ABSTRACT

Several research efforts have been directed towards in-situ fabrication of titanium matrix composites (TMCs) from Ti and B_4C powder mixtures as one of the ways to improve the physical and mechanical properties of titanium and its alloys. In this perspective, the present study reports the development of in-situ particulate reinforced titanium matrix composites from TiH_2-B_4C and Ti-B_6O powder mixtures

The relationship between densification and microstructure and mechanical properties (hardness and fracture toughness) of pure Ti and in-situ reinforced titanium matrix composites have been studied in detail using pressureless and hot-pressing techniques. Titanium hydride powder was compacted into cylindrical pellets that were used to produce pure Ti through dehydrogenation and pressureless sintering technique. Various composition of TiH_2-B_4C powder mixtures were initially milled using alumina balls in a planetary mill. The milling was to achieve homogeneous mixing and distribution of the ceramic partially in the TiH_2 powder, as well as uniform distribution of reinforcing phases on the resulting Ti matrix.

Dehydrogenation and conversion of loose powder and compacts of TiH_2 powder was carried out in argon atmosphere and complete removal of hydrogen was achieved at 680 and 715^oC for loose and compacted powder respectively. Pressureless sintering of pure Ti from TiH_2 was carried out between 750-1400^oC, while pressureless sintering and hot pressing of TiH_2-B_4C was carried out in the temperature range1100-1400^oC using 30MPa for hot pressed samples in argon atmosphere. Different sintering times were considered. The microstructure and phase composition of the sintered and hot-pressed materials were characterized using scanning electron microscopy (SEM) and X-ray diffractometry (XRD). Densities of the sintered and hot-pressed materials were measured to determine the extent of densification, while Vickers hardness and indentation fracture toughness were used to measure the mechanical properties of the sintered and hot-pressed materials.

...gher densification of above 99% of theoretical density compared to literature where lower densification and swelling was observed. Its Vickers hardness is higher than that of commercial Ti sintered under the same conditions.

Titanium matrix composites (TMCs) with different volume content of in-situ formed reinforcements $(TiB + TiC)$ were successfully produced. The amount of reinforcements formed increases with increased amount of B_4C used in the starting powder mixtures, while the amount of needle-type TiB decrease and size and amount of blocky-type TiB increase with increasing volume fraction of TiB. Dense materials and improved Vickers hardness were achieved by the hot-pressed composites especially at 1400^oC compared to the pressureless sintered composites under the same conditions and to the relevant literature. TMCs produced in this study show higher Vickers hardness compared to available data in the literature. The hardness was found to depend on the volume content of the reinforcing phases. However, the fracture toughness obtained is low ($5.3MPa.m^{1/2}$) in comparison to pure Ti but is comparable with reported data in the literature.

The mechanisms leading to the achievement of improved densification and higher hardness and the reasons for lower fracture toughness with different sintering temperature and composition of reinforcements in the composites are critically analysed. It has been shown that pure Ti can be pressureless sintered using TiH_2 and reinforced Ti matrix composites with improved densification and mechanical properties can be produced from TiH_2-B_4C powder mixtures. Further work on the comprehensive study of the mechanical properties of these composites would enhance the industrial potential of using these materials and the processing route to produce economically feasible titanium matrix composites.