GKN Powder Metallurgy targets sustainable and resilient regional NdFeB magnet production

As the shift to vehicles with electrified powertrains gathers pace, the need for sustainable, locally produced high-performance magnets has become critical. GKN Powder Metallurgy is rising to this challenge by establishing NdFeB magnet production in Europe and North America, with a focus on reducing or eliminating the use of heavy rare earth elements (HREEs) such as terbium and dysprosium. In this article, Gordon Hutchinson, Vice President Magnets, outlines the company's progress, technology strategy, and vision for a resilient magnet supply chain.

Part of the Dowlais Group plc, GKN Powder Metallurgy employs over 5,000 people across twenty-eight manufacturing locations and two innovation centres. The company is a world-leading provider of metal powders and high-precision sintered components, and is the only fully vertically integrated company in the Powder Metallurgy industry.

In co-development with its customers and business partners, GKN Powder Metallurgy offers a range of best-in-class Powder Metallurgy technologies to solve complex challenges in the automotive and industrial sectors, delivering sustainable and innovative solutions. Nearly all the material used by the company comes from recycled scrap steel, and it holds 'Platinum' status in the EcoVadis sustainability assessment. It supplies ten million Powder Metallurgy parts per day and makes extensive use of advanced automation and digital tools to ensure high standards of quality and delivery.

GKN PM's mission to support regional magnet production

In 2022, GKN Powder Metallurgy began its journey to establish a sustainable and local permanent magnet production capacity. Since then, the company has made significant progress, including establishing a technology centre in Cinnaminson, New Jersey, and developing a small-scale production line at its innovation centre in Radevormwald, Germany. The site, located an hour north of Bonn, is now preparing for

Fig. 1 Inside one of GKN Powder Metallurgy's manufacturing sites (Courtesy GKN Powder Metallurgy)

Fig. 2 Measurement and inspection of NdFeB magnets produced at GKN Powder Metallurgy's Radevormwald site (Courtesy GKN Powder Metallurgy)

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the launch of neodymium iron boron (NdFeB) magnet production, with an initial capacity of 200 tonnes per year.

This article explores GKN Powder Metallurgy's progress in developing and industrialising magnet technology for the electric vehicle (EV) industry, with a focus on preparing for scaled production at the Radevormwald site. Of particular interest is the company's work on magnets with reduced levels of heavy rare earth elements (HREEs) – specifically terbium (Tb) and dysprosium (Dy) – as well as HREE-free grades. These developments offer significant benefits, including cost reductions, Environmental, Social and Governance (ESG) improvements, and enhanced supply chain and geopolitical resilience, by enabling the production of high-performance magnets within local, sustainable, and robust supply chains in Europe and North America.

Navigating supply chain challenges for EV magnets

Driven by the green transition away from internal combustion engines (ICEs) toward a mix of battery electric vehicles (BEVs) and hybrids, there is increasing demand for new technologies and products to support the growing BEV and hybrid sectors. Sintered NdFeB magnets – used in over 75% of BEV or hybrid traction motors today – are a key component. These magnets are also used across a wide range of non-automotive applications, including wind energy, automation, industrial motors, and defence.

With its long-standing expertise in powder and component manufacturing, GKN Powder Metallurgy identified the supply of magnets for BEVs and hybrid vehicles as a strategic opportunity. These highly engineered components are in increasing demand, yet regional supply in both Europe and North America remains limited.

