Reforms and Progress Aimed at Expanding Organic Growth

Dedicated to "becoming the world's leading high-performance materials company," the Hitachi Metals Group is pursuing reforms aimed at expanding the business globally while improving profitability.

Expanding organic growth will be the key to achieving the targets of our Medium-term Management Plan. To this end, we are powerfully promoting the Corporate *Monozukuri* Innovation Project while expediting research and development.

In this section, we introduce specific examples of efforts to build innovative *monozukuri* skills through IoT technologies, carry out R&D innovation from medium- to long-term and cross-business perspectives, and develop a solution sales system that generates high added value.

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Building World-Class *Monozukuri* Skills

Drastic reforms for the future

Seeking to expand organic growth, we are engaging in GEMBA (workplace) and manufacturing technology innovations based on cross-organizational and medium- to long-term perspectives. The aim is to solidify our foundation as a manufacturer and reinforce our potential for sustained growth. Our goal is to build *monozukuri* skills that are among the best in the world by actively introducing advanced technologies in segments such as process technologies, CAE*, and IoT.

* CAE (computer-aided engineering): Using computer-based simulations to verify whether or not a designed structure would meet performance requirements, even before it is built.

Deploying IoT technologies at business locations

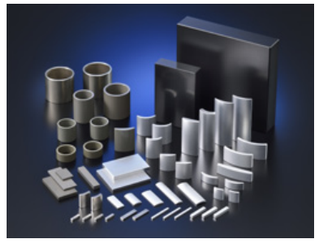
As the name ("Internet of things") implies, IoT enables huge volumes of information to be collected from Internet-connected devices and converted to "big data," then analyzed to create new knowledge and value. Even in the manufacturing sector, more and more companies are introducing IoT technologies to improve production efficiency. While Hitachi Metals is mainly involved in materials-based *monozukuri*, the adoption of technologies allowing real-time information visualization and traceability can lead to more stable manufacturing and improved product quality. Accordingly, we are actively adopting IoT technologies at each of our business locations.

Using sensors to visualize information enables data on the status of a device and processing conditions to be accumulated when a malfunction occurs, allowing the source of the problem to be identified and measures to be taken. For this reason, we are installing sensors in our equipment and introducing smart devices, while swiftly establishing an environment for acquiring and analyzing big data. Moreover, by deploying big data to develop our advanced *monozukuri* technologies globally, we will create systems allowing each location of business to mobilize IoT technologies at a high level, in our quest to become the world's leading high-performance materials company.

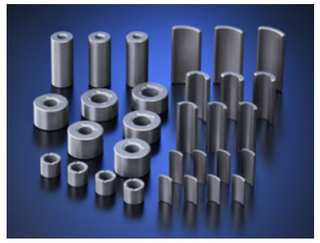
Initiatives

Location	Objectives	Methods
Kyushu Works	Improve product quality, pass rate, and traceability	Big data analysis
Ibaraki Works	Improve production efficiency	Big data analysis
Kumagaya Works	Improve product quality and pass rate	Sensing technologies; big data analysis
Yasugi Works	Eliminate waste; visualize work-in-process, lead time, product quality, and operational status	Use of smart devices (handsets, etc.); big data analysis

Innovative production line for neodymium magnets and ferrite magnets introduced



Neodymium magnets "NEOMAX®"



Ferrite magnets "NMF™"

To address the flourishing demand for drive motors for plug-in hybrid and electric vehicle motors, as well as other electric motors, we are building an innovative production line for neodymium magnets and ferrite magnets at the Kumagaya Works, with operation scheduled to begin in fiscal 2018.

The new production line is planned for installation in a new facility to be constructed within the Kumagaya Works. In addition to IoT technologies, it will feature new production technologies designed to optimize the magnet production process, enabling product quality and productivity to be maximized simultaneously. We will also use IoT technologies to share data on manufacturing quality globally.

At the same time, we will relocate the Magnetic Materials Research Laboratory to the Kumagaya district, bringing it together with the information system component business of the Magnetic Materials Company at the Kumagaya district.

