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Elaboration and Characterization of in-situ CrC- Ni(Al, Cr) Composites Elaborated from Ni and Cr_2AlC Precursors

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Abstract : Metal matrix composites (MMCs) have been of big interest for a few decades. Their major drawback lies in their enhanced mechanical performance over unreinforced alloys. They found ground in many engineering fields, such as aeronautics, aerospace, automotive, and other structural applications. One of the most used alloys as a matrix is nickel alloys, which meet the need for high-temperature mechanical properties; some attempts have been made to develop nickel base composites reinforced by high melt point and high modulus particulates. Among the carbides used as reinforcing particulates, chromium carbide is interesting for wear applications; it is widely used as a tribological coating material in high-temperature applications requiring high wear resistance and hardness. Moreover, a set of properties make it suitable for use in MMCs, such as toughness, the good corrosion and oxidation resistance of its three polymorphs -the cubic (Cr23C6), the hexagonal (Cr7C3), and the orthorhombic (Cr3C2)-, and it's coefficient of thermal expansion that is almost equal to that of metals. The in-situ synthesis of CrC-reinforced Ni matrix composites could be achieved by the powder metallurgy route. To ensure the in-situ reactions during the sintering process, the use of phase precursors is necessary. Recently, new precursor materials have been proposed; these materials are called MAX phases. The MAX phases are thermodynamically stable nano-laminated materials displaying unusual and sometimes unique properties. These novel phases possess Mn+1AXn chemistry, where n is 1, 2, or 3, M is an early transition metal element, A is an A-group element, and X is C or N. Herein, the pressureless sintering method is used to elaborate Ni/Cr2AlC composites. Four composites were elaborated from 5, 10, 15 and 20 wt% of Cr2AlC MAX phase precursor which fully reacted with Ni-matrix at 1100 °C sintering temperature for 4 h in argon atmosphere. XRD results showed that Cr2AlC MAX phase was totally decomposed forming chromium carbide Cr7C3, and the released Al and Cr atoms diffused in Ni matrix giving rise to γ-Ni(Al,Cr) solid solution and γ'-Ni3(Al,Cr) intermetallic. Scanning Electron Microscopy (SEM) of the elaborated samples showed the presence of nanosized Cr7C3 reinforcing particles embedded in the Ni metal matrix, which have a direct impact on the tribological properties of the composites and their hardness. All the composites exhibited higher hardness than pure Ni; whereas adding 15 wt% of Cr2AlC gives the highest hardness (1.85 GPa). Using a ball-on-disc tribometer, dry sliding tests for the elaborated composites against 100Cr6 steel ball were studied under different applied loads. The microstructures and worn surface characteristics were then analyzed using SEM and Raman spectroscopy. The results show that all the composites exhibited better wear resistance compared to pure Ni, which could be explained by the formation of a lubricious tribo-layer during sliding and the good bonding between the Ni matrix and the reinforcing phases.

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