Currently, approximately 95% of magnets for EV motors are manu-

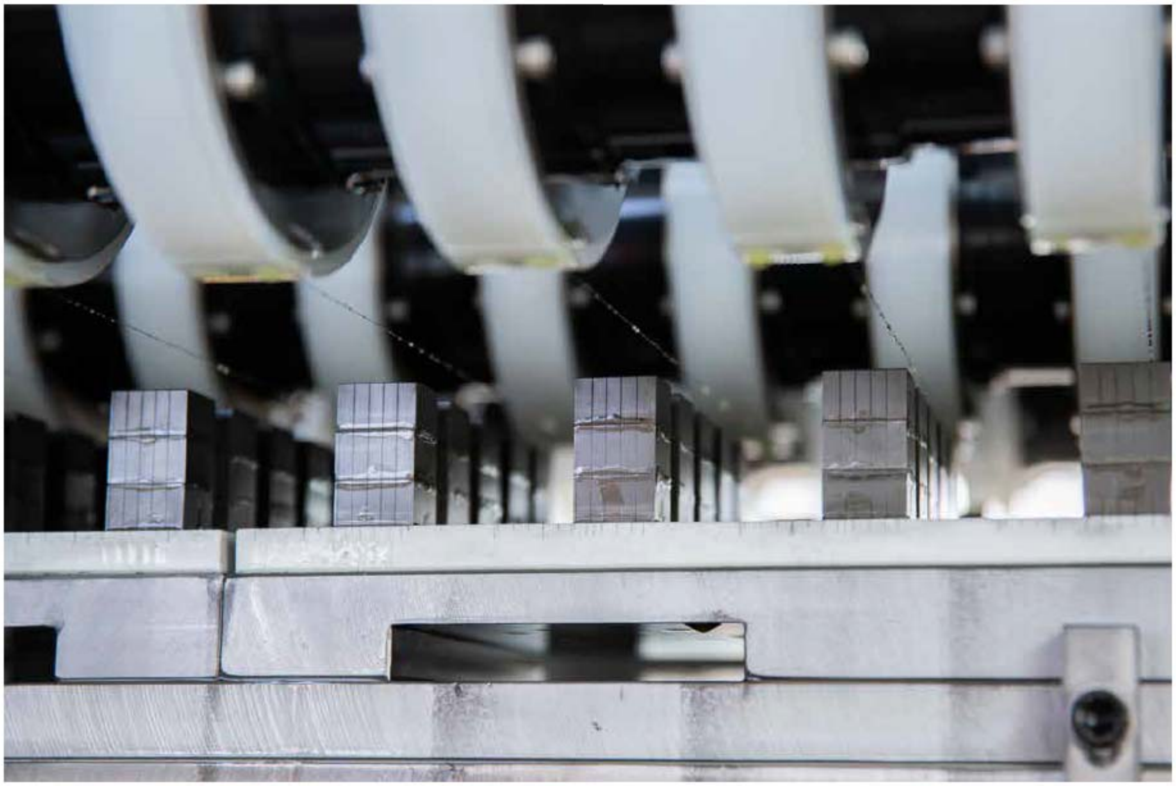

Fig. 3 The wire cutting of NdFeB magnets in Radevormwald (Courtesy GKN Powder Metallurgy)

factured in China. OEM customers are, however, increasingly looking to develop a regional, localised and more sustainable supply base in Europe and North America, alongside the established supply from China. There is already a well-established supply base in Japan, but this is primarily for the domestic market.

The global supply of magnetic rare earth elements – including neodymium, praseodymium, terbium, and dysprosium – is facing increasing scrutiny due to geopolitical risks. In April, China introduced export controls on terbium and dysprosium, including their oxides and derived materials, which are exported from China and used across a wide range of industries globally. These controls require a government approval process that can take up to forty-five working days, increasing the risk of disruption, cost spikes, and long-term supply insecurity for these critical materials.

The mining and processing of the rare earth metals used in EV magnets are associated with low ESG ratings and a history of significant environmental damage caused by extraction and refining activities. There is, therefore, a need and desire to create an improved and sustainable supply chain for these materials.

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The EU passed its Critical Raw Materials Act in early 2024, aiming to enhance the development of local supplies of certain materials and reduce dependence on imports, which primarily come from China. The Joint Research Centre assessed the supply risk of various elements identified as critical raw materials for the EU, as well as the technologies and sectors in which these materials are utilised. The light rare earth and heavy rare earth metals used in magnets are rated as the

Fig. 4 View of a press and jet milling equipment in Radevormwald (Courtesy GKN Powder Metallurgy)

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highest risk in the supply chain for Europe and have a direct impact across a wide range of industries, most notably traction motors for EVs. A similar government assessment in the US has recognised the high supply chain risk associated with NdFeB magnets and their applications.

