

Management Strategies

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Strategy and Vision – Message from the CEO



Becoming a high-performance materials company unparalleled in the world

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Representative Executive Officer,
President and Chief Executive Officer

Introduction

Under the Fiscal Year 2018 Medium-Term Management Plan, the Hitachi Metals Group aims to expand its businesses globally and improve its profitability. Along with organic growth, we will seize opportunities for further growth through mergers and acquisitions, and work continuously to renovate our portfolio. With our diverse business portfolio that has evolved over the more than 100 years since the Company was established, we aim to become even stronger by bringing together diverse high-performance materials, and demonstrate a conglomerate premium unique to Hitachi Metals.

In the automobile industry, the shift toward EVs* is rapidly accelerating as the overall manufacturing industry is experiencing a major wave of technological innovation led by the Internet of Things (IoT) and artificial intelligence (AI). These developments are providing a strong boost to the Hitachi Metals Group. Hitachi Metals' strength as a high-performance materials company unparalleled in the world lies in being able to address the shift to EVs by proposing integrated solutions that involve magnets, soft magnetic materials, and power cables for high-efficiency motors, as well as integrated

solutions for the IoT and AI with semiconductor-related products such as lead frame materials, LTCC substrates, and mass flow controllers.

Looking back at fiscal 2017

Fiscal 2017 was my first year as President and CEO. During that year, we faced three difficult operating issues, but I believe we have made steady improvements in each area. Through *monozukuri* innovation, we overcame production technology issues for the automotive heat-resistant cast component HERCUNITE™ for significantly increased yields, while also reviewing our pricing with the understanding of customers, and in March 2018, the business turned profitable on a single-month basis. With regard to aluminum wheels, AAP St. Marys Corp. implemented the highly efficient *monozukuri* management reforms of Waupaca Foundry, Inc., the world's best casting manufacturer, resulting in higher production efficiency. With a jump in costs for secondary materials including graphite electrodes and heat-resistant materials, earnings have been pressured in the specialty steel business in particular, but in fiscal 2018 our customers agreed to the

*1 Refers to electric vehicles (EVs) including hybrid electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs).

Strategy and Vision – Message from the CEO

introduction of a surcharge system as a new method for setting prices. This allows fluctuations in raw material prices to be reflected in product prices and minimizes the impact of those fluctuations on the Company's operating results.

At the same time during fiscal 2017, we made solid progress with three cross-organizational reforms. Along with research and development, *monozukuri*, and sales being carried out based on common, companywide policies at the four internal companies—Specialty Steel, Magnetic Materials, Functional Components, and Cable Materials—management is becoming highly transparent. The *monozukuri* innovation that we initiated in fiscal 2016 has been further strengthened from April 2018 with the shift to a structure whereby the Technology, Research & Development Division has primary responsibility for “Technological Innovations” and the newly established GEMBA Innovation Management Division primarily responsible for “GEMBA (Workplace) Reforms.” With regard to sales innovation, employees are experiencing major synergies through the handling of companywide product groups as sets that transcend the divisions of each internal company. The research wing of the Global Research & Innovative Technology center (GRIT), a companywide R&D organization, was completed in April, and many customers have already visited the facility and directly seen the extent of the Hitachi Metals Group's potential.

During fiscal 2017 we also emphasized the strengthening of communication with stakeholders. In terms of senior-level sales, I personally visited customers, and for investor relations, we held numerous small meetings with analysts, briefings, and other events to engage in direct dialog with investors. We also held roughly 50 town hall meetings globally, which provided opportunities for direct dialog with close to 10% of the Hitachi Metals Group's global workforce of approximately 30,000 people.

Although our operating results are not yet satisfactory, the direction we are taking is clearly being understood across the Group, communication is improving, and technological innovation like EVs is boosting the Hitachi Metals Group's prospects.

Key issues for fiscal 2018

The first key issue for fiscal 2018 is to implement price revisions. Jumps in prices for raw materials and secondary materials in fiscal 2017 depressed operating income by roughly ¥6 billion. Measures and new products introduced at the specialty steel business over several years are showing results, but there has been a large impact from the steep rise in prices for secondary materials, and we have been unable to have our strengths fully reflected in operating results. Through dialog with customers, we were able to introduce a surcharge system

in July 2018 in which price fluctuations for secondary materials are reflected in product prices.

We are also emphasizing the early deployment of our strategic capital expenditure. Major investments made during the April-June quarter are successively nearing completion, including the GRIT research wing, the innovative production lines for ferrite magnets and rare earth magnets at the Kumagaya Works, the new continuous casting and rolling line for wire and cable conductor materials at the Ibaraki Works, and the Yasugi Works' 10,000-ton free forging press. The new line for cladding materials at the Tsuchiura Works will commence operations early in 2019. In addition to increasing production capacity, the early deployment of these major investments will increase marginal profit rates by improving yields and reducing variable costs in other ways as well. At the same time, we will aggressively pursue orders to increase the effect of increased production capability, thereby increasing total marginal profit.

Magnets are a business bound to gain importance as the shift to EVs progresses, and by having production capacity prior to the emergence of demand, we will gain the trust of customers for our degree of stability in procurement in addition to product quality. The innovative production line for rare earth magnets has been approved by customers and begun full-scale operations. This line applies heavy rare earth diffusion

technology, uses IoT for process management, and automates inspection processes. We will increase and strengthen these lines going forward, with the aim of rapid growth.

Progress in R&D innovation

Internal companies' research labs focus on refining existing products and medium-term product development, while GRIT pursues the challenge of technological innovation with a view 10 to 20 years into the future. Changes in technological trends pose a major threat to the special materials handled by the Hitachi Metals Group, but by introducing our own technological innovation in terms of both materials development and process development, these changes can become major opportunities for growth. We are also pursuing product areas we have not previously handled and aiming for open innovation with customers, the Hitachi Group, and research institutions. GRIT has incorporated the former Production System Laboratory and the Magnetic Materials Research Laboratory has moved to the same floor. We expect this to lead to internal, cross-organizational innovation.

