

Magnetics Industry Overview by Walt Benecki

2004 China Magnet Symposium Highlights Recent Industry Trends

The 2004 China Magnet Symposium was held in Xian, PRC on May 17-19, 2004. The conference's leadoff speaker was Mr. Hong Feng, previous Chief of the State Planning Commission's Rare Earth Office. Mr. Hong reported that, in January 2003, the worldwide proven reserves of Rare Earth Oxides were 88 million tons, of which China claimed 31% and Russia 22%. Base REO reserves were 150 million tons of which China had 58% and Russia 14%. Hong reported that China mines 80-90 thousand tons of REO each year (which represents 85% of world REO mining volume). About 35-50 thousand tons of China's REO are exported.

Professor Yang Luo provided a broad overview of China's sintered NdFeB industry. Professor Luo reported that China's production of sintered NdFeB magnets reached a new record of 18,460 tons in 2003 (an annual increase of 109%) and is expected to reach 90,000 tons by 2010. Professor Luo estimated the 2003 worldwide magnet production split as follows: ferrite magnets (51%), NdFeB (47%), SmCo magnets (1.5%) and Alnico at only 0.5%.

Professor Luo reported that China now manufactures 73% of the world's sintered NdFeB but only 25% of bonded NdFeB (due to significant production in Thailand). Ceramic ferrite production is split between China (41%) and Japan (34%). Japan is retaining a significant share position on the strength of high-performance ferrite grades containing LaCo additions. Luo indicated that the average price of sintered NdFeB in China has dropped by 40% over the past 5 years to \$35/kg in 2003. This is reportedly less than half Western NdFeB price levels. Price, of course, depends on material grades. In China, grade 28 material averages \$28/kg while grade 52 material is \$115/kg (compared with \$160/kg in the West).

One of the larger applications for sintered NdFeB in China is electric bicycles. Approximately 1,300 tons were used for this application in 2003 with each motor utilizing about 380 grams of grade 38-40 material. At \$38/kg, this translates to \$14.40 per motor. Professor Luo reported that 3.5 million electric bicycles were manufactured in 2003 and production is expected to increase to 15 million units by 2007.

Dr. John Croat, Advanced Magnetic Materials, indicated that AMM's isotropic bonded NdFeB powder production in 2003 was 3,600 tons and is expected to grow to over 7,000 tons by 2008. Croat confirmed that Japanese companies continue to be the dominant manufacturers of bonded NdFeB, but their market share is declining as production moves to China and other areas in Southeast Asia.

Dr. Hideki Harada, Chairman of JABM, reported that there has been a gradual movement of bonded magnet production to China since 2000. About 65% of Japan's bonded rare earth production has now moved offshore, however 69% of bonded ferrite production has remained in Japan (mainly magnet rolls for office automation equipment). Small motors are a major consumer of NdFeB powder in Japan and consume 68% of the country's bonded RE magnet output. According to Harada, one interesting note is that 14% of Japan's bonded magnet production is now SmFeN.

Dr. Harada highlighted a few recent bonded magnet technologies developing in Japan. SPRAX-II (produced by Sumitomo Special Metals) is a nano-composite FeB/Nd₂Fe₁₄B material produced by strip casting. The density of Sprax II powder is higher than MQ powder, therefore providing some improved properties. Sm(Fe-Mn)N (developed by Sumitomo Metal Mining) has a larger particle size (up to 30

microns) and has relatively high coercivity. Reduced cost is achieved by using a reduction-diffusion process. Thermal stability of this product is excellent and claimed to be similar to $\text{Sm}_2\text{Co}_{17}$.

Daido Electric has developed a rapidly quenched SmFeN bonded magnet with $\text{SmFe}_9\text{N}_{1.5}$ composition that reportedly achieves a higher performance than conventional NdFeB rapidly quenched material. It is also claimed to have superior corrosion resistance. Matsushita Electric Industries (Panasonic) have developed a bonded flexible magnet that uses a 50:50 mixture of anisotropic NdFeB and SmFeN bonded with epoxy resin. The mixture is rolled to a semi-hard condition to make magnetically oriented sheet which is then hot pressed into ring or segment shapes with an energy product of 20 MGOe.

Dr. Sam Lui, University of Dayton, USA, presented an interesting paper describing recent developments in nano-hybrid materials development. Dr. Lui described new nano materials that require relatively short anneal cycles and results in isotropic bonded magnets with energy product approaching 20 MGOe. Fully dense anisotropic nano magnets have been produced with 46 MGOe.

Prof. R. Harris, University of Birmingham, UK, presented a paper entitled, "The Hydrogen Processing of Magnets – Past, Present and Future". Professor Harris pointed out that NdFeB is the only material that exhibits anisotropy after hydrogen decrepitation and he proposed that hydrogen decrepitation be utilized to permit reuse of scrap NdFeB magnets.

Mr. K. Tokuhara, Neomax Ltd. (Previously Sumitomo Special Metals) reported on, "High Performance NdFeB Sintered Magnets and their Applications". Tokuhara reported that Japan's 2002 sintered NdFeB magnet production was 4,750 tons. Major applications included VCM (36%), motors (32%), and MRI (17%). Tokuhara indicated that motor applications are increasing with electric power steering and hybrid electric vehicles adding to this category.

