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Effect of Heating Mode on Sinterability of Fe-Ni Steels

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ABSTRACT

The present study examines the effect of heating mode on the densification, microstructure, and mechanical properties of iron–nickel steel with graphite and phosphorus addition. The compacts were sintered in conventional (radiatively-heated) and microwave (2.45 GHz, multimode) furnaces at 1120°C for 1 hour in forming gas (dissociated ammonia atmosphere, 95% N_2-5% H_2). The experimental results show that microwave sintered alloy has better properties compared with the conventionally sintered counterparts. Detailed analyses by using optical microscopy and scanning electron microscopy (SEM) reveal that microwave sintered sample has finer microstructure. SEM examination of the fractured surfaces indicate that a mixed mode fracture containing both, ductile and brittle types, is present in microwave sintered alloy, in contrast with the brittle fracture only in conventional sintered counterpart.

KEYWORDS: Microwave sintering, ferrous alloys, mechanical properties, microstructure

INTRODUCTION

In recent years powder metallurgy (PM) steel components are increasingly being utilized for automotive and structural applications [German, 1994]. As compared to conventional casting techniques, PM processing offers advantages such as lower processing temperature, near net - shaping, high density, greater material utilization (> 95%) and more refined microstructure that provides superior material properties [Kaysser et al., 1985]. In order to improve the mechanical properties of the PM materials alloying elements are generally added; for example in case of ferrous materials copper, nickel, carbon in the form of graphite, and phosphorus in the form of ferro-phosphorus, (Fe_3P) are added [Andrej, 1995]. In order to avoid thermal shock, the conventional sintering furnace involves heating at very slow rate (<10 °C/min) and with isothermal holds at intermediate temperatures. This not only increases the process time, but also results in microstructural coarsening during sintering, leading to the degradation of mechanical properties, while one of the techniques to overcome this problem is through microwaves [Rao et al., 1995].

Microwave sintering of iron, nickel, phosphorus metal powders has not been reported in the literature, but various other powder metals, metal composites and ceramics have