The Steel Industry over the Next Two Decades

This article comprehensively reviews how megatrends in the major steel-consuming industries as explained in the preceding articles will impact the global steel industry. Fundamentally, the global steel industry will face the following four challenges over the next twenty years, driven by a continuous rise in global steel demand; slowing steel demand growth due to decreasing steel intensity; a need for more advanced steel products; upgrading to eco-friendly and smart steelmaking processes; and changes in manufacturing based on the Fourth Industrial Revolution.

Slowing steel demand growth with decreasing steel intensity

An industry-wise approach is used to forecast global steel demand: steel demand in each steel-consuming industry is projected and then combined in order to estimate total steel demand. To this end, production and steel intensity\(^1\) in each of the four major steel-consuming industries are projected through 2035 as shown in Table 1. By multiplying production amount (or investment amount) by steel intensity, the steel demand for each industry can be calculated.

In the automobile industry, global production is expected to grow at a compound annual growth rate (CAGR) of 1.6% through 2035, but steel intensity per vehicle is projected to fall by about 20% by 2035 compared to 2015. This means that it will be difficult for steel demand in the automobile industry to increase. The same is true for the shipbuilding industry, but steel demand in this sector is indeed expected to grow slowly since shipbuilding demand is estimated to recover starting around 2025 and the decline in steel intensity will remain around only 10%.

In the case of the construction industry, a steady increase in global construction investment will offset the decline of its steel intensity, leading to a stable overall increase in steel demand. In the energy sector, there will be only slight changes in steel intensity and energy investment, so steel demand will follow suit.

---

Steel intensity is defined as the amount of