Tokuhara reported that the Prius HEV is currently manufactured at a rate of 2000/month and is expected to quickly increase to 5,000/month. The Prius HEV uses Neomax in both the motor (1.5kg) and generator (0.5 kg) as well as a compressor motor for air-conditioning. Another Toyota hybrid, the Alphard Wagon, has both a front wheel drive motor-generator and a rear wheel drive motor generator. Neomax production was 2,500 tons (8.8 million pieces) in 2002 and increased to 3,000 tons (103 million pieces) in 2003. Neomax now has a plant in Dongguant, China, for machining and surface treatment of magnets for Nissan.

Bo-Ping Hu, Zhong Ke San Huan, reported on San Huan's NdFeB business status. They now have six magnet plants in China with sales of approximately \$70 USD million in 2003. Total production capacity is currently 4,500 tons with planned capacity of 6,500 tons for 2005. N50 series high grade magnets are now in production. This year, San Huan has seen the price of Nd metal increase approximately 12% versus 2003 levels.

Dr. Kenji Ohmori, Sumitomo Metal Mining Co., Ltd., presented a paper entitled "Injection Molded SmFeN Anisotropic Magnets using Unsaturated Polyester Resin". SMMC is utilizing an unsaturated polyester with short curing time at 100-200C. Sumitomo's anisotropic SmFeN has 3 micron particle size and delivers 35 MGOe. Ohmori reported that mold shrinkage of UP can be controlled and shear strength is reported to be similar to polyamide resin. Thin sheets 0.3mm thick can be produced with good magnetic properties.

Takeshi Ida, representing MagX Company, Ltd., gave a paper that provided a general background to bonded magnets and described MagX's development of flexible bonded magnets delivering 12.9 MGOe

with irreversible loss at 120C of less than 1%. Both thermal stability and corrosion resistance are said to be better than NdFeB.

Prof. W.C. Chang, Taiwan University, reported on “High Performance PrFeB type Nanocomposite Ribbons with High B Concentration”. Chang described laboratory work which substitutes Nb, V, Ti and Zr for Fe in PrFeB nanocomposites with high boron. Optimum magnetic properties obtained were 18.7 MGOe.

Ms. Joanne Jia, Hangzhou Permanent Magnet Group, provided a status report on the Chinese Alnico industry. China Alnico production was 1000 tons in 1960s, 2000 tons in 1970s and is now 3000 tons. The main applications were watt-hour meters (35%) and automotive (20%). Approximately 32% of China’s alnico production is currently exported. HPMG produces 60% of China’s Alnico. Jia indicated that the present price of Cobalt (\$60/kg) contributes \$14.40/kg to the current price of Alnico.

Mr. Chen Guohuo, China Magnetic Materials & Devices Association, reported that China produced 3,500 tons of soft ferrite in 1980 and production has increased to 90,000 tons in 2003. With over 100 soft ferrite manufacturers in China, capacity is expected to increase to 160,000 tons by 2005. Of note was the observation that a number of Western companies are building new ferrite plants in China.

George C. Hadjipanayis, University of Delaware, USA, reported on “Recent Studies in Bulk 2:17 and Nanocomposite RE-Co Magnets”. Hadjipanayis discussed nanocomposite magnets that have a theoretical energy product of 100 MGOe. He reported some success with PrCO₅ die upset magnets with 10% Sm content. They are currently working on magnetic hardening of SmCo with Zr and Cu substitution. Development of fully-dense Sm-Co-Fe nanocomposite magnets with Cu and Ga additions reportedly increased coercivity and energy product. Hadjipanayis indicated that these new products may find future applications in military, aerospace and automotive applications.

Zhang Xin-yu, Beijing Thinova Magnetics Co., Ltd., gave a paper entitled “High Performance Magnets made by Traditional Equipment”. This presentation described the manufacture of a complex formulation of NdFeB with Co and Tb additions and smaller amounts of Al and Cu. Thinova’s method of manufacture also includes the addition of “special lubricants” to improve orientation during pressing. B-H curves with a very square characteristic demonstrate a high Hci. The process reportedly helps to control oxygen content and prevents grain growth, resulting in improved corrosion resistance and lower irreversible flux loss.

John G.W. West, Consultant, UK, presented a paper entitled, “Future Designs of Permanent Magnet Motors and Generators for Cars” West described the use of permanent magnets in starters, alternators and the trend to starter-alternators. West also detailed the trend to Hybrid Electric Vehicles using permanent magnet motors.

Dr. Bi Chao, Data Storage Institute, reported on “The Role of High Performance Permanent Magnets in the Development of Spindle Motors used in Hard Disc Drives”. In 2003, spindle motor production reached 250 million units. The majority of units produced were 3.5 inch, but 2.5 inch increased by 35% and 1.8 inch increased 380%. 1” and 0.85” drives are expected to be increasing in 2005. The spindle motors are sensorless brushless DC and require high torque/volume, high efficiency and high reliability.

Masaaki Tokunaga, Hitachi Metals Ltd., provided a summary of the wide range of Rare Earth Magnets before concentrating on HDDR NdFeB produced with Hitachi’s HILOP process. These magnets deliver high Energy Product (55 MGOe) and improved corrosion resistance and bending strength. Work on nanocomposite magnets reportedly show a lower temperature coefficient of coercivity.

As this writer was unable to personally attend the 2004 China Magnet Symposium, the detailed notes of Mr. John G.W. West (Email: JohnGWWest@compuserve.com) were very much appreciated in preparing this article. John is a well known consulting engineer specializing in automotive electrical systems

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