TRENDS

Connected Manufacturing Practices that Pioneer Future of Manufacturing
How the IoT is Enabling the Creation of New Value through Things

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We are in the midst of the Fourth Industrial Revolution, with new developments in digital technologies such as the Internet of Things bringing changes to many areas of society. In manufacturing in particular, it is expected to improve productivity and enable the automation of production processes, including greater sharing and use of data through the application of the Internet of Things to production machinery and the digitalization and networking of these processes. Given that smart manufacturing initiatives are underway around the world, including the Industrie 4.0 policies being pursued by the German government and the Industrial Internet Consortium made up of mainly US companies, how should Japanese manufacturers address digitalization? Moreover, where do the challenges lie when introducing the Internet of Things into the manufacturing workplace? *Hitachi Review* put these questions to Yasuyuki Nishioka of Hosei University, a leader in the field of manufacturing digitalization and the founder of the Industrial Value Chain Initiative that aims to achieve smart manufacturing using the Internet of Things.

Changes in Attitude Called for by Digitalization

The Fourth Industrial Revolution has arrived, bringing digital technologies that are transforming a variety of different industries. In manufacturing, smart practices that utilize technologies such as the Internet of Things (IoT) and artificial intelligence (AI) have been attracting attention. While work in these areas is ongoing in Japan, the feeling I get from the latest trends is that we are now getting past that initial boom in which the concept seemed to be getting ahead of itself. In fact, we are at the stage where an increasing number of companies are asking what they can or should do in their own operations and are getting started on those things that are actually doable.

While it is easy to talk about the "digitalization of manufacturing," one of the past strengths of manufacturing in Japan is that it was built around the skills and know-how of particular people and it is likely that many managers will be unable to adopt a different attitude. Nevertheless, smart manufacturing is a disruptive innovation that will transform traditional manufacturing practices and the risk for Japan is that it will wake up one day to discover that the world has left it behind.

Looking globally, China and Southeast Asia, home to a large proportion of the world's factories, are investing money and people in the fusion of digital technologies and manufacturing, seeing it as an opportunity to enhance competitiveness. Young people are finding work at factories and the IT staff needed to make use of digital technologies are also being well trained. It seems beyond doubt that the trend toward

smart practices will only accelerate. European countries such as Germany have strategies firmly in place that include standardization, and are steadily transforming their vision into reality.

In Japan, meanwhile, although we have a grand vision in the form of Society 5.0, the feeling is that we have been slower to translate it into specific strategies. Right now, I believe it is vital that we make steady progress on a private-sector-led digital transformation, especially those manufacturers who feel a sense of urgency.

Reinterpreting Manufacturing Processes as Value

Recent years have seen a shift in the main forms of value in society from the tangible to the intangible. One example that is already well established is the shift from owning hardware to renting computing functions made possible by cloud computer services. Another topical example is the business model whereby aircraft engines are paid for based on operating hours or engine revolutions. The automotive industry is also seeing rapid growth in car sharing services whereby people rent a vehicle when they need one rather than purchasing their own.

This pay-per-use business model is based on the concept of supplying customers not with a tangible product on its own, but with intangibles such as the benefits or experiences that the product provides. It is helping transform the manufacturing industry and its products into services. While much lip service is paid to the need for manufacturers to adapt to this trend, not all products can be delivered through this model. For all that people talk about the future as one where money is made from intangibles and services rather than tangible goods, it seems that many companies remain confused as to what exactly they should be doing.

One suggestion for a way forward is to place greater emphasis on the considerations of users rather than producers by taking a closer view of how products are used in practice, using the IoT to collect data that not only can be incorporated into the development of the next round of products, but that can also be used to resolve any issues on the spot. Services have already

been launched that collect post-sale operational data from products to provide the best possible maintenance and other management support, and another potential model involves monitoring how products are actually used and improving their value by making post-sale enhancements.

Another possible approach is to treat the activity of manufacturing itself as a value-generating service. While manufacturing and services are treated as separate industries, the difference lies in whether the outputs that customers pay for are tangible or intangible. When transitioning from the tangible to the intangible and from goods to services, I believe it is possible that the way we think of existing manufacturing operations, rather than being defined in terms of the products or components that are output, can be reinterpreted in a way that sees the manufacturing processes themselves as a form of value.

Something that has been noted for some time is that treating factories as a cost center and focusing solely on cost reduction only serves to degrade those factories. The way these plants are managed would likely change significantly if they were instead treated as centers for the creation of value through services. For example, methodologies and ways of thinking exist that treat factories as profit centers such as the department-based profit management used in the Amoeba Management System. By using the IoT for operational data collection and monitoring, it should be possible to improve productivity and establish ways of treating this as value.