With the market undergoing major changes and cross-sales beginning to show results, GRIT's promotion function is also important. Promoting product groups across internal company boundaries makes it possible to combine or upgrade current products with a view to meeting market need 10 to 20 years

Summary of FY2017

- Implemented measures against three negative factors for profits (heat-resistant casting components, aluminum wheels, rise in raw materials prices) and expect the factors to be solved.
- Accelerated three companywide initiatives (R&D, *monozukuri*, sales).
- Strengthened communication with stakeholders (town-hall style meetings: direct communication with more than 2,000 employees; increased direct dialogue opportunities with investors; aggressive sales by top management).

Change in corporate culture:
Transparency and reliability of management, sharing of values, improved motivation of employees

A positive corporate culture that is oriented to the creation of new value

Priority Issues of FY2018

► Price revision

Corporate-led pricing that “maximizes the aggregate of marginal profit”

Review and expand application of the surcharge system (price revisions for products not covered by the system)

► Early launch of investments and harvesting gains

Specialty Steel Products	10,000-ton class free forging press, cladding materials, rolls for steel mills, etc.
Magnetic Materials and Applications	Innovative production line, acquisition of Santoku, etc.
Functional Components and Equipment	New casting line for piping components, etc.
Wires, Cables, and Related Products	New continuous casting & rolling line, innovative production lines for magnet wires, etc.
Corporate	Opening of new building at GRIT, corporate research lab

The first year of “New Hitachi Metals”

Strategy and Vision – Message from the CEO

into the future. With products like materials indispensable for clean engines and materials that contribute to the shift to EVs, the Hitachi Metals Group is a genuinely development-driven company paving the way for the future with both current products and innovative advanced materials.

Progress in *monozukuri* innovation

Monozukuri innovation comprises both workplace reforms and technological innovations, and significant progress is being made in workplace reforms in particular. We are using the “2S-3F” concept (Sort Out, Set In Order, Fixed Location, Fixed Quantity and Fixed Item) to clear up workplaces through bottom-up activities and working to make activities “visible,” and spreading this globally through workplace exchanges. This is stimulating employees to learn from each other across internal companies, and a new Hitachi Metals Group culture is taking root. It is extremely important for everyone, including senior management, to have a common understanding of what might happen in the workplace, including safety-related activities. The GEMBA Innovation Management Division, reporting directly to the President, was established in April to accelerate this process.

Technological innovation has also achieved successes including the introduction of an innovative production line for magnets, and in fiscal 2017 a concentrated investment of

management resources was made for *monozukuri* innovation in HERCUNITE™. We are putting renewed effort into technological innovation in fiscal 2018, as we strive to strengthen *monozukuri* innovation in this area as well as workplace reforms.

Progress in sales innovation

Hitachi Metals provides customers with technologically advanced, unique products with industry-leading production capability and cost competitiveness. This is, in essence, “the mass production of high-quality materials” that we seek. The idea of selling technologically advanced products at high prices and maintaining profit margins would limit areas where we can be globally competitive, and high growth cannot be expected.

Under the Business Activity Power Up Project, cross-organizational functions like the common understanding of our basic policy for pricing as “maximizing the aggregate of marginal profit” are being strengthened, and staffing at sales divisions is being increased. In terms of efforts to develop new products and new markets using companywide resources across internal companies, we have launched a project for next-generation automotive parts and materials, led by younger employees. Over the long term, we will closely follow long-term trends in technology and market growth, including

the shift to EVs and weight reduction in iron castings, and work with GRIT to create a roadmap for a product portfolio strategy and new business creation.

Capital strategies and shareholder returns

Capital expenditure will remain at the ¥100 billion level in both fiscal 2017 and fiscal 2018, focusing on proactive investment for growth and investment for streamlining to strengthen workplaces, but we see this as the peak and plan to implement capital expenditure not exceeding the amount of depreciation and amortization from fiscal 2019. With respect to shareholder returns, our policy is to emphasize a balance between investment and returns to shareholders, and we have raised our dividend payout ratio target to 30% from the previous 25%.

Corporate governance

Hitachi Metals is a company with a nominating committee, etc., and our organization is managed so that management oversight and operational execution function effectively. This year we have reviewed the roles of the Board of Directors and Executive Committee, which executes business operations, so that deliberations of the Board of Directors will not duplicate those of the Executive Committee, leaving the Board to focus on long-term business strategy and engage in active discussions on the direction Hitachi Metals should take.

Becoming the world’s leading high-performance materials company

The Hitachi Metals Group seeks to increase its corporate value by using unique products to create new value for customers and contribute to resolving underlying social issues.

To achieve this, we are working to instill a vibrant corporate culture in which each employee is a soldier fighting on the front line of the workplace, with a sense of determination to implement the strength of “One Force for Change.” This means using diversity to achieve successive innovations that other companies cannot match and create unique products, for continuous growth to become a high-performance materials company unparalleled in the world. We ask that you look forward to that.

Acceleration of Growth by Strengthening Corporate Functions

R&D (GRIT)	<ul style="list-style-type: none"> Promote creation of new business with a view to threats and opportunities. Strengthen human resources development/education functions (sales divisions, group companies). Enhance the process of identifying and evaluating new technologies and R&D speed in cooperation with sales.
Sales	<ul style="list-style-type: none"> Carry out multilayered proposal activities including top management, utilizing GRIT. Strengthen relationships with customers by establishing an account sales system. Carry out cross-sectional projects.
<i>Monozukuri</i>	<ul style="list-style-type: none"> Carry out activities based on the two pillars of “GEMBA (workplace) Reforms” and “Technological Innovations.” Establish the GEMBA Innovation Management Division. Implement technological innovations for the entire materials flow using IoT.