Through these measures, we have positioned the Kumagaya Works as a "mother plant" where control of the neodymium magnet and ferrite magnet businesses is centralized. By bringing together the research laboratory and the plant, we will accelerate technological development and production to reflect customer needs.

Image of completed new magnetic materials facility at the Kumagaya Works

Develop innovative, environment-friendly, hot-processing techniques

At the Yasugi Works, we introduced new equipment after conducting a major review of hot-processing techniques used in forging mill production. Hot processing refers to the rolling of iron ingots taken from a heating furnace. Since it is an important process for delivering materials to the entire Yasugi Works, we revamped our large-scale facilities while operating existing equipment.

In addition to improving productivity, we paid attention to material flows and energy costs from this revamp, reducing CO_2 emissions and significantly improving yield. Specifically, the use of a new type of gas fuel in the heating furnace allowed materials to be heated uniformly, resulting in lower energy costs and CO_2 emissions. In the rectangular steel material manufacturing process, we improved product quality and shortened the processing time by optimizing the anvil shape and reviewing the manufacturing process. Furthermore, we made it possible to manufacture circular billets using a forging mill, leading to an improved working environment and more effective collection and recycling of waste material. In addition, we deployed IoT technologies to visualize shape measurement of hot steel and other factors, and used the resulting data to perform online automatic control and raise the level of quality control.

Three positive outcomes

1 Renewal of heating furnaces

Our heating furnaces used heavy oil, which emits large amounts of CO_2, and the furnaces themselves were aging, having been in operation for 30 years. For these reasons, we introduced a new type of furnace and changed the fuel to gas.

Achieved lower energy costs, significant reduction of CO_2 emissions, and uniform heating of materials.

2 Enhanced efficiency of rectangular steel processing

In the rectangular steel manufacturing process, we optimized the anvil shape and otherwise reviewed our manufacturing procedures. We also made our production line compatible with SLD-i™, a new steel type that is expected to be mass-produced in the future.

Achieved improved quality and shorter processing time, in addition to more uniform distortion.

3 Circular billet production

Conventional rectangular billets are ground with a grindstone, which is bad for the workplace environment and wasteful. For these reasons, we used a forging mill, which allows surface cutting, to make circular billets.

Improved working environment and more effective collection and recycling of waste material.

Innovation

Driving R&D to Open Up New Future Potential

Becoming a genuinely development-driven company

We are strengthening R&D in our quest to become a genuinely development-driven company. Innovative R&D plays an important role in reinforcing our competitiveness at the global level. Accordingly, in April 2017, we established our Corporate Research Lab, the Global Research & Innovative Technology center (GRIT), to spearhead medium- to long-term R&D topics focusing on advanced materials. In these and other ways, we have been working hard to enhance our R&D system with a view toward the next generation. By emphasizing innovative R&D and new business creation, we will expand organic growth to deliver sustained growth and contribute to society.

Carrying out new business creation from medium- to long-term perspectives

Creating new businesses is a key prerequisite to achieving improved profitability and steady business expansion at the global level. Due to advancements in chemistry and technologies, moreover, materials handled by Hitachi Metals are constantly threatened by the sudden appearance of alternative materials. For example, in the automotive sector, where weight reduction is a major priority, various materials may emerge to replace conventional cast iron, such as aluminum-based composite materials and carbon nanotube-reinforced aluminum alloys.

For new business creation, therefore, we examined the various threats and opportunities in each business field and identified medium- to long-term R&D themes, envisaging the next 10 to 20 years. We have set 15 specific topics—including metal materials, additive manufacturing, composite materials, new magnets, composite materials and multiple materials, aluminum conductors and compound conductors—and we will expedite innovation in the fields of automobiles, railways, aircraft, and energy. From fiscal 2016 through fiscal 2018, we plan to invest ¥12 billion in R&D aimed at new business creation.