GKN Powder Metallurgy has over seventy years of experience in the supply and technology leadership for iron powders and sintered metal components in the global automotive industry. Its expertise in metal powder manufacturing, combined with its capabilities in key processes used in magnet production, prompted the company to explore entry into the magnet market – a strategic move driven by growing demand from BEVs, hybrid vehicles, and wind power generation.

After an internal strategic review, and encouraging discussions with key customers, GKN Powder Metallurgy began its journey towards magnet production.

Towards sustainable magnets: reducing or eliminating terbium and dysprosium use

NdFeB magnets were independently discovered in 1983 by researchers at General Motors in the United States and Sumitomo Special Metals in Japan (now part of Proterial, following its earlier transition through Hitachi). Over time, magnet production in the US and Europe ceased, and had almost entirely moved to China by the late 1980s, where the mining, oxide separation, metals processing, and magnet manufacturing grew into a multi-billion-dollar industry.

GKN Powder Metallurgy produced magnets on a small scale in the 1980s using earlier technologies. Having re-entered the industry in 2022, GKN has undergone a rapid re-learning process to catch up with more than thirty years of global magnet technology development.

EV magnets require rare earth elements to achieve the high performance demanded in traction motors. Light rare earths, such as neodymium (Nd) and praseodymium (Pr), form the basis of strong magnetic properties, while small additions of heavy rare earths like terbium and dysprosium are used to improve thermal stability. When alloyed with iron and other elements (for example, NdFeB), these materials enable the production of magnets with high residual magnetic flux (remanence) and resistance to demagnetisation (coercivity). These properties are critical in EV motor applications, where magnets must retain performance at elevated operating temperatures of 150–200°C.

However, these HREEs present significant challenges. They are the most expensive elements in magnet production, with Tb reaching $3,000 per kg in 2022, and are subject to volatile pricing and geopolitical supply risks. Further, the extraction of Tb and Dy involves intensive mining and processing, which consumes large amounts of water, acids, solvents, and energy. This has historically caused severe environmental damage, particularly in southern China and northern Myanmar. Securing a stable and sustainable supply of these critical materials is therefore a growing concern.

GKN Powder Metallurgy responded to these challenges by developing innovative new magnet technologies that significantly reduce – or entirely eliminate – the use of HREEs, while maintaining or enhancing performance. The company has invested in small-scale engineering facilities in the US and Germany, equipped for magnet production and testing and, over the past two years, its technical teams have developed solutions that achieve industry-leading low levels of HREE usage.

Fig. 5 NdFeB powder jet milling machine (Courtesy GKN Powder Metallurgy)

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H_{cj} (kOe) \ $(BH)_{max}$ (MGOe)	28	30	33	35	38	40	42	45	48	50	52	54	56	58	T_{max} (°C)
40	28VH	30VH	33VH	35VH	38VH	40VH	42VH								230
35	28AH	30AH	33AH	35AH	38AH	40AH	42AH	45AH	48AH						230
30	28EH	30EH	33EH	35EH	38EH	40EH	42EH	45EH	48EH	50EH	52EH				200
25	28UH	30UH	33UH	35UH	38UH	40UH	42UH	45UH	48UH	50UH	52UH	54UH	56UH		180
20			33SH	35SH	38SH	40SH	42SH	45SH	48SH	50SH	52SH	54SH	56SH	58SH	150
17			33H	35H	38H	40H	42H	45H	48H	50H	52H	54H	56H	58H	120
14				35M	38M	40M	42M	45M	48M	50M	52M	54M	56M	58M	100
12				N35	N38	N40	N42	N45	N48	N50	N52	N54	N56	N58	80

Dy-rich / Tb-lean | Tb-lean | GKN magnet main focus (EV motor grades) | Dy only | HREE-free

Table 1 GKN Powder Metallurgy's range of NdFeB magnets produced to date (Courtesy GKN Powder Metallurgy)

The company's progress has leveraged skills in materials formulation, powder production, and magnet processing. Fast feedback trials and process optimisation were supported through benchmarking, collaborations with universities and agencies in the US, Germany, and the UK, and input from close customer partnerships.