A genuinely development-driven company

The mass production of high-quality materials



Examples of Initiatives in Target Areas

EV*-related products

The rapid shift toward electric power is one of the measures being taken to reduce the environmental load of automobiles, and EV production is seen growing by 30% annually on a unit basis. Hitachi Metals is able to use the advanced technologies and *monozukuri* capabilities it has developed over the years in a range of areas that are growing with unlimited potential; in addition to drive motors, these include inverters, batteries, chargers, power semiconductors, and various sensors that are essential to safety and autonomous driving. We see this as a major opportunity, and will work toward contributing to the realization of a low-carbon society together with sustainable growth.

A total supplier of high-performance materials

Becoming a core supplier of EV-related products

With powertrains being powered electrically, innovation is being sought not only in drive motors, but also in all major necessary components, including higher output and lighter weight for automotive-use secondary batteries, and brake and handle controls for automated driving. Hitachi Metals is able to supply a total range of various high-performance materials, including magnets for drive motors, inverters and converters, and soft magnetic materials and cladding materials used in secondary batteries. We are therefore accelerating our development and production with the aim of being a core supplier of EV-related products that is also a reliable partner.

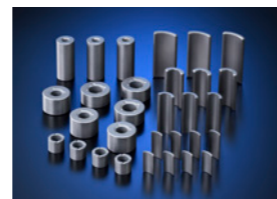
Hitachi Metals' products driving EV evolution

Products for "moving"

- NEOMAX® neodymium magnets
- NMF™ ferrite magnets
- Amorphous motor core materials
- Magnet wires for high-efficiency motors



NEOMAX® neodymium magnets



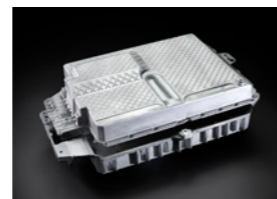
NMF™ ferrite magnets

Products for "storing"

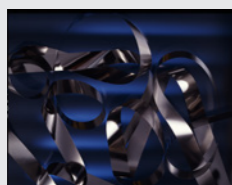
- Cladding current collector for large-capacity lithium ion batteries
- Aluminum battery cases



Lithium battery-use cladding materials



Aluminum battery case



FINEMET® ribbon

Increasing production capacity for FINEMET®

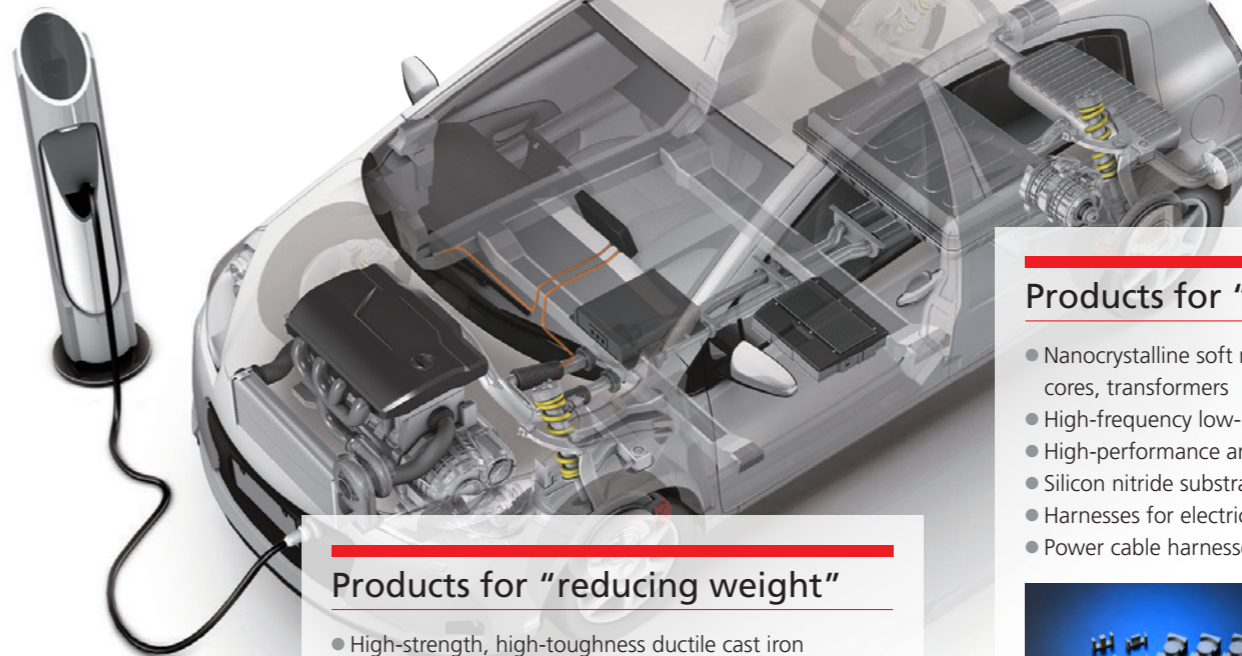
With the aim of smaller sizes and lighter weights for power supply circuits used in equipment with an output of more than several kilowatts, including electric vehicles, railways, and renewable energy systems, drivers need to operate at even higher frequencies. The magnetic steel sheets previously used in high-frequency ranges, however, experience significant iron loss (loss of the energy generated in the iron core) when used in transformers and reactors, causing a loss of electric power that leads to issues including lower efficiency and higher temperatures. In addition, shifting to higher frequencies means that the associated high-frequency noise needs to be addressed. To resolve this, FINEMET®, a nanocrystalline soft magnetic material with high magnetic permeability and high flux density with low iron loss, has proven effective for use as the iron core in equipment including transformers, reactors, and chokes for noise filters. To meet market needs, Hitachi Metals is boosting the capacity of its production line with a planned three-fold increase by the end of fiscal 2018 (compared with fiscal 2017). We are also improving processes in an effort to enhance quality on an individual piece basis.



