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Analysis of density and mechanical properties of high velocity compacted iron powder

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A new method for producing higher density PM parts, high velocity compaction (HVC), was presented in the paper. Using water atomized pure iron powder without lubricant admixed as the staring material, ring samples were compacted by the technique. Scanning electron microscopy (SEM) and a computer controlled universal testing machine were used to investigate the morphologies and the mechanical properties of samples, respectively. The relationships among the impact velocity, the green density, the sintered density, the bending strength and the tensile strength were discussed. The results show that with increasing impact velocity, the green density and the bending strength increase gradually, so the sintered density does. In addition, the tensile strength of sintered material is improved continuously with the sintered density enhancing. In the study, the sintered density of 7.545 g/cm^3 and the tensile strength of 190 MPa are achieved at the optimal impact velocity of 9.8 m/s.
KEY WORDS Powder metallurgy; High velocity compaction; Density; Mechanical properties; Iron powder

1 Introduction

Some metal parts, such as bearings and filters, require high porosity to retain oil, but in most cases the highest practical density is indispensable for strength, ductility and surface quality, etc. In addition, green compacts with higher density are beneficial to transport before sintering and have better dimensional stability during sintering than lower density parts[1]. In recent years, there are a number of methods for preparing high density components, such as warm compaction, double compaction (P2S2), explosive compaction, powder forging and high velocity compaction (HVC). Warm compaction method depends on a special lubricant, but the lubricant used may reduce the sintered density and decrease the mechanical properties of parts. Double compaction technology has been established for many years, but is limited for high costs. Explosive compaction technique is limited owing to the explosive used and the low productivity. For powder forging, the surface finish and tool economy are inferior compared to other mentioned processes above. So for many high

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performance applications the HVC process is the most attractive from cost/performance point of view[2,3].

The HVC technique is similar to conventional process but consists in accelerating a hammer and inputting impact energy instead of force. The hammer strikes the upper punch with a given kinetic energy and the stress increases in a very short time[4]. The press enables to achieve densification in a short time, less than 0.3 s, shorter than conventional compaction but longer than explosive pressing (0.001 s)[5]. Advantages of the process are high density, uniform density distribution, low ejection force and low springback, *etc.*, but only can single-level parts be produced and the die is expensive[6].

Recently, iron based powders with lubricant added were investigated using HVC[5,7,8] and a comparative study of conventional pressing and HVC was done[8,9]. Although the lubricant admixed can reduce inter-particle friction, its most important role is to overcome particle-die wall friction[10,11]. Furthermore, no lubricant can burn off substantially during sintering, whilst leaving ashes inside the part. So, it hinders the diffusion process during sintering. In the paper, iron powder without lubricant added was pressed by HVC, and then the density and the mechanical properties of parts were discussed.

2 Experimental Procedure

Water atomized pure iron powder without lubricant admixed as the starting materials was compacted adopting HVC method. Characteristics and image of the powder were shown in Table 1 and Fig.1, respectively. Ring parts, with outer and inner diameters of 60 mm and 30 mm, respectively, were prepared as shown in Fig.2. The mass of filled powder was 100 g for each pressing and three specimens were produced at each impact velocity.

The HVC device and the schematic illustration of compaction process were shown in Fig.3a and Fig.3b, respectively. The die was equipped on the tool adapter, whereas the

Table 1 Characteristics of water atomized pure iron powder

Apparent density (g/cm^3)	Tap density (g/cm^3)	Flowability (s/50 g)	Particle size distribution (volume pct)			
			<46 μm	46–76 μm	76–150 μm	>150 μm
3.10	3.92	25.4	35.1	33.5	25.3	6.1

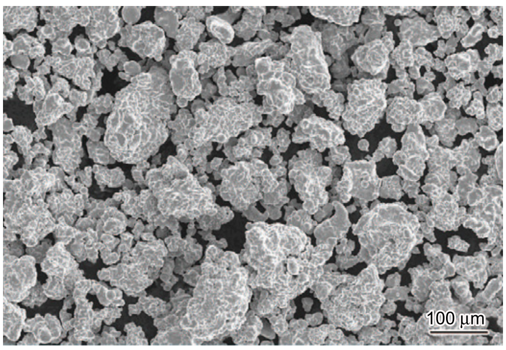

Fig.1 Image of water atomized pure iron powder.

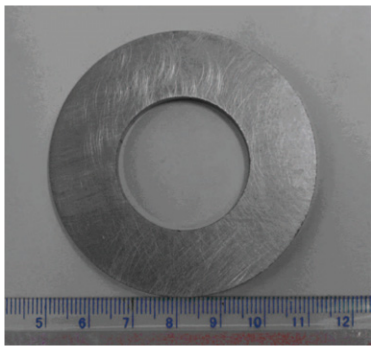

Fig.2 Ring sample.