Medium- to long-term R&D topics concentrated on threats and opportunities (examples)

Company	Current products	Development theme (based on perceived threats)
Metal Materials	Mold materials	Additive manufacturing
	Aircraft- and energy-related materials (ultra heat-resistant steel)	Composite materials
Magnetic Materials	Neodymium magnets	New magnets
Functional Components	Cast iron (NM)	Composite materials and multiple materials
Cable Materials	Copper wire	Aluminum conductors and compound conductors

Targeting innovation through a revolutionary research system

Under our current system, in which each internal company has its own research laboratory, we have consistently created products with distinctive characteristics unique to Hitachi Metals that meet the needs of customers. To realize new, high-performance materials with future potential, however, it is important to conduct cross-organizational R&D that transcends internal company lines.

In addition to leading-edge research sourced from perceived threats and opportunities, our new GRIT, established in April 2017, will actively spearhead cross-organizational R&D that goes well beyond internal company boundaries. It will also expedite open innovation through close collaboration with external institutions, such as Hitachi, Ltd. and universities. Moreover, we are positioning GRIT to fulfill an important mission as a place to foster research personnel. For this reason, we will accelerate exchanges with exceptional engineers around the world in an open environment to create innovations never seen before.

TOPICS

Open innovation initiatives

Establishing NIMS–Hitachi Metals Next-Generation Materials Development Center

In July 2016, we established NIMS–Hitachi Metals Next-Generation Materials Development Center in collaboration with the National Institute for Materials Science (NIMS), and started research into practical applications for next-generation ultra heat-resistant alloys. Using this research to develop metal materials for aircraft engines and gas turbines will help reduce CO_2 emissions and conserve resources.

Signing ceremony

Participation in IBM research consortium

Hitachi Metals participates as a founding member in the IBM Research Frontiers Institute, a research consortium established by IBM Corporation in 2016. The institute promotes research into materials development methods using neuromorphic computing*1 and other cognitive technologies*2, as well as MI*3, and is targeting dramatic progress in advanced materials research and development.

*1 Neuromorphic computing: The use of computers to process signals in a way similar to that of the cranial nerve.

*2 Cognitive technology: Technology that extracts and analyzes relevant information from huge amounts of data, learning from such information and past experiences to support human decision-making and actions.

*3 MI (materials informatics): Scientific method for solving various problems concerning matter and materials science by utilizing a vast and diverse amount of data related to computer science and the physical and chemical properties of matter and materials.

Patent Office Commissioner Prize received

Hitachi Metals received a Patent Office Commissioner Prize of the FY2016 National Invention Awards, hosted by the Japan Institute of Invention and Innovation, for its invention of a method for manufacturing maraging steel. Maraging steel is a type of steel with both high strength and high toughness. Hitachi Metals developed a technology for controlling to an extremely fine degree the inclusions generated in the steel ingot melting process, leading to dramatic improvement in maraging steel's fatigue strength.

CVT belt materials

Award ceremony

Tackling disruptive innovation with open environments and free-thinking research

Kenichi Inoue
Head of Global Research & Innovative Technology center, Technology, Research & Development Division; General Manager of Strategic Innovation Department

After in-house brainstorming, we decided on the name "Global Research & Innovative Technology center (GRIT)" for our new Corporate Research Lab. In English, "grit" means "fighting spirit and enthusiasm that prevail against all odds, the power to persevere," which embodies the philosophy of the new laboratory.

One attribute that greatly differentiates Hitachi Metals from other companies is the diversity of the materials it handles, resulting from its proactive development of materials other than metals. The medium- to long-term R&D topics for new business creation that we have launched are unlike those of other companies, and we will promote them without excluding any possibility.

Commitment is the key part of R&D. Simple images that anybody can conceive of and develop will inevitably be created by somebody. The goal of our R&D efforts is to provide impressive benefits to people, society, and the environment. Human beings are greatly interested in, and concerned about, what they can easily visualize 10 and 20 years down the road, which is where the real seeds of innovation lie. I am aware that my mission as head of the center is to create an environment and provide motivation for uncovering these seeded ideas. I also believe in the importance of integrating the technologies of our internal companies. In addition to cross-organizationally mixing the technologies of all companies, we will actively incorporate MI and AI* techniques to innovate our process technologies.

