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Anisotropy of ternary and (Zr, Ga) addition magnetic powders

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Abstract. Both non-homogenization treatment Zr, Ga addition and ternary Strip Casting alloy flakes can be used to prepare anisotropy HDDR NdFeB magnetic powders. This illustrates that anisotropy formation of magnetic powders neither depends on element addition nor depends on homogenization heat treatment of SC flakes. But the HDDR process procedure also plays an important role in anisotropy inducement. Highly anisotropic magnetic powders are attributed to rapid disproportionation reaction course, slow desorption-recombination reaction course, and optimum recombination hydrogen pressure during HDDR procedure process. This paper will provide an important guidance for preparing highly anisotropy magnetic powders with low cost.

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Key words: magnetic powders, SC alloy flakes, HDDR process, anisotropy

1 Introduction

The HDDR process (hydrogenation, disproportionation, desorption and recombination) has attracted broad attention for producing anisotropic Nd-Fe-B magnetic powders. Early experiment results indicated that addition of elements such as Co, Zr, Nb and Ga is prerequisite for anisotropy inducement in NdFeB-type alloys treated by the HDDR process [1]. The subsequent experiments showed that the anisotropic magnetic powders can also be obtained from purely ternary alloy subjected to an optimum HDDR process treatment [2-5]. Not only the elements addition, but also the HDDR process plays an important role in anisotropy formation. The HDDR magnetic powders are commonly prepared from segregated master ingots, and their magnetic properties are low due to the existence of soft magnetic phase α-Fe in master ingots. The SC (strip casting) alloy flakes have a good

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columnar crystalline structure, the main phase $Nd_2Fe_{14}B$ is uniformly separated by the symmetrical Nd-rich phase fine lamella and α-Fe is nonexistent, which is very suitable for preparing HDDR magnetic powders [6]. The HDDR magnetic powders prepared directly from non-heat-treated SC alloy flakes are isotropic [7]. But the anisotropic magnetic powders can be prepared from heat-treated SC alloy flakes subjected to the HDDR process [8]. Up to date, element addition and homogenization heat treatment of SC flakes are necessary condition or not for anisotropy formation, which has still not been reported. Based on current research situation, This paper tries to prepare anisotropic magnetic powder by using non-heat-treated Zr, Ga addition and ternary SC alloy flakes.

2 Experimental procedure

The $Nd_{12.8}Fe_{72}Co_{7.8}B_7Zr_{0.1}Ga_{0.3}$ and $Nd_{13.5}Fe_{79.5}B_7$ alloys are prepared using induction melting under argon atmosphere. The crushed alloys are put into the quartz tube of SC equipment waiting for melting, and then the molten alloys are ejected onto a copper wheel surface rotating at a speed of 3m/s to form the SC alloy flakes. The non-heat-treated SC alloy flakes are carried out a modified HDDR process to prepare the NdFeB magnetic powders. And the modified process schematic diagram is shown in Fig.1. First, the SC flakes are heated from room temperature to 800°C at a heating rate of 15°C/min in the hydrogen pressure of 1×10^5 Pa, and then kept at this temperature and pressure for 10 min-5 h. Second, the disproportionation products are followed by a slow desorption reaction at 850°C for 30min under hydrogen pressure of 10-70 kPa, and then followed by a fast desorption reaction in the high vacuum of 5×10^{-3} Pa at 850°C for 1h. Last, the alloys are quenched to room temperature in the argon atmosphere pressure of 1×10^5 Pa. After the magnetic powders are aligned in a magnetic field of 1.2 MAm^{-1}, their properties are measured using the vibrating sample magnetometer (VSM) with a maximum field of 2 MAm^{-1} at room temperature. The alignment degree of anisotropy (DOA) of the magnetic powders is evaluated using the ratio of remanence to saturation magnetization (B_r/B_s, the value of B_s is the actually measured value of the magnetic powders).

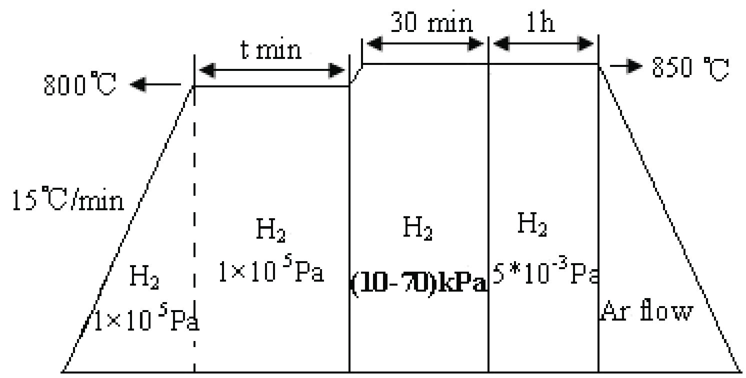

Figure 1: HDDR process schematic drawing.