NEOMAX® neodymium magnets

NEOMAX® neodymium magnets make motors smaller and more efficient

NEOMAX® is a neodymium magnet with superior magnetic characteristics of which Hitachi Metals led the world in developing and launching the mass production. It is widely used in EV powertrains, which need to have high output. At our innovative production line that started mass production in September 2018, extensive automation and the use of the Internet of Things have achieved significant increases in product quality and productivity, in response to increased market demand. In addition, by making Santoku Corporation a subsidiary in April 2018, we have reduced procurement costs for raw materials and concentrated alloy manufacturing and recycling to increase production volume and build an integrated development structure. Going forward, we will focus on reducing the size and increasing the efficiency of motors, and expand and bolster our lineup of high-performance magnets that use less volume of heavy rare earth elements.



Products for "transmitting"

- Nanocrystalline soft magnetic material FINEMET® coils, cores, transformers
- High-frequency low-loss soft ferrite cores
- High-performance amorphous powder cores
- Silicon nitride substrates
- Harnesses for electric parking brakes
- Power cable harnesses for hybrid vehicles



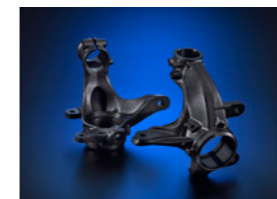
High-frequency low-loss soft ferrite cores



Amorphous powder cores

Products for "reducing weight"

- High-strength, high-toughness ductile cast iron
- OMEGA KNUCKLE®
- SCUBA™ fashionable aluminum road wheels
- Aluminum motor housings
- Tools for friction stir welding (FSW)
- NEOMAX® neodymium magnets



OMEGA KNUCKLE®



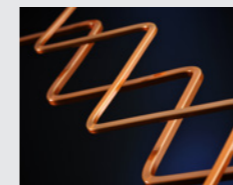
Aluminum motor housing



Harness for electric parking brakes



Power cable harness for hybrid vehicles



Magnet wires for high-efficiency motors

Expanding magnet wire business in anticipation of robust EV demand

The magnet wire business, which includes magnet wires for drive motors, is growing from the use of HiFC™ high-performance pure copper and the introduction of innovative production lines. HiFC™ was developed by Hitachi Metals by adding trace amounts of titanium to copper, which controls the actions of the impurities oxygen and sulfur, while properties including conductivity, flexibility, and weldability are enhanced. Using HiFC™ for motor magnet wires increases productivity in manufacturing the motors while also reducing their size and weight and increasing their efficiency and reliability. In addition, we have introduced innovative production lines in Japan and Thailand to accelerate *monozukuri* and expand the magnet wire business.



Silicon nitride substrate with high thermal conductivity for use in power semiconductor module

Silicon nitride substrate makes dramatic improvement in cooling properties for power modules

Power modules efficiently transform and control electric power, and their use is spreading rapidly in control components for electric vehicles, rolling stock, and motors for industrial machinery. In addition to insulation, insulating substrates used in power modules need thermal conductivity for the efficient transfer of the heat emitted from power semiconductors, and the sophisticated mechanical property of resistance against the stress created by the temperature cycle. In addition, the use of silicon carbide (SiC) semiconductors as next-generation power semiconductors is seen increasing going forward, leading to heightening requirements for high thermal conductivity and mechanical properties in insulating substrates. The silicon nitride substrate developed by Hitachi Metals has both high thermal conductivity and mechanical properties. Use of this substrate can be expected to reduce the size and lower the cost of cooling mechanisms in power modules. The use of SiC semiconductors could also make it possible to operate at higher temperatures.

* EV refers to electric vehicles including hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV).

Reforms and Progress Aimed at Expanding Organic Growth

Stepping up pursuit of *monozukuri* innovation

The *monozukuri* innovation that the Hitachi Metals Group is focused on pursuing seeks to activate employees and generate cash through the fusion of "GEMBA (workplace) reforms" and technological innovation in areas including productivity, materials processes, machine processing, and the Internet of Things. In the area of GEMBA reforms in particular, we established a new GEMBA Innovation Management Division in April 2018 as a cornerstone for these activities. Working in cooperation with the Technology, Research & Development Division, this new division will further accelerate GEMBA reforms at all Group locations around the world.

Manufacturing Innovation

Case 1

Using IoT technologies to lay a foundation for plant reform

At the Specialty Steel Company's Yasugi Works, operational reform is proceeding under YoT (Yasugi's Internet of Things), with data visualization and the use of IoT technologies operating side by side in what we call the YoT Project.

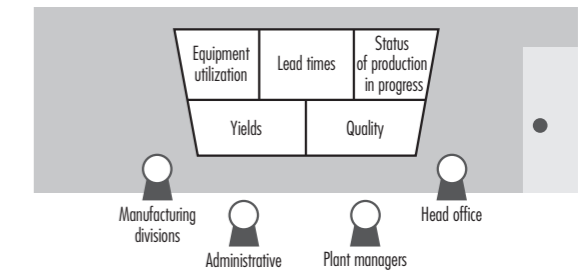
Within the Hitachi Metals Group, specialty steel manufacturing is known as producing small lots of a large number of product types. Because processes including melting, hot processing, and cold processing are completely separated, production management to date has been carried out by material and process. This has meant that even if we tried to manage the plant's overall production on an integrated basis, discussions with common parameters for optimization of product management could not take place. Therefore, as a way of visualizing data, we began to build a common, cross-division platform to understand the plant as a whole, including the utilization of main equipment, the status of production and production in progress for each process, lead times and yields, and occurrence of defects.

This made it possible for all manufacturing divisions, administrative divisions, and plant managers to access data from the same screen, facilitating appropriate identification of issues and formulation of countermeasures. In addition, the

use of IoT technologies allowed us to transfer inventory operations for raw materials from pen and paper to smart devices, which succeeded in reducing the time involved by half. We are also moving forward with the use of sensing to collect equipment data automatically.

