World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:10, No:06, 2016

Dependence of Densification, Hardness and Wear Behaviors of Ti6Al4V Powders on Sintering Temperature

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Abstract : The sintering step in powder metallurgy (P/M) processes is very sensitive as it determines to a large extent the properties of the final component produced. Spark plasma sintering over the past decade has been extensively used in consolidating a wide range of materials including metallic alloy powders. This novel, non-conventional sintering method has proven to be advantageous offering full densification of materials, high heating rates, low sintering temperatures, and short sintering cycles over conventional sintering methods. Ti6Al4V has been adjudged the most widely used α+β alloy due to its impressive mechanical performance in service environments, especially in the aerospace and automobile industries being a light metal alloy with the capacity for fuel efficiency needed in these industries. The P/M route has been a promising method for the fabrication of parts made from Ti6Al4V alloy due to its cost and material loss reductions and the ability to produce near net and intricate shapes. However, the use of this alloy has been largely limited owing to its relatively poor hardness and wear properties. The effect of sintering temperature on the densification, hardness, and wear behaviors of spark plasma sintered Ti6Al4V powders was investigated in this present study. Sintering of the alloy powders was performed in the 650–850°C temperature range at a constant heating rate, applied pressure and holding time of 100°C/min, 50 MPa and 5 min, respectively. Density measurements were carried out according to Archimedes’ principle and microhardness tests were performed on sectioned as-polished surfaces at a load of 100gf and dwell time of 15 s. Dry sliding wear tests were performed at varied sliding loads of 5, 15, 25 and 35 N using the ball-on-disc tribometer configuration with WC as the counterface material. Microstructural characterization of the sintered samples and wear tracks were carried out using SEM and EDX techniques. The density and hardness characteristics of sintered samples increased with increasing sintering temperature. Near full densification (99.6% of the theoretical density) and Vickers’ micro-indentation hardness of 360 HV were attained at 850°C. The coefficient of friction (COF) and wear depth improved significantly with increased sintering temperature under all the loading conditions examined, except at 25 N indicating better mechanical properties at high sintering temperatures. Worn surface analyses showed the wear mechanism was a synergy of adhesive and abrasive wears, although the former was prevalent.

Keywords : hardness, powder metallurgy, spark plasma sintering, wear
Conference Title : ICMME 2016 : International Conference on Metal Materials and Engineering
Conference Location : Copenhagen, Denmark
Conference Dates : June 27-28, 2016