A Three-Pronged Approach

Just as I sat down to write this article, an interesting news item came in my e-mail.[1,2] It was about a newly established US research program on permanent magnets, funded for $4.6 million by ARPA-E. Many of the institutional names are familiar: University of Delaware, University of Nebraska, Northeastern University, Ames Laboratory and Electron Energy Corporation. The program has three distinct areas to examine

1. Previously uninvestigated rare earth alloys
2. Magnets without rare earths
3. Exchange magnets, nanocomposites of NdFeB and iron

The stated goal is to develop magnets less dependent on neodymium by one or more of the three methods.

This is a wonderful development for our industry which has not had much domestic research support or activity of late. These are also grand and worthy targets, and good organizations involved. Although I will freely admit that as a self-described "rare earth magnet guy" target #2 makes me a little queasy. However, I would like to make a couple of comments that might improve the outcome of this project.

While it is nice to see a non-academic participant, Electron Energy, it is disappointing that there is only one. It would certainly be better to have more companies involved. Any fruit of this work will need to be scaled up to a commercial level and that is best done by including people who understand the manufacturing process. It is critical that they are included in the discussion earlier, rather than later.

It is also disappointing to see no users of permanent magnets involved in this work. The article begins by saying "a magnet (is) the heart of high-tech products," something that I think everyone reading this magazine believes wholeheartedly. Wouldn't it make sense to have people who actually use these components involved in the project to assure that the research moves in a beneficial direction? I think it would.

In my humble opinion, this project would be far more likely to produce useful results with more people who either know how to make a magnet on a commercial scale or use them in one or more of the popular applications. Otherwise we run the risk of coming up with something that nominally meets the targets of the program but ultimately isn't useful to the industry. The history of permanent magnet development in the 20th century clearly shows several examples of materials that met a research goal yet failed either to become or to remain commercially viable. This is a warning that we need to heed.

And if I haven't yet been as offensive as a Socha Baron Cohen movie, I would like to add a fourth prong to the project.

Almost immediately after NdFeB magnets arrived in the early 1980's, we have been adding Dy and Tb to increase H_{ci}. Many people claim this substitution makes these alloys high-temperature alloys, in an awkward bit of logic. In reality these additions only make the H_{ci} tolerable at elevated temperatures by making the H_{ci} at room temperature huge. Ironically this increase happens without significantly altering any thermal characteristic of the magnet.

The problem with Dy and Tb is that we are locked into a paradigm which limits our thinking. The paradigm is *we cannot simultaneously have high $(BH)_{max}$ and H_{ci} in NdFeB magnets*. It certainly is what happens when we increase the Dy and/or Tb content from zero to about 7% in the alloy, the H_{ci} increases and the $(BH)_{max}$ decreases in a predictable linear way. But we face a more important and subtle question. Is it the *only* *way* to increase H_{ci}, or is it simply *a way* to do it? The fact that we can obtain significant H_{ci} with little or no Dy in die upset NdFeB magnets leads me to believe heavy rare earth additions are not the only way to increase H_{ci}. That is why I believe the latter is true and not the former. The challenge for us is to find a way to control both H_{ci} and its temperature coefficient, commonly called β, with less Dy or Tb, so that we could have a 50 MGOe material with decent H_{ci} at 150°C. Even though such a material might use a little bit more Nd than a typical NdFeB alloy with a few percent Dy, it could remove much of the upward pricing pressure on Dy, which is actually a more urgent issue than Nd these days. So my fourth prong is, find a way to reduce our dependence on Dy and Tb.

There are two projects that I am working on this summer that I wanted to mention.

The first is with Walt Benecki and Terry Clagett, which Walt is describing elsewhere in this issue. Our report, The Global Permanent Magnet Industry 2010-2020 will contain our assessments of the key current issues of our business and our predictions about the next 10 years. It promises to be a very valuable resource.[3]

The other project that I am working on is with Steve Constantinides from Arnold Magnetic Technologies and Steve Sprague from Proto Laminations. It is a Permanent Magnet database with the very large goal of trying to organize information about all commercially available permanent magnet materials is a very user-friendly way. This work is supported by the Permanent Magnet Division (PMD) and the Electric Motor Education and Research Foundation (EMERF) of the SMMA The Motor & Motion Association. (How's that for an alphabet soup!) Our inspiration for this project is the Lamination Steel CD, edited by Steve Sprague.[4]

We may be approaching you with a request for magnet data for inclusion in the database. I sincerely hope that you will help us. We have had a very good response to many of our requests. Several people have gone above and beyond to provide information and other services. We greatly appreciate your help, but a few people have ignored our requests and I would like to plead with them in this space to cooperate with us. Please understand that our requests for information are part of a comprehensive effort that will benefit everyone in our industry. It will only be really successful if we can get *everyone* to cooperate.

1. www.livescience.com/technology/new-generation-magnets-rare-earths-100409.html
2. www.art-sci.udel.edu/Stories/UDWins44MilliontoDevelop/tabid/1161/Default.aspx
3. www.webmagnetics.com/featuredItem.asp
4. www.smma.org/EMERF.htm

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Spontaneous Materials

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