World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:12, No:08, 2018

Combined Synchrotron Radiography and Diffraction for in Situ Study of Reactive Infiltration of Aluminum into Iron Porous Preform

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Abstract : The use of Fe-Al based intermetallics as an alternative to Cr/Ni based stainless steels is very promising for industrial applications that use critical raw materials parts under extreme conditions. However, the development of advanced Fe-Al based intermetallics with appropriate mechanical properties presents several challenges that involve appropriate processing and microstructure control. A processing strategy is being developed which aims at producing a net-shape porous Fe-based preform that is infiltrated with molten Al or Al-alloy. In the present work, porous Fe-based preforms produced by two different methods (selective laser melting (SLM) and Kochanek-process (KE)) are studied during infiltration with molten aluminum. In the objective to elucidate the mechanisms underlying the formation of Fe-Al intermetallic phases during infiltration, an in-house furnace has been designed for in situ observation of infiltration at synchrotron facilities combining x-ray radiography (XR) and x-ray diffraction (XRD) techniques. The feasibility of this approach has been demonstrated, and information about the melt flow front propagation has been obtained. In addition, reactive infiltration has been achieved where a bi-phased intermetallic layer has been identified to be formed between the solid Fe and liquid Al. In particular, a tongue-like Fe_2Al_5 phase adhering to the Fe and a needle-like Fe_4Al_{13} phase adhering to the Al were observed. The growth of the intermetallic compound was found to be dependent on the temperature gradient present along the preform as well as on the reaction time which will be discussed in view of the different obtained results.

Keywords : combined synchrotron radiography and diffraction, Fe-Al intermetallic compounds, in-situ molten Al infiltration, porous solid Fe preforms
Conference Title : ICMSMM 2018 : International Conference on Materials Science, Metal and Manufacturing
Conference Location : Barcelona, Spain
Conference Dates : August 20-21, 2018