The Fourth Wave of Manufacturing: What It Means to the Asian Steel Industry

The Fourth Industrial Revolution is bringing massive changes to mankind through accelerated integration of traditional industries and ICT. The Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) are forcing traditional industrial structures to rapidly change. The scale, scope, and complexity of these changes will be unprecedented. Steelmakers are also actively developing advanced technologies to respond to the massive paradigm shift. The leading steel mills will customize technologies such as AI and virtual factories and apply them to the production sites. They will strengthen integration along value chains by connecting clients and suppliers through smart factories.
The Fourth Industrial Revolution: The Winds of Change Are Blowing in the Steel Industry
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“Mastering the Fourth Industrial Revolution” was the official theme of the World Economic Forum, held in Davos, Switzerland early this year. The news from this forum was that boundaries between the digital, physical, and biological spheres will disappear, and the convergence of technologies will be expedited, ushering in a new era of unprecedented experiences for humanity.

We are already experiencing enormous changes. With accelerating technological innovation across industries, the landscape of traditional industries is changing, as are the value chains and market players of traditional industries. The steel industry is no exception. What fundamental changes can we anticipate? How will they affect manufacturing, and what must the steel industry do to prepare?

Traditional industries on the brink of collapse
Over 100 years elapsed between the First Industrial Revolution, which was triggered by the advent of steam engines, and the Second Industrial Revolution, which was characterized by the use of electricity and conveyor belts. Another 60 years passed before the Third Industrial Revolution, which was brought on by the invention of personal computers and the Internet. Now, after only 20-30 years, the world is facing the Fourth Industrial Revolution.

Change is ever-accelerating and its impact is ever-stronger. In the midst of the Fourth Industrial Revolution, which is characterized by big data, the Internet of Things (IoT), artificial intelligence (AI), virtual reality/augmented reality (VR/AR), and 3D printing, competition in technological innovation is breaking down every aspect of traditional industries at an alarming speed.

First, conventional labor structures are collapsing. About 3-4 years ago, AI-produced earthquake and weather news stories appeared in the Los Angeles Times. Although this was much talked about, the news stories were comprised only of simple facts. At that time, AI was a convenient tool and a friend to human journalists pressured by deadlines. But now, AI is replacing human
AI has a significant presence in manufacturing as well. Baxter, a robot that costs less than USD 30,000, works 24/7 in manufacturing plants in various fields. Kiva robots stack and pick up products in Amazon warehouses. The World Economic Forum predicts that 4.759 million clerical and administrative jobs, and 1.609 million manufacturing and production jobs will be lost in the next five years. The traditional labor structures of many industrial fields have begun to collapse.

Second, industrial structures are breaking down. Traditional companies are losing their footing due to the appearance of new competitors equipped with innovative technologies and differentiated business models. The most dramatic changes are unfolding in the automotive, energy, and finance industries.

Internal combustion engines are giving way to electric vehicles (EVs) and self-driving cars, which can be described as smart devices with wheels. In one blow, this shift will devastate the long-established automotive parts supply chain, which has been centered on engines and transmissions. This could happen in only a few years, not in the distant future.

The traditional structure of the energy industry is also crumbling. The spread of decentralized energy generation is destroying the current centralized generation paradigm. Grid parity is projected to occur by around 2020, meaning that a developing technology will produce electricity for the same cost as traditional technologies. This indicates that the traditional structure of the energy industry is bound to change. Massive transformations have already begun in Germany, Australia, and the USA.
The current finance industry is also faltering. The emergence of mobile payment providers, such as Samsung Pay and Apple Pay, is upsetting the traditional payment market structure. Internet-only banks and cloud funding are shifting the financial paradigm. In China’s payment and lending markets, the share of mobile and Internet firms exceeds that of traditional financial institutions.

Destruction of industrial structures will spread to all industries. The established rules are already changing, and the hegemonies that have led industries are losing ground. Companies from different fields are making inroads and challenging traditional industries.

Third, traditional methods of creating value are also being destroyed. The common expectation of what costs money is being overturned. Energy, often regarded as paid goods, can become free. In the USA, Tesla provides its customers with free charging through its vast network of “supercharger” stations. In Japan, a telecommunication company branched into the electricity business, and bundled telecommunication and broadcast services with electricity. This means that energy will potentially become free of charge, just like e-mail and video streaming.

The price of an item with zero marginal cost moves toward zero. With the rise of the shared economy, which links the information of suppliers and customers on one platform, the concept of ownership is changing. This changes the understanding of value and upends traditional business models. Airbnb and Uber show how it is possible to enter the accommodation and transportation businesses without investment in fixed assets such as hotels and cars, disrupting the traditional way of creating value.

