Welding of high performance metal matrix composite materials: the ICME approach

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Abstract

The material development cycle is becoming too slow if compared with other technologies sectors like IT and electronics. The materials scientists’ community needs to bring materials science back to the core of human development. ICME (Integrated Computational Materials Engineer) is a new discipline that uses advanced computational tools to simulate material microstructures, processes and their links with the final properties. There is the need for a new way to design tailor-made materials with a faster and cheaper development cycle while creating products that meet “real-world” functionalities rather than vague set of specifications. Using the ICME approach, cutting edge computational thermodynamics models were employed in order to assist the microstructure characterization and refinement during the TIG welding of a functionally graded composite material with outstanding wear and corrosion resistance. The DICTRA diffusion model accurately predicted the carbon diffusion during sintering, Thermo-Calc and TC-PRISMA models described the thermodynamic and kinetics of harmful carbide precipitation, while COMSOL Multiphysics furnished the temperature distribution profile at every timestep during TIG welding of the material. Bainite transformation and the influence of chromium and molybdenum was studied and modelled with MAP_STEEL software. The simulations were then compared with experimental observations and a very good agreement between computational works and experiments was found for both thermodynamic and kinetics predictions. The use of this new system proved to be a robust assistance to the classic development method and the material microstructures and processes were carefully adjusted in order to increase corrosion resistance and weldability. This new approach to material development can radically change the way we think and we make materials. The results suggest that the use of computational tools is a reality that can dramatically increase the efficiency of the material development.

Keywords: ICME, computational materials design, computational thermodynamics, CALPHAD method, CAE, FEA, welding engineering, steel microstructures characterization, WC-Co metal matrix composite.