This cross-disciplinary effort has allowed GKN PM to develop and benchmark its magnets rapidly against current industry standards. The result is a range of high-performance magnets (Table 1) with reduced reliance on rare and geopolitically sensitive elements, produced using lab-scale production equipment in Cinnaminson and Radevormwald.

Magnet grades

Magnets are graded by their performance, specifically remanence and coercivity. Coercivity is especially crucial, as it correlates directly with the magnet's ability to resist demagnetisation at high temperatures. When temperatures approach or exceed the Curie point, NdFeB magnets begin to lose their magnetic properties – making high coercivity essential for maintaining performance under thermal stress.

EV motors typically operate at high temperatures, depending on the motor design and cooling circuit. To ensure reliable performance under these conditions, magnets are graded by coercivity, with industry-standard labels of 'SH', 'UH', and 'EH' corresponding to maximum operating temperatures of 150°C, 180°C, and 200°C. GKN PM has developed optimised solutions for each of these grades of magnets, which minimise the usage of the HREE terbium and dysprosium, thereby reducing the product's costs and ESG footprint.

SH Grade (150°C)
A HREE-free product using a special blend of light rare earth compounds to achieve the required coercivity without any heavy rare earths, providing a sustainable supply chain and enhanced ESG performance.

UH Grade (180°C)
A Tb-free product that uses dysprosium, eliminating the need for the rare and expensive Tb.

EH Grade (200°C)
A 'Lean Tb' product, comparable to technologies in China and Japan, that reduces the need for Tb.

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Fig. 6 Magnet wire cutting machines (Courtesy GKN Powder Metallurgy)

rating, as the HREE elements are the most energy- and resource-intensive products to produce.

The magnets' performance is measured by the energy product $(BH)_{max}$, which refers to the maximum energy the magnet can transfer, and coercivity (H_{cj}), which measures resistance to demagnetisation when exposed to external magnetic fields or temperature fluctuations. It also directly correlates with the magnet's maximum operating temperature, making it particularly important for high-power motor applications, such as those used in EVs.

It should also be noted that the EU's Critical Raw Materials Act aims to use 25% recycled material for NdFeB magnets by 2030. In support of this initiative, GKN PM is working with several suppliers in the EU to offer NdFeB magnets made from recycled materials to the market. Currently, GKN PM is manufacturing a sample batch of magnets made from 100% recycled materials for a major OEM as a technology demonstrator.

"Fast feedback trials and process optimisation were supported through benchmarking, collaborations with universities and agencies in the US, Germany, and the UK, and input from close customer partnerships."

Manufacturing readiness

GKN Powder Metallurgy's new production site for NdFeB magnets in Radevormwald, with a capacity of 200 tonnes per year, will function as a demonstrator plant for GKN to showcase its manufacturing capabilities on an industrial scale and will serve as a blueprint for future expansion in the EU and North America.

All key production machines are scheduled to arrive in the first and second quarters of 2025, with initial production samples planned for customer validation programmes in the fourth quarter of 2025. The site can be expanded as needed. GKN PM has a second-stage plan for a larger facility capable of producing up to 4,000 tonnes of NdFeB magnets annually in the EU. Additionally, manufacturing facilities are available

Fig. 7 Magnet grinding and machining line (Courtesy GKN Powder Metallurgy)

in the US to establish local capacity according to customer demand.

Conclusion

Following the chip shortages of 2021 and the changing geopolitical landscape, most automotive OEMs and EV motor manufacturers are looking to establish regional supply bases in Europe, North America, and Asia. To date, GKN Powder Metallurgy has produced magnets for twenty-one different customer grades and supplied samples and test parts to five different customers for technical evaluation. In each case, the company achieved the required magnetic properties for the applications.

The company continues to develop its product Technology Readiness Level for optimised technical solutions for NdFeB magnets. Now that the first manufacturing capability is coming online, GKN PM is working with a range of customers on programme validation requirements and commercial negotiations for the first production volumes in the near future.

Author

Gordon Hutchinson
Vice President Magnets
GKN Powder Metallurgy
Central Boulevard
Blythe Valley Park
Solihull B90 8AS
UK

www.gknpm.com