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Characterization of Al-Al_3Ni Composites Synthesized In-situ via Powder Metallurgy Method

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***Abstract*— Al-Al_3Ni composites due to their high strength, creep resistance, fatigue resistance, good ductility, adequate toughness, high corrosion resistance and hardness have gained considerable attention in recent years. In the present investigation, for the first time, powder metallurgy (PM) method was used to in-situ produce Al-Al_3Ni composites. Commercially pure aluminum powders (63-125 µm) and the same sized pure nickel powders used as starting materials. The Al and Ni powders were initially soaked in NaOH and acetone respectively to remove their surface impurities. The Al/Ni powder mixtures with different Ni contents subjected to cold pressing and sintering at different temperatures for various times. Samples of Al powders without Ni addition were also prepared using identical procedures as for Al/Ni composites to serve as the reference samples. The results of XRD, optical microscopy and SEM studies as well as Brinell hardness measurements performed on the sintered compacts revealed that even after 75 minutes sintering of an Al/Ni compact at 640 ˚C, the unreacted Ni particles could be detected in the sample. The increased sintering temperature to 655˚C resulted in more effective interaction between Al and Ni during sintering at 15 minutes. However, sintering at this temperature for longer periods of time resulted in partial melting and deformation of the samples. Therefore, Ni powders subjected to high-energy ball milling to increase their activity. The XRD results confirmed that sintering at 655˚C of the Al/Ni powder compact containing 15wt.% of ball-milled Ni resulted in complete reaction and Al-Al_3Ni eutectic formed without any unreacted Ni. The porosity level of the samples increased with increasing percentage of Al_3Ni phase in the matrix. Brinell hardness values of all the composite samples were higher than that of their reference counterpart. The Al-20wt.% Ni sample prepared by milled Ni exhibited the maximum hardness value being almost three times of that of the reference sample. However, the increased content of milled Ni to 25wt.% resulted in some unreacted Ni particles in the matrix as was confirmed by XRD studies.**

Keywords: Al-Al_3Ni Composites, In-situ method, Powder metallurgy, Ball milling, Sintering, Hardness, XRD, OM, SEM.

1. INTRODUCTION

Among metal matrix composites (MMCs), aluminum matrix composites have received much attention due to their low density, low cost compared to other light alloys such as lithium and titanium and good properties such as strength, flexibility and corrosion resistance [1-3]. The processing methods of these composites can be broadly divided into two methods of ex-situ and in-situ techniques. In ex-situ processes, the second phase material is initially prepared and then incorporated in the matrix using a specified process such as casting or powder metallurgy. In these processes, the distribution of the second phase in the matrix is usually non-uniform and this problem results in inferior strength and toughness of the produced composite. Another drawback for ex-situ methods is incident of distractive chemical reactions at the reinforcement/matrix interface, weak bonding due to impurities on the surface of reinforcing phase and its imperfect wettability with the matrix all contribute to inferior mechanical properties of MMCs [4-7]. In the in-situ processes, the rod shape or lamellar reinforcements are created during plane front solidification of alloys [8]. Also the reinforcing particles can be formed by a chemical reaction during processing of the composite. The in-situ formed particles are very fine, thermodynamically stable and well distributed in the matrix alloy and can withstand higher service temperatures. The interface at the reinforcing particle/matrix is clean and causes strong bonding between two adjacent phases resulting in superior mechanical properties specially at elevated temperatures [4, 5, 9-16].

On the other hand, for applications that require low weight, high thermal stability, corrosion resistance and suitable mechanical properties at high temperatures, aluminum intermetallics are used as structural materials. Al-Ni intermetallics are used in transportation, aerospace and similar industries, but their low ductility and low toughness at