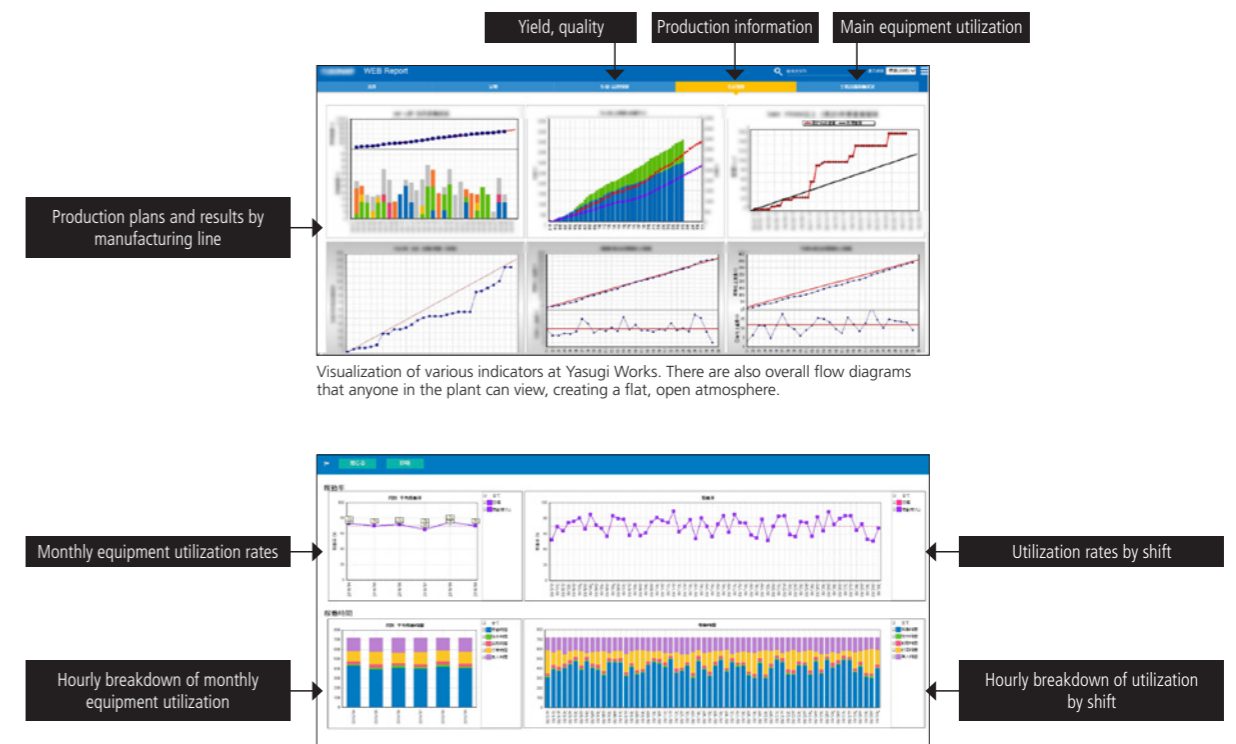
This YoT Project is one framework whereby we are using technology to make advances on the plant floor. Going forward, we will make further advances in the use of this framework for *monozukuri* innovation and enhancing productivity and safety.

Overview of use of common cross-division platform



Multifaceted understanding of situation and resolution of issues across divisions

Common cross-division platform screens



Visualization of various indicators at Yasugi Works. There are also overall flow diagrams that anyone in the plant can view, creating a flat, open atmosphere.

The utilization analysis screen makes it possible to identify discrepancies between utilization times and work operation times for main equipment.

Case 2

Advancing "2S-3F" activities from the workplace for the workplace

The Hitachi Metals Group is rolling out "2S-3F" activities as a Companywide initiative at the core of *monozukuri*, as we work to improve workplace environments and increase inventory turnover rates through the two "S" initiatives of Sort Out and Set In Order, and three "F" initiatives of Fixed Location, Fixed Quantity and Fixed Item at manufacturing sites.

For example, various 2S-3F activities are being implemented at the Cable Materials Company's Ibaraki Works with a basic concept of "creating an environment where it is easy to work." By rearranging the layout of the rewiring line for machinery cables for optimal line of flow, conveyance times during operations were reduced by roughly half. In cable end

processing operations, which are prone to produce inconsistent quality, making our own work chassis and tool rod have made it possible to reduce the roughly 4-kilogram electric saws to 1.2-kilograms load on the tool rod, resulting in significant improvements in operational efficiency and quality.

Implementing improvements based on feedback from the workplace is the starting point of 2S-3F activities, and by having the workplaces themselves implement the improvements, progress is being made through detailed improvements. This continuous activity is leading to dramatic improvements in workplace environments, and is improving operational efficiency ratios.

Rewiring line for machinery cables



Case 3

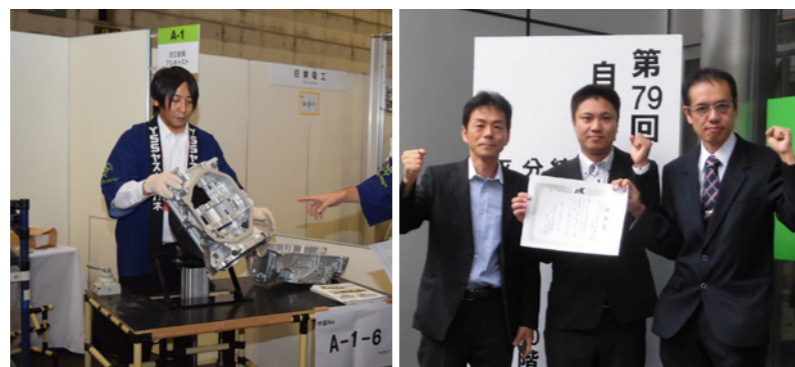
Disseminating the successes of workplace reforms through external exhibitions and presentations

The Hitachi Metals Group is proactively disseminating the successes of workplace reforms through various external venues.