In the era of the Fourth Industrial Revolution, intangible value exceeds tangible value. In the automotive industry, for instance, the value of data such as driving patterns and locations, may exceed the value of cars, and provide much greater opportunities to car makers because a car becomes a source of various customer data
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and a channel for delivering new services to customers. This explains why Google has paid USD 3.2 billion for a household device maker, Nest. Its true value lies not in its hardware, but in the data that the hardware collects from each household.

Companies like Tesla, Google, and Amazon, are branching into traditional industries. But, instead of following the conventional way of doing business, they introduce a new business model weaponizing data and software. Who will win this competition?

How do countries prepare for the future of manufacturing?

The rapid change of the traditional industry and disruptive advances in technology is threatening the very survival of countries and companies built on manufacturing.

For industrialized countries, which have long been suffered from high labor costs, stagnant production, and decline in the labor force, the Fourth Industrial Revolution is a breakthrough, and an opportunity to take the leadership in the future.

In the USA, under President Barack Obama’s Reshoring Initiative, the Advanced Manufacturing Partnership (AMP) was launched in 2011, and the National Network for Manufacturing Innovation (NNMI) was issued in 2013 to enhance manufacturing capabilities by supporting collaboration between industry and academia. In October 2015, Washington released the “New Strategy for American Innovation” to regain U.S. technological innovation leadership in the global manufacturing market by increasing investment in R&D, mainly in nine areas of strategic opportunity: advanced manufacturing, precision medicine, the BRAIN initiative, advanced vehicles, smart cities, clean energy and energy efficient technologies, educational technology, space, and new frontiers in computing.

Germany unveiled the High-Tech Strategy 2020 in November 2011, which identifies future projects, including Industrie 4.0. The underlying

| Keywords for National Policies Regarding the Fourth Industrial Revolution |
|---|---|---|---|
| **Germany** | **USA** | **China** | **Japan** |
| Industry 4.0 | Advanced Manufacturing | Made in China 2025, Internet Plus | New Robot Strategy |
| Cyber Phyical System (CPS) | Manufacturing reshoring | Integration of informatization and industrialization | Robot-based new industrial revolution |
The concept of Industrie 4.0 is to integrate manufacturing and ICT via IoT, 3D printing, and cyber physical system (CPS) for networked and intelligent production facilities. All processes concerning raw materials, production, logistics, service, and products are connected to networks through embedded systems and controlled through CPS. By setting these technologies as national standards, Germany is showing its determination to assume technology leadership in the Fourth Industrial Revolution.

In response to the U.S. Advanced Manufacturing Partnership and Germany’s Industrie 4.0, Japan’s strategy is to improve manufacturing competitiveness centering on its relatively competitive robotics field. To this end, Japan announced the New Robot Strategy in 2015, which aims to robotize objects so as to greatly increase the utilization of robotics, and to utilize the data produced to create new wealth, ultimately contributing to solving social problems and increasing competitiveness in the manufacturing and service sectors.

China is preparing for the Fourth Industrial Revolution by two separate initiatives: “Made in China 2025” and “Internet Plus.” The “Made in China 2025” plan is a strategy to comprehensively upgrade Chinese industry to achieve qualitative growth, with a view to transforming China from a manufacturing giant based on cheap labor costs and cost competitiveness into a global manufacturing power backed by technological innovation. Recognizing the integration of the Internet and traditional industries as a new engine for industrial development, China announced the “Internet Plus” action plan, which aims to build the world’s largest Internet platform, and carries out smart manufacturing development strategy through the integration of manufacturing and Internet technologies.

The intensifying competition in technological innovation among companies and countries is rapidly reshaping the landscape of manufacturing. The concepts of customers and their demand are being redefined. Production methods, company structures, and value chains are all changing.

In the future, products and services must move beyond ready-made customization. Extreme flexibility is required in the production process in order to satisfy individual needs without compromising cost. Mass Personalization is the future of manufacturing in the Fourth Industrial Revolution.
Changes for consumers: the era of “mass personalization”
Consumers want products and services tailored to their needs, but diversity means cost to companies. In the past, companies tried their best to reduce production costs through standardization and mass production. As the satisfaction of customers’ various needs has become a key element of differentiation, companies have segmented and targeted markets and customers, and pursued customization to give more choices to customers. For example, customers are offered ready-made clothes in more colors and sizes.

