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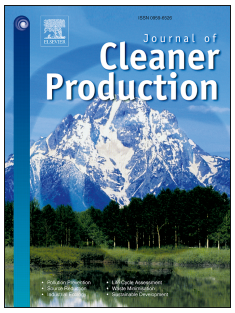

The Use of Hydrogen to Separate and Recycle Neodymium-Iron-Boron-type Magnets from Electronic Waste

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The Use of Hydrogen to Separate and Recycle Neodymium-Iron-Boron-type Magnets from Electronic Waste

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Abstract – The rare earth metals have been identified by the European Union and the United States as being at greatest supply risk of all the materials for clean energy technologies. Of particular concern are neodymium and dysprosium, both of which are employed in neodymium-iron-boron based magnets. Recycling of magnets based on these materials and contained within obsolete electronic equipment, could provide an additional and secure supply. In the present work, hydrogen has been employed as a processing agent to decrepitate sintered neodymium-iron-boron based magnets contained within hard disk drives into a demagnetised, hydrogenated powder. This powder was then extracted mechanically from the devices with an extraction efficiency of 90 ±5 % and processed further using a combination of sieves and ball bearings, to produce a powder containing <330 parts per million of nickel contamination. It is then possible for the extracted powder to be re-processed in a number of ways, namely, directly by blending and re-sintering to form fully dense magnets, by Hydrogenation, Disproportionation, Desorption, Recombination processing to produce an anisotropic coercive powder suitable for bonded magnets, by re-melting; or by chemical extraction of the rare earth elements from the alloy. For example, it was shown that, by the re-sintering route, it was possible to recover >90% of the magnetic properties of the starting material with significantly less energy than that employed in primary magnet production. The particular route used will depend upon the magnetic properties required, the level of contamination of the extracted material and the compositional variation of the feedstock. The various possibilities have been summarised in a flow diagram.

Key Words – Hydrogen, Magnets, NdFeB, Recycle, Rare-Earth.

INTRODUCTION:

Rare earth magnets based upon neodymium-iron-boron (NdFeB) are employed in many clean energy and high tech applications, including hard disk drives (HDDs), motors in electric vehicles and electric generators in wind turbines.

In recent years, the supply of rare earth metals has come under considerable strain. China currently provides over 85% of rare earth metals to the world market but, in recent years, began to impose export quotas. This resulted in dramatic price fluctuations for the rare earth metals, in particular, neodymium, praseodymium and dysprosium, the rare earth constituents of NdFeB magnets. According to the EU Critical Materials list (2010, 2014) and the US Department of Energy's energy critical element list (2010), the rare earth metals are classified as at greatest risk of supply shortages compared to those of all other materials used for clean energy technologies.

There are several ways in which these material shortages could be addressed including: (a) opening rare earth mines in countries outside of China, (b) using alternative technologies which do not contain rare earths (c) reducing the amount of rare earth metal used in particular