The Company displayed eight exhibits at the Karakuri KAIZEN® Exhibition 2017, held by the Japan Institute of Plant Maintenance. Karakuri KAIZEN aims to use old technologies and principles based on leverage and gravity to improve operations using simple mechanisms. One of our exhibits, "Is it comfortable? (an inspection platform that uses spherical bearings and springs to easily and freely set an inspection surface without supporting it by hand)" was selected as one of "10 items of note" in the organizing committee's brochure.

In addition, two teams from Hitachi Metals participated in the Japan Iron and Steel Federation's 79th Voluntary Control Activity Seminar. The Yasugi Works inspection group's

presentation on its Inspection Efficiency Up Project, demonstrating a peripheral visual inspection method, was awarded a top prize in recognition of its improved operability and quality through reevaluating how visual inspections should be done.



* Karakuri KAIZEN is a registered trademark of the Japan Institute of Plant Maintenance.

R&D Innovation

GRIT research center creating disruptive and discontinuous innovation

Against the backdrop of current megatrends, the frameworks of industries themselves are changing in a variety of sectors. To address these rapid environmental changes, we believe that in addition to swifter decision-making, cross-sector initiatives that transcend internal company boundaries, and innovation that looks 20 years into the future, are important. With the aim of being a "genuinely development-driven company," we have established a corporate research lab to conduct research and development in advanced materials and processes that will lead to sustainable growth and contribute to society. We are embarking on a new stage of "change and challenges" in research and development.

R & D

R&D Innovation



Kenichi Inoue

Head of Global Research & Innovative Technology center, Technology, Research & Development Division

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.

Overview of GRIT and its direction

Pursuing the challenge of impossible, discontinuous innovation through continuous research and development

The Global Research & Innovative Technology center (GRIT) was established as a corporate research lab, and with the construction of the new research wing complete, GRIT has begun full-scale operations. In English, GRIT has the connotation of “the strength to follow through with undaunted courage and mettle, even when something is difficult,” which exemplifies our spirit of creating new technologies for 10 to 20 years into the future.

The new research wing represents an investment of roughly ¥10 billion, with a layout based on the concept of open space to facilitate active discussion. Even meeting rooms have glass walls, creating an image that contrasts sharply with that of a closed research facility. A major, unique feature of the facility is that in addition to research and development, GRIT can play a major role in marketing activities, with equipment in place for demonstrations of 3D printers and machine tools, as well as an exhibition space for presentations of Hitachi Metals’ products and technologies.

Digitalization, as seen in the Internet of Things (IoT) and artificial intelligence (AI), has already brought about creative disruption in a number of industries. Well-known examples include major innovations in production systems and the shift from gasoline-powered to electric vehicles. It is easy to move forward with continuous innovation, but today, in the midst of a paradigm shift, it is necessary to take a different approach that will bring about discontinuous innovation and disruptive innovation. GRIT was born as a venue where this can take place.

In addition to consolidating Hitachi Metals’ experience and expertise, GRIT is focusing on being a venue for open innovation and the creation of free and open-minded ideas. A research area named Open Lab, for example, functions as a space where staff can work together with outside research partners and customers in a free and open atmosphere to resolve issues and create innovations. GRIT has no special rooms for me. This is so that discussions can take place and work can be done anywhere. By working in GRIT’s various spaces, I intend to break down existing organizational levels.

Global Research & Innovative Technology center

■ Founding principle

To promote research, development, and innovation for the future, looking beyond the present, to become a genuinely development-driven company.

■ Concept

1. Lay the path for sustainable growth in the future through advanced materials and processes
2. Cultivate the growth of human resources
3. Act as Hitachi Metals’ technology base

GRIT’s missions

Use new strategic approaches to develop innovative materials

Materials have driven industrial technology innovation, and the development of innovative, advanced materials is the starting point for social transformation. Recognizing the importance of this development and innovation, GRIT looks beyond iron and metals and pursues development themes for research into

R&D Innovation

advanced materials for the medium to long term.

Research and development at GRIT are actually carried out by the Advanced Materials Development Department and the Advanced Process Development Department. The Advanced Materials Development Department is currently pursuing research into advanced materials under 16 designated themes. In addition, the Advanced Process Development Department is using advanced digital technologies to collect data via the IoT and analyze it using AI, and by providing feedback to the development site, we are pursuing production technology innovation through engineering.

Another of GRIT's important missions is to commercialize its research and innovation. For this reason, a new Business Innovation Department has been established within GRIT to assume functions across internal companies. A Strategic Innovation Department has also been established to produce research and development. This is where highly experienced managers identify new research themes, and groundbreaking trials are carried out under the guidance of these managers, who provide researchers with a clear direction for their work from start to finish. Researchers tend to submerge themselves in their research without considering its commercial possibilities, but by taking a strategic approach led by the Business Innovation Department and the Strategic Innovation Department, we expect to accelerate innovation at the global level.

Examples of research and development

Turnaround concepts transforming threats into business opportunities

GRIT is engaged in medium- to long-term research with a view toward threats and opportunities. One example of this is the development of metal powders for metal 3D printers.

Today's specialty steels are manufactured using complicated processes like melting, forging, and scraping, but we believe a switch to the use of metal 3D printers has significant potential for future cost benefits with ultra-small-lot components like

aircraft parts. We also believe there may be similar benefits with metal 3D printers in the automotive sector for parts where strength is not a particular requirement. These predictions would have been conventionally seen as a threat to Hitachi Metals, but if we can achieve technological innovation, these could become major opportunities.

In this way, we will approach the field of metal 3D printers, a technology that is changing *monozukuri* in significant ways, by looking beyond existing products including stainless steel, nickel-based alloys, and aluminum alloys, and developing various new materials using the special features of additive manufacturing. GRIT does not simply make materials; it uses CAE* analysis technology, which we have accumulated, to simulate the properties and deformations of metals in advance, and conduct repeated verification to develop recipes for each material. One of these successes has been the joint development with Hitachi, Ltd.'s R&D group of metal powder for metal additive manufacturing. This has made it possible to manufacture with high-entropy alloys.