In the future, products and services must move beyond ready-made customization. Customers are no longer mere segments and targets. They define and select products and services to meet their individual needs. All customers will be able to wear personalized clothes, not ready-made clothes. What matters is cost. Variety should not compromise cost. Extreme flexibility is required in the production process in order to satisfy individual needs without compromising cost. Mass personalization is the future of manufacturing in the Fourth Industrial Revolution.

Changes for suppliers: dynamic intelligence, real-time enterprise, and servitization
Production sites need fundamental change in order to produce products tailored to each consumer. This is a transformation from a mass production-based, centralized production system to a decentralized, unmanned autonomous system that provides extreme flexibility.

In a centralized production system, processing data are entered into a central controller and production facilities process materials as programmed. However, in a decentralized production system, processing data are embedded in materials and production facilities. After collecting information from the surrounding environment and sensors attached to the product, facilities recognize the current situation and start operation autonomously. This enables precise control of each process and part.

This new dynamic alters the age-old concept of automation. Central control, fixed products, and scheduled processes become distributed control, designed products, and flexible processes. The automation of the past was based on static intelligence, by which facilities merely fulfilled the orders given, but the automation of the future is based on dynamic intelligence, by which facilities react to changing situations.

Siemens’ Amberg factory adopted radio-frequency identification (RFID) and barcodes for every product and component. Through machine-to-machine (M2M) communication using over 1,000 sensors and scanners, the factory processes and integrates 50 million pieces of data per day. It manufactures more than 1,000 types of 12 million programmable logic controls (PLCs) in an average year, and still has only 11 defects per million (Production quality of 99.9988%).

A second change is the transition into real-time enterprises based on the integration of business logic and manufacturing logic. As
In addition to being flexible, a production system needs to ensure the visibility of real-time operational data and provide insight for better and faster decision-making along the value chain. Markets become more volatile and product life cycles become shorter to meet rapidly changing customer needs, it is important how fast and accurately corporate can meet time-to-market goals. In addition to being flexible, a production system needs to ensure the visibility of real-time operational data and provide insight for better and faster decision-making along the value chain, from product design, sourcing, and supply to logistics, distribution, and sales.

To this end, companies are integrating business logic and manufacturing logic. By integrating manufacturing logic, which controls production processes, and business logic, which manages production schedules, material/inventory management, and logistics, companies strive to minimize time-to-market. By ensuring integrated data visibility in all product life cycles, Siemens oversees all processes of product planning, design, production, and facility management at a glance, ultimately halving time-to-market.

A third change is the expansion of value chains beyond manufacturing to remote-control-based servitization. In general, value creation in manufacturing is completed upon release of a product. Customer service used to be considered a cost by corporations. Now the release of a product is the start of the sale of new services. Corporations can collect customer information and usage patterns from sensors attached to products. GE has launched Predix, a cloud-based platform for industrial internet applications, that combines people, machines, big data and analytics. Predix analyzes and manages data being generated from purchase to customer service as sensors are attached to everything from aircraft engines to medical equipment. For example, the platform as a service (PaaS) helps jet engines fix themselves and supports the operation of power plants in remote places. It also helps distribute and process data flowing out of medical imaging systems.

The steel industry in the fourth industrial revolution
The Fourth Industrial Revolution is also gaining...
ground in the steel industry, and new changes are becoming apparent. One change is the integration of digital networks in value chains. Plants, companies, and even the entire steel industry can be integrated into a single digital ecosystem.

Germany’s ThyssenKrupp is building an integrated digital system to allow real-time information on orders and production to be shared among the company, suppliers, and client companies. For example, Hüttenwerke Krupp Mannesmann (HKM), a supplier of hot-rolled strip steel to ThyssenKrupp Hoesch Hohenlimburg, shares order and production information in real-time with ThyssenKrupp. The two companies coordinate in advance the order of production processes and timing of deliveries, minimizing waste in production and swiftly responding to customer needs. By expanding the scope and depth of digital integration, ThyssenKrupp plans to reduce time-to-market to 24-28 hours for all of its plants.

Tata Steel Europe is also seeking digital integration of logistics processes to allow clients to monitor scheduling of shipments in real time. For example, a client at a steel plant in the Netherlands is provided with information on the location and arrival time of a vessel loaded with HR steel products, allowing the company to achieve optimal inventory management.

The Fourth Industrial Revolution is spreading throughout the steel industry. Tata Steel is planning to digitalize all transactions between its steel plants and customers within two years. It also plans to combine information networks with Klockner, the largest steel trader in Europe. The two companies already share order and purchase data for the UK market, and they plan to expand the scope of integration to other European countries and the USA.

Another change is the trend toward Amazon-like, online-based steel trading platforms. Klockner will build an online transaction platform by 2017. If the platform is successful, the traditional steel trading structure will face a revolutionary transformation.

