particular, PM technologies have exceptional advantages if a porous NiTi microstructure is required. Porous structures can be readily obtained by incomplete sintering, space holding, or additive manufacturing (3D printing). One example of the utilization of a porous structure is for surgical implants.[3] Porosity on the implant surface not only benefits the bone-tissue ingrowth, but also provides an effective way of reducing the stiffness of the implant. Reducing the implant stiffness to that of bone helps mitigate a phenomenon of stress shielding that usually leads to failure of the implant.[4] In PM, the conventional press-and-sinter process is by far the most widely used method to fabricate NiTi alloys and is a simple, cost-effective, and highly efficient route.[5] Prealloyed NiTi, or elemental Ti and Ni powders, are mixed and pressed into compacts under a pressure of 200–1,100 MPa. The green compacts are then sintered in a protective atmosphere or under vacuum at a temperature of 900–1,200 °C. The pores in the sintered NiTi alloys are caused by several factors, such as original pores in the green parts,[6] the Kirkendall effect,[6,7] a transient liquid phase,[6] and phase transformation (alloying).[8]

The use of TiH_2 powder has been claimed to promote densification and

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