We are accelerating our research and development using CAE analysis technology to optimize materials, and we plan to make major advances in developing light, strong, new materials for the automotive, aircraft, and energy-related segments. In addition to new materials, we also intend to apply this to product development for special, single-batch production. Going forward, although iron will remain our main material, we will look to develop compound metals using combinations of a wide range of materials with various functions, including superalloys, aluminum, carbon nanotubes, and ceramics.

Another of GRIT's R&D themes is to develop products together with customers. In the development of magnets for EV motors, for example, the amount of valuable heavy rare earth metals used has a major impact on productivity and costs. We are therefore working with customers to make heavy rare-earth-free and less-rare-earth magnets higher performance.

Medium- to long-term R&D themes taking into account threats and opportunities (examples)

Company	Current products	Development theme based on perceived threats
Specialty Steel	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

Open innovation and future outlook

Resolving social issues through open innovation and human resource development

The pursuit of open innovation is one of GRIT's important missions. We are already engaged in open innovation, working closely with Hitachi, Ltd., as well as with universities, companies, and other third-party institutions.

In July 2016, we opened the NIMS-Hitachi Metals Next-Generation Materials Development Center jointly with the National Institute for Materials Science (NIMS) and began researching practical uses for next-generation ultra heat-resistant alloys. The use of this research in metal materials for aircraft engines and gas turbines is contributing to reductions in CO₂ emissions and resource conservation.

GRIT is also playing an important role as a center for human resource development. Previously, most researchers hired as new university graduates were assigned to the research lab of one of the internal companies, but we are increasing the portion assigned to GRIT to give them more opportunities to understand the businesses of the entire Hitachi Metals Group immediately after joining the company. GRIT is also teaching technological skills needed by technical service staff, and dispatching them to customers' locations around the world to understand their various needs firsthand. When they return to GRIT, they are able to use that expertise in their research and development. In addition, we are considering using GRIT for the training of coaching staff for local sales staff in places like China, which is expected to be the main battleground for EVs going forward, and holding training programs at GRIT for local sales staff.



GRIT's mission is to conduct research and development that creates discontinuous innovation and to take the lead in bringing that innovation to commercialization. We are also planning to open an overseas center in roughly five years, to be able to identify global trends as quickly as possible. As a venue for finding research partners and business proposals, and for deepening interaction and cooperation with overseas researchers and outside institutions, GRIT is proactively making use of and training regional human resources. Looking ahead, GRIT's research and development contributing to the resolution of social issues as well as the Hitachi Metals Group's sustainable growth can be expected.

* CAE: Computer Aided Engineering. The use of computer simulations to determine whether designed items can perform the functions required prior to actually producing the item.

Success in manufacturing with high-entropy alloys using a metal 3D printer

Together with Hitachi, Ltd.'s R&D group, GRIT has developed metal powder for metal additive manufacturing (metal 3D printers), and by identifying process requirements that use this development, successfully developed manufacturing technology with the high-entropy alloy "HiPEACE®*."

High-entropy alloys are defined as alloys that include at least five chemical elements in roughly equal amounts and feature no main element. These alloys are superior in terms of strength and corrosion resistance, but are also difficult to cast and process. GRIT verified properties and deformations in high-entropy alloy by using its CAE analysis technology, which we have accumulated, and has succeeded in optimizing high-entropy alloys for additive manufacturing.

We have confirmed that these high-entropy alloys are strong, malleable, and corrosion-resistant, and can be used in harsher environments than nickel-based alloys. We will pursue further verification testing going forward, with the aim of practical applications.

* HiPEACE® (Hitachi Printable Extreme Alloy for Corrosive Environment) is a registered trademark of Hitachi, Ltd.



"HiPEACE®" high-entropy alloy

Solutions

Bringing together “strong individuality” for rapid growth of the aircraft business

The Hitachi Metals Group’s Medium-Term Management Plan designates aircraft/energy-related materials business as an area of high growth, and we are proactively making large investments in this business. This has included the 840-ton ring mill at the Okegawa Works, which commenced operations in November 2015, where we have pursued innovative technologies from certification to mass production of aircraft engine materials. This has resulted in orders for and mass production of combustor case materials for aircraft engines. In the spirit of *wa sureba tsuyoshi*, solutions that bring together strong individual elements are leading to major breakthroughs.



Solutions

Solution Case Study

Beginning development for aircraft engine-use combustor case materials

The Specialty Steel Company’s Okegawa Works installed and started operating an 840-ton ring mill, with pressure capability that ranks among the world’s largest, in November 2015 to expand our business in the aircraft/energy-related market, which is earmarked as a future growth driver. This has made it possible to manufacture combustor case materials for medium-sized to large engines.

Hitachi Metals America, Ltd. (HMA) is our contact point in North America for a major aircraft engine manufacturer. In addition to the record of accomplishment in manufacturing many types of aircraft/energy-related materials established at the Okegawa and Yasugi works, HMA proactively presented our robust equipment capabilities. Interest shown by the major U.S. aircraft engine manufacturer led to our decision to develop aircraft engine-use combustor case materials.

Bringing together technological capabilities and sales capabilities for undisputed “strong individuality”

Passenger jet aircraft are entrusted with the lives of many people and require an exacting degree of safety, and international systems operate independently for the certification of strict quality management systems and special process operations for aircraft parts. Therefore, in addition to advanced technological capabilities, materials manufacturers require production structures and certifications that meet strict quality requirements.

The rolling of aircraft engine materials encompasses a great challenge from the unique degree of difficulty in processing the nickel alloy used for mass production. The Okegawa Works is applying its expertise from a 350-ton ring mill, which was



(From left) Hiroki Yanase and Jun Osone of the Specialty Steel Company’s Okegawa Works, Shiyoji Samori of the Okegawa Works who cooperated with development, and Toshiyuki Mitsuji of the Aerospace & Energy Materials Business Unit



the main piece of equipment used, to acquire expertise in the use of an 840-ton ring mill, and working with engineers at the Yasugi Works was able to achieve required settings for metal forming and heat treatment processes. This enabled the development of aircraft engine-use combustor case materials in 2016, and the mass production of combustor case materials for new types of engines that will be used in next-generation passenger jet aircraft.