Other important missions of GRIT are the exchange of researchers and personnel development. In the new facility, we will emphasize a collaborative environment, including bringing together the Advanced Materials Development Department and the Process & Machine Development Department, while encouraging the growth of researchers through exchanges in open forums. Moreover, we plan to expand overseas operations in the next five years. In addition to quickly catching up with global trends, we hope to deepen exchanges and collaborations with overseas researchers who have different ideas and approaches.

*AI: artificial intelligence

Profile

Joined Hitachi Metals in 1993 and assigned to the Metallurgical Research Laboratory. Involved in the development of surface treatment (coating) technologies, which attracted attention of mold manufacturers and automakers. Launched the full-scale surface modification business in 2005 with the establishment of the Surface Modification Center (current name: Solution and Engineering Center in the Specialty Steel Company, Yasugi Works). Appointed General Manager of Technology at High-Grade Metals Company (current name: Specialty Steel Company) in 2016. Assigned to lead GRIT in 2017.

Innovation

Deploying a Solutions System to Reform Existing Businesses

Disruptive innovation created by renewed customer focus

There is an accelerating worldwide shift to railways as a means of providing mass transportation with reduced environmental impact. Hitachi Metals has been operating in the rolling stock cable business in Japan and overseas for some time. In addition to the production of cables for rolling stock, we have launched a comprehensive solutions-based business with offerings ranging from cable design to the design and manufacture of harnesses, and the outfitting of harnesses. Seeking to strengthen our solutions system for European markets, in 2016 we established a harness assembly line for rolling stock cable at our location in the Czech Republic, which has excellent access to various European countries. We will elevate our railway segment to a new level in an effort to expand our share of the global market.

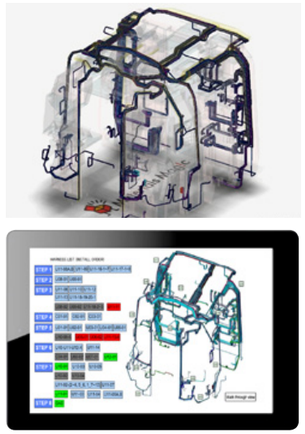
Commuter train for Scotland for which the Hitachi Group received orders

Shift in emphasis from “goods” to “solutions and services”

Having reaffirmed the benefits of meeting the pent-up demand from global rolling stock manufacturers, we launched a comprehensive solutions-based business with offerings ranging from the design of cables for rolling stock and the design and manufacture of harnesses to the outfitting of harnesses, in addition to the production of cables. A harness is a modularized component in which multiple wires are bundled. In this way, we can combine around 1,000 wires into 50 harnesses for use in the first car of rolling stock. This allows a huge reduction in the number of components and helps improve outfitting, workability, and convenience for customers. To date, rolling stock manufacturers have designed cable and manufactured and fitted out harnesses in-house alongside rolling stock design, which entailed considerable time and cost for measurement and outfitting. In response, we deployed 3D CAD technologies to provide comprehensive one-stop solutions ranging from rolling stock cable manufacture and wire design to the design, manufacture, and outfitting of harnesses. In harness manufacturing technology, which is one of the solutions, we developed an innovative digital harness board, which we deployed in the Czech Republic in 2016.

Wires and cables for rolling stock

Class 800 train manufactured for the Intercity Express Programme (IEP) in the United Kingdom (order received by the Hitachi Group)



3D design data screens
Top: 3D wiring technology
Bottom: Outfitting wiring technology

Innovative solutions and services based on original concepts

Here, we handled the cable design function on behalf of the rolling stock manufacturer, utilizing 3D design data provided by the manufacturer to create the wiring for each cable using 3D CAD. We designed a modularized harness that allows cable outfitting to be done easily and efficiently. We also reused 3D harness design data to develop an outfitting navigation system. In addition, we developed a series of instructional animations for a tablet or PC showing customers the correct way to connect and outfit the harness. In these solutions and services, we rigorously explore ways to enhance customer benefits and our own value, which leads to a win-win outcome.