While talk of services tends to direct people's attention toward downstream processes, the fact that so much attention is paid to services these days means, I believe, that now more than ever we should be reminding ourselves that services have their origin in products. This is because an emphasis on intangibles does not mean that tangible goods no longer have any value.

Support for Bottom-up Reforms that Suit Japanese Manufacturing

Reforming manufacturing in ways that draw on Japan's strengths is also needed to further enhance the value of goods. While the key to reform lies in the IoT and other

digital technology, the situation that many manufacturers face is that they lack the experience (case studies), expertise, and personnel to adopt the IoT. This is what led us in 2015 to establish the Industrial Value Chain Initiative (IVI) as a forum for promoting the integration of digital technology and manufacturing practices.

At IVI, we define smart manufacturing as connected manufacturing. The word "smart" is associated with intelligence, something that arises out of an ability to communicate with other people. It is this connectedness that we emphasize.

Factories are essentially closed worlds and standard practice is to keep interaction with and connections to the outside world to a minimum. This gives rise to terminology and other cultural forms that are only understood within the company or plant, posing an obstacle to connectivity with computer networks. It was the idea of creating a place where people from manufacturing can talk frankly about their shared concerns and discuss the future of their industry that led to the establishment of IVI as a way to eliminate this obstacle.

Now, five years after its launch, the initiative has more than 250 member companies ranging from large corporations to small and medium-sized enterprises. What IVI actually does is hold working groups on 15 to 20 topics (business scenarios) each year in which participants from 10 to 15 companies work on how to address the issue being raised. Topics are chosen for their relevance to actual manufacturing, such as the use of data in quality assurance, use of the IoT in predictive maintenance, and the digitalization of specialist skills. By having staff from a variety of different companies gather around the same table to debate the given topic, these working groups provide useful forums for people to learn from one another by sharing know-how and exchanging information.

Smart manufacturing, as the term is used in Europe and North America, refers to top-down reforms that seek to establish a new type of manufacturing. On the other hand, it is bottom-up reforms that are better suited to the manufacturing industry in Japan, which has had success in the past with improvement activities that are people-driven and workplace-inspired. The

IVI working groups start by defining an "as-is" model of how the issue being addressed currently manifests and a "to-be" model that envisages what could be done using the IoT and other technologies, and then determines things like where digitalization is needed to address the issue and the requirements for system implementation. The working group then visits plants or uses them to run system trials to verify the viability of its solutions. This involves working through the plan-do-check-act (PDCA) cycle, first determining the issues still to be addressed based on the issues that arose during the trials, then considering ways of resolving these issues, which are then put into practice. Along with sharing the know-how they acquire from this process, the participants in each working group present their final results at a symposium or publish them in print to make their work available as something that other manufacturers with similar issues can refer to.

In Japanese-style improvement activities, it is important that plant staff who are familiar with the work incorporate techniques for resolving issues into current systems for doing that work. IVI has devised the industrial value chain implementation method (IVIM) for identifying and sharing issues and for using this as a basis for deciding what to work on and how to resolve the issues. IVIM is intended to be an example of one of these bottom-up system development methodologies that approach the task from a workplace perspective.

Putting Manufacturing Data Trading into Practice to Improve Productivity

IVI has an action plan made up of three phases of three years each. Like the *shuhari** concept from martial arts, the first phase was based on connected manufacturing and involved an approach in which different companies considered and acted on challenges together, including coming up with methods like IVIM. The second phase currently in its second year involves developing the concept into an actual practice. One example of what this entails is the implementation and

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* *Shuhari* describes the three stages of learning mastery in Japanese martial arts: acquiring the fundamentals, breaking with tradition, and transcending traditional wisdom.

operation of a system that supports the trading of manufacturing data between companies, as was recently reported in the news media.

In FY2018, IVI was contracted by the Ministry of Economy, Trade and Industry to undertake a project on the open integration of manufacturing platforms with the aim of implementing the IVIM process as a way of using data to coordinate operations across different companies. The new manufacturing data trading system uses the connected industries open framework (CIOF) for data distribution that was developed as part of the project and utilizes blockchain technology to provide a secure means for the inter-company trading of manufacturing data such as product design data, operational data from production equipment, and quality inspection data. The aim is to facilitate improvements such as shorter development times and higher productivity by inviting 100 large Japanese manufacturers to share a wide variety of manufacturing-related data between companies. The system is scheduled to go live in the spring of 2020.

It goes without saying that the use of data holds the key to manufacturing in the era of the IoT. While past practice in the manufacturing industry has been to keep a tight hold of manufacturing data that is a source of competitiveness, providing companies with the ability to share data with trusted partners in a secure environment offers many benefits in terms of making business faster and more efficient. Enabling the flow of data between companies should boost the industrial competitiveness of Japan as a whole. We want this new data trading system to be a first step toward achieving connected manufacturing.

Standardization Essential to Strengthening Links between Companies

IVI holds regional seminars that take the form of workshops and is also working on providing a platform for learning about digital technologies such as the IoT, and on establishing a nationwide network for information exchange.

Collaboration between companies is what will determine the future of manufacturing. While the level of collaboration may vary, from the exchange and sharing of knowledge and information to the shared use of manufacturing data like that in the data distribution system described above, strengthening the links between the companies that make up value chains will be essential. This makes standards more important than ever.

One important concept used by IVI is that of gradual standards. While standardization is needed to expand collaboration between companies, standardizing on a single protocol for linking factories is likely to be difficult. My hope is to expand interconnections while still allowing companies to maintain their strengths in competitive areas by having them progressively standardize their own particular protocols.

Meanwhile, given the ongoing progress of globalization, we need also to prioritize work on using international standardization to spread the Japanese approach to manufacturing more widely. My impression of standardization over recent years is that de facto standards are coming to have a greater weight than de jure standards. Particularly in areas where interoperability is crucial, once the methods used for interoperation are in place, subsequent entrants to the field have no choice but to adopt them. This is why it is important that we commit now to standardization and work with manufacturing reform initiatives taking place overseas, such as Germany's Industrie 4.0 and USA's Industrial Internet Consortium.

Engaging in Collaboration with an Attitude of Learning Alongside Overseas Partners

One of the challenges I see for Japanese manufacturing is that people have closed minds that trap them into thinking in national terms. While the number of companies such as Hitachi that are globalizing at a faster pace continues to rise, many companies still limit themselves to a domestic outlook. Now more than ever, by looking outward and hiring overseas staff, it is very important to understand the differences between Japan and the rest of the world with respect to the diversity that provides the soil for faster decision-making and innovation. Through my research and my involvement

Graduated from the Department of Mechanical Engineering, Faculty of Science and Engineering, Waseda University in 1985. After working as a systems engineer at a software startup in Japan, he obtained a doctorate in engineering from the University of Tokyo in 1996. From 2003 to 2004, he was a visiting scholar at the Massachusetts Institute of Technology. He took up his current position in 2007. In 2014, he led a study group on Industrie 4.0 in his capacity as director of the Manufacturing Systems Division of the Japan Society of Mechanical Engineers and subsequently founded Industrial Value Chain Initiative (IVI). In his position as President of IVI, he play a leading role in the digitalization of Japanese manufacturing.

with IVI, there is much that I have learned personally from engaging with people who work in manufacturing outside Japan.

What you need to be aware of when dealing with overseas countries is that communication is two-way. Rather than simply learning from overseas countries through observation and other means, we will be left behind by the global tide of the Fourth Industrial Revolution unless we promulgate information about the Japanese approach and what Japan has accomplished and establish a relationship of learning from one another. While issues such as intellectual property still exist, I believe this is a time to reconsider drawing the line between open and closed.

While manufacturing plants have lots of valuable data and other information, keeping it hidden risks letting it go to waste. Making a strategic demarcation between what truly needs to be kept confidential and what should be opened to view, and engaging in borderless collaboration at a global level, are essential to the reform of manufacturing.

When considering what comes next after integrating manufacturing and digital technology, one future I believe in is the creation of a circular economy that is autonomous and sustainable, as symbolized by the United Nations' Sustainable Development Goals (SDGs). An autonomous manufacturing plant will be able to use data to eliminate waste in production processes and obtain knowledge and other information from outside the plant to dramatically increase productivity. Alternatively, the integration of goods and digital technology should enable the supply of products that come bundled with services. This has the potential to open up a new world of manufacturing that continues on beyond the point where a product is produced or sold.

A world where links between goods are a generator of value should be one where Japan, with its strong manufacturing tradition, should be able to put its capabilities to good use. With the aim of exploring the future of the manufacturing industry from Japan, I intend to pool my strengths with those of you who work in manufacturing to continue pursuing the digitalization of our industry.