The Hitachi Metals Group was able to succeed with this project by using the Okegawa Works’ superior manufacturing technology combined with the expertise and sales capabilities of the Aerospace & Energy Materials Business Unit, and through cooperation with HMA, which has connections with the major aircraft engine manufacturer. This embodies the spirit of our *wa sureba tsuyoshi* (“strength through harmony”) Corporate Philosophy by bringing together the “strong individuality” represented by the enthusiasm of all involved, including technological expertise and sales.

Technological breakthroughs in orders and mass production

Processing of the material WASPALOY®*1 was the key to orders and mass production of aircraft engine-use combustor case materials. WASPALOY® is a nickel-based alloy that has good strength at high temperatures and excellent high-temperature corrosion and sulfidation resistance. The other main ultra heat-resistant nickel-based alloy is Alloy 718*2. WASPALOY®

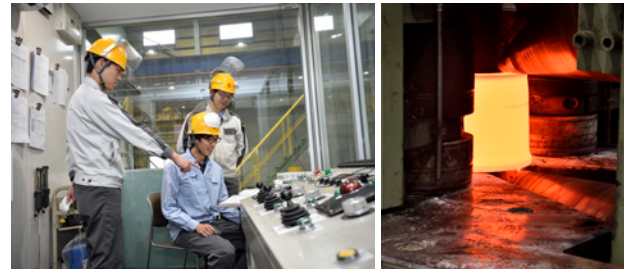
has a superior strength than Alloy 718 at high temperatures, but is also more difficult to form. Following a series of highly detailed studies to derive the optimal operation conditions, the Okegawa Works acquired technological expertise and created proprietary forming technologies of WASPALOY®. This was an important technological breakthrough.

Currently, the Okegawa Works is the only facility in Japan that is able to mass produce combustor case materials for medium-sized and large aircraft engines with WASPALOY®. We have already received inquiries from other aircraft engine manufacturers and started several new projects. Going forward, the Hitachi Metals Group will continue to strengthen its aircraft/energy-related materials business through combinations of “strong individuality.” We are aiming for sales

of more than ¥60 billion as one of the world’s top four companies in the area by fiscal 2025.

*1 Registered trademark of United Technologies Corporation. An ultra heat-resistant nickel-based alloy that is stronger than Alloy 718 in high-temperature ranges.

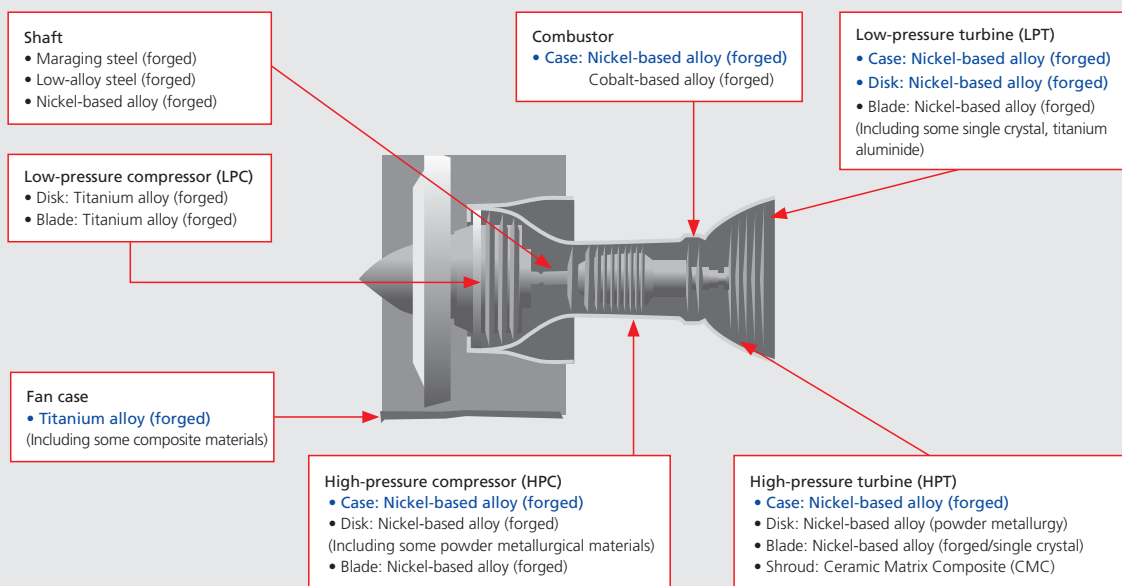
*2 An ultra heat-resistant nickel-based alloy with superior strength at high temperatures.



Special properties of nickel-based alloys and target products for aircraft engines

Jet aircraft engines use the energy from combustion gas to turn fans that propel the aircraft. Temperatures inside the engine can reach as high as 1,600 degrees Celsius, and enhancing heat resistance is the key to achieving efficiency. Therefore, nickel-based alloys, which are heat resistant and strong at high temperatures, are the main material used especially for the so-called hot section—the area within the engine through which pressurized, combusted air passes. The high heat resistance of nickel-based alloys is what makes them difficult to form, and limits the appropriate temperature range at which forming can be done. By bringing together our experience, knowledge, and technological expertise in ring mills, the Hitachi Metals Group has achieved optimization of production processes and operation conditions to satisfy our customers’ requirements. With the Hitachi Metals Group’s innovative nickel-based alloy processing technologies and 840-ton ring mill, we anticipate increased sales of a variety of products in addition to combustor cases.

Cross-section view of an aircraft engine and most-used materials



Note: Blue lettering indicates products for which increased sales are anticipated following installation of 840-ton ring mill.