Materials and Design 32 (2011) 1273–1282

Contents lists available at ScienceDirect

Materials and Design

journal homepage: www.elsevier.com/locate/matdes

Wear behavior and mechanical performance of metal injection molded Fe–2Ni sintered components

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ARTICLE INFO

Article history:
Received 2 July 2010
Accepted 28 September 2010
Available online 25 October 2010

Keywords:
Powder metallurgy
Ferrous metals and alloys
Wear

ABSTRACT

The microstructure, mechanical properties, and wear behavior of two key components of a hinge fabricated from a metal injection molding process that was then sintered and heat treated under various conditions were analyzed using an optical microscope, a pin-on-disk tester, an open-closed reciprocal wear tester, and a scanning electron microscope. Optical photomicrograph revealed a serious decarburization in the sintered component, suggesting that an increase in carbon content would be necessary to improve mechanical properties. At the initial stage of the open-closed reciprocal wear test, the obverse inclined planes of both components exhibited plastic deformation and depression. As the number of test cycles increased, an increase in cold welding, metal adhesion, spalling, delamination, and surface fatigue was observed, triggering a decrease in metal thickness, which in turn altered the shape of the components. In this study, the optimal parameters to satisfy commercial application requirements were obtained when the components were carburized at 870 °C for 30 min, quenched in oil, and finally tempered at 250 °C for 1 h.

1. Introduction

Hinges are widely used in 3C (Computer, Communications, and Consumer Electronics) products. Various hinge designs are available, including ones with multiple degrees of freedom and ones with a hollow axial cylinder to accommodate wires for electrical signal transmission [1,2]. A typical example of a hinge application is on a laptop to adjust the angle of the LCD screen. Fig. 1 shows a pivot hinge from a laptop. The two key components of a hinge are the sliding component (A) and the fixed component (B). A hinge uses the axial force from a spring to compress the sliding and fixed components together to produce a radial frictional force. These two components work together to deliver the required friction force for maintaining the LCD screen in position. The typical range of the dimensions of these components is between 2 and 35 mm, and the components are usually complicated in shape. Desirable hinge design properties include a smooth sliding action, precise size, high strength, high hardness, adequate toughness, fatigue-resistant, wear-resistant, and low cost. For typical commercial hinge applications, the torque exerted on a hinge is between 3.5 and 15 kgf-cm, the minimum required life of a hinge is 20,000 cycles, and a torque descend no more than 30% when in the closed mode.

Metal injection molding (MIM) is suitable for manufacturing small components with complex geometries [3,4]. Carbonyl iron powder is one of the most commonly used materials for metal injection molding. Its popularity is attributed to its superior mechanical properties, ease in heat-treatment, and competitive price. One major drawback of the carbonyl iron powder, however, is the abnormal grain growth that occurs in the final stage of sintering, resulting in the density of the sintered component only attaining 96% of its theoretical value, even when a vacuum furnace is used in conjunction with a high sintering temperature of 1300 °C [5–7]. To improve the mechanical properties of MIM sintered components, nickel powder is often added to carbonyl iron powder as an alloying element. The abnormal grain growth of carbonyl iron can be effectively controlled by the dissolution of nickel into the iron matrix. The addition of nickel to iron suppresses abnormal grain growth in the final stage of sintering and is beneficial in increasing the density of a component [8–10]. It is shown through experiments that a chemical composition of Fe–10Ni (wt.%) attains the highest sintered density with a relatively small grain size [11]. However, when both cost and performance are taken into account, a chemical composition of Fe–2Ni (wt.%) is normally adopted [12,13]. However, no research has been found that focuses on the wear behavior and mechanical properties of MIM Fe–2Ni sintered components. This study was carried out to evaluate the influence of heat-treatment on the mechanical properties of MIM Fe–2Ni components and the relationship between open-closed reciprocal wear test cycles and wear behavior to understand the mechanisms of wear in a hinge component to improve its quality.

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doi:10.1016/j.matdes.2010.09.034