By also using IoT technologies to develop a digital harness board, we enhanced the efficiency and quality of harness manufacturing, which was previously highly reliant on operators.

Since all of these are breakthrough solutions and services, including the related business model, we have applied for 35 patents in Japan and overseas, ranging from cable design methods to outfitting navigation and digital harness boards.

Shifting emphasis from price competition to a powerful growth engine

Booth at InnoTrans 2016 trade fair

By providing comprehensive solutions and services, we have created added value that cannot be compared with our conventional cable sales business.

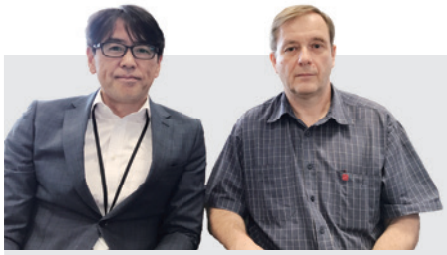
Using 3D in harness design greatly shortens the rolling stock design time for customers, and our outfitting navigation system has prevented outfitting error and lowered man-hours by 50%. This has greatly reduced lead times, from design to manufacture, for our rolling stock manufacturing customers. Furthermore, since the process can be simulated even without an actual vehicle, it is playing a positive role in the training of unskilled workers.

Enhancing the efficiency of harness manufacture and outfitting is a major issue for rolling stock manufacturers. Accordingly, Hitachi Metals received numerous specific inquiries when it exhibited these solutions and services at InnoTrans 2016, the International Trade Fair for Transport Technology, Innovative Components-Vehicles-Systems, held in September 2016, the largest of its kind. Some companies have already visited our harness assembly line at our location in the Czech Republic, and we look forward to attracting orders for new projects in the near future. Currently, we are the only company that provides comprehensive solutions, and this is attracting a great deal of interest because we are performing part of the manufacturer's role to deliver time and cost reductions.

With a new growth engine built on original comprehensive solutions, Hitachi Metals plans to increase sales in the railway segment by not only advancing its business laterally to domestic manufacturers but also expediting business growth on a global scale.

Comparison of Wire Usage for Rolling Stock

Type	Wire volume	Vehicle length
Commuter train (4 cars)	150 km	90 m
High-speed train (5 cars)	220 km	125 m

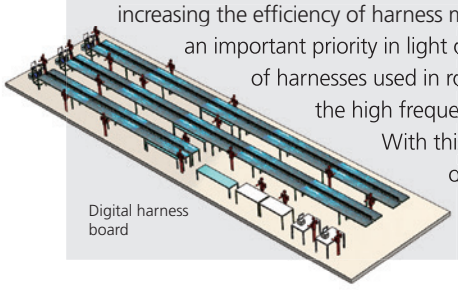


Innovative digital harness board developed from scratch

Kenji Kawase (left)
Manager, 1st Engineering Sec., 2nd Engineering Dept.
Electric Wire & Cable Business Unit, Cable Materials Company

Rostislav Varga (right)
IT Manager, IT Section, Hitachi Cable Europe, s.r.o.

In the past, harnesses were produced using wooden boards onto which design drawing printouts were affixed. However, increasing the efficiency of harness manufacturing became an important priority in light of the numerous types of harnesses used in rolling stock, as well as the high frequency of model changes. With this in mind, we developed our own groundbreaking digital harness board that directly projects the harness design drawing. Thus, we created a manufacturing environment that enables flexible responses to design changes, in addition to model changes. We also introduced IoT technologies to handle automatic distribution, collation, and disconnection of cables, as well as work navigation, and we adopted traceability to allow visualization of work records and progress. In the Czech Republic, we have introduced a long assembly line that can manufacture harnesses up to 30 meters in length.



Digital harness board