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Effect of carbusintering on densification behavior and mechanical properties of Fe–2%Ni–x%Cu alloys

Shuangyu Liu [a,*], Hong Zhang [a], Jiandong Hu [b]

[a] College of Mechanical and Electric Engineering, Changchun University of Science and Technology, No. 7089 WeiXing Road, Changchun 130022, PR China
[b] The Key Lab of Automobile Materials, Ministry of Education, College of Materials Science and Engineering, Jilin University, Changchun 130025, PR China

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ABSTRACT

Densification behavior and mechanical properties of Fe–Ni–Cu alloys prepared by carbusintering (CBS) and conventional sintering (CS) were studied. Carbusintering process showed the improved properties and high density compared with conventional sintering process. These differences can be explained by the microstructure and the diffusion of copper in iron powder. Microstructure observations indicated that the carbusintering process favored to refine grain size. Diffusion model analysis indicated that the diffusion coefficient of copper in iron was up to 0.63×10^{-14} m^2/s during carbusintering process. After heat treatment, the hardness, impact energy and ultimate fracture strength of carbusintered compact are increased to 48HRC (484 HV), 13 J and 531 MPa, respectively. The use of CBS process was able to make process simple by taking sintering and carburizing as one step. The higher carbon content of the surface in P/M parts can be easily achieved compared to conventional carburizing.

1. Introduction

Powder metallurgy (P/M) technology has been frequently used to manufacture a verity of mechanical components owing to its low energy consumption, high materials utilization, and low cost of production, resulting from the near net shape process [1,2]. Copper and nickel have been proved to be an effective alloying additive for conventional iron based P/M parts [3]. The copper in iron implements strengthening by either solid solution hardening or the formation of copper precipitates. Nickel mainly enhances hardenability of P/M materials. Further improvement can be achieved by subsequent heat treatments to form martensite with fine precipitates. Copper usually causes problems in dimensional control owing to the expansion phenomenon during sintering even though it can significantly improves the mechanical properties of iron based powder compacts. The expansion of Fe–Cu compacts has been reported extensively. It is thought to related to copper rich liquid phase penetration of inter- and intraparticle grain boundaries. This expansion phenomenon can be inhibited by using different methods. Carbon addition has been found to increase the dihedral angle and lessen the copper penetration effect, which decreases compact growth [4]. Griff and German described that a larger specific surface area of the iron powder and particle size of copper powder, such as in reduced iron powder, and lower compacting pressure favored to reduce copper growth [5]. Wanibe et al. reported that expansion could be overcome by the particle rearrangement effect when the copper content was more than 10% [6]. In addition, Chawla et al. has compared the microstructure and tensile behavior of two Fe–0.5Mo–1.5Cu–1.75Ni alloys made by binder treated and diffusion alloying processes, respectively. The results indicated that the binder treatment can provide a variety of advantages in manufacturing, over diffusion alloyed powders, including faster and more consistent flow into the die cavity, increased green density, and reduction of fine particle dusting [7]. Bocchini [8] reported that if mechanical strength is the main requirement for the application and some impact strength should be ensured, the 'hybrid' materials, combining pre-alloyed molybdenum and diffusion bonded nickel are the best choice. Nuria Candela [9] reported that pre-alloyed Fe–3.5%Mo were mixed with copper, nickel and graphite as alloying elements to improve the density and final properties of the materials. The test with the unnotched specimens was carried out with an available energy of 9.2 J. But only after heat treatment, the good mechanical strength can be ensured.

The surface hardening was usually carried out for P/M components to obtain a harder surface layers and tough core, which exhibit both high wear resistance and strength. In the past few years, surface hardening processes such as plasma nitriding [10], nitriding and nitrocarburizing [11], as well as surface carburizing and carbonitriding [12] treatments have been widely used for the surface hardening treatments of P/M parts. However, surface hardening processes has long production cycle and complicated equipment. For conventional carburization process, such as solid carburization process, it has a lot

* Corresponding author. Tel.: +86 431 8558 2207; fax: +86 431 8538 4427.
E-mail address: liushuangyu@cust.edu.cn (S. Liu).

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