In a traditional steel market, steelmakers stock inventory and await orders without knowing exact demand. Inventory is a burden on traders. If a mechanism that drastically reduces inventory burden and strikes a balance between demand and supply, an Amazon of the steel industry is foreseeable.

Through its Internet transaction platform, Klockner shares not only its own product information, but competitors’ product information, with a view to increasing transaction efficiency and cost transparency, and eliminating inefficiency in the steel trading structure. The company anticipates a reduction in net working capital of 10%, and savings of EUR 100 million. It hopes to handle more than half of sales through the transaction platform by 2019.

China is also building online steel transaction platforms. Baosteel Group established the Shanghai Steel Trade Center in 2013, and developed it into steel e-commerce platform, called “Ouyeel” in 2015. Shagang Group built its own steel e-commerce platforms, Jiulong Online, in 2014. This trend shows that information in the value chain of production, distribution, and con-
Consumption is gradually being integrated. In the near future, it is possible that all information on supply and demand of steel will be open to every producer and customer.

Still another change is the advent of “digital genome map” of steelworks. Herein lies the key to the steel-making process in the Fourth Industrial Revolution. This is the heart of POSCO’s vision of the future of steel plants.

There is a big difference between the assembly process for producing automobiles and the continuous process for making steel. It is very difficult and expensive to apply a decentralized, unmanned autonomous system, which is useful in assembling components, to the continuous process of steel, which involves liquid steel at high temperatures moving at high speeds. As the share of labor cost is relatively low in the steel-making process, automation will not bring tremendous benefits in the short term. Furthermore, the steel-making process is mostly automated because it handles heavy raw materials and equipment. What then is the vision of a future steel plant set by POSCO, the largest steelmaker in Korea?

The answer is the development of the “data genome map” based on data and software. The Human Genome Project aims to determine the sequence of the three billion chemical base pairs that make up human DNA, eventually allowing personalized diagnosis and disease prevention. This work seeks to understand the substance of life and unlock hidden potential. A smart steel factory mimics this idea, aiming to collect and

Table: Realization of the Fourth Industrial Revolution in Steel Plants

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<thead>
<tr>
<th>Category</th>
<th>Current State</th>
<th>Future State</th>
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<tbody>
<tr>
<td>Supply</td>
<td>Supply as scheduled</td>
<td>Supply as needed</td>
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<tr>
<td>Quality</td>
<td>QC after production</td>
<td>Detect defects on the line</td>
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<tr>
<td>Energy</td>
<td>Supply as scheduled</td>
<td>Supply as needed</td>
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<tr>
<td>Facility</td>
<td>Repair defects</td>
<td>Predictive maintenance</td>
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<tr>
<td>Production</td>
<td>Scheduled &amp; Static</td>
<td>Optimal &amp; Flexible</td>
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analyze all microdata generated in the production process, and determine the cause of every event. By identifying the exact cause of quality and production issues, and reviewing the status of facilities, steelmakers will be able to solve chronic problems and create new value.

Every aspect of a steel plant, including production, facilities, energy, environment, safety, and quality, is subject to a smart factory. POSCO envisions a steel plant that can sense, analyze, and control its conditions, just as a human can feel, think, and respond. POSCO’s smart factory project, currently taking place at Gwangyang plate plant, will gradually be extended to all production areas.

What must the steel industry consider for the future? The Fourth Industrial Revolution seems to be just around the corner. The steel industry is not exempt from its effects. It is unknown what calamities might befall the industrial structure and value chain of the steel industry. Are there defense mechanisms for survival?

As stated earlier, the core of the Fourth Industrial Revolution is data and software. GE has a long history and tradition as an automation company in power generation and energy, but it has declared itself to be a software company. Siemens invests in solutions that integrate data and software for all of a company’s product lines. In the automotive industry, more than half of BMW’s R&D staff are software engineers.

Likewise, a steel company in the Fourth Industrial Revolution might need to become a "software engineering company that produces steel," not a “company that buys and uses software well.” It may sound odd that a steel company needs to become a software engineering company. However, what actually increases productivity, determines the quality of products, and ensures that facilities work properly is not visible hardware, but the engineering and processing knowledge behind it. Software is not merely algorithms and code, but the embodiment of this knowledge.

The steel industry creates profits by selling steel products. However, the real value is in data and software. In order to properly respond to the Fourth Industrial Revolution, steel companies must first understand the value of these intangibles and make the necessary investments. Dieter Zetsche, Chairman of Daimler, gave the steel industry something to think about when he said that mobility will be fueled by software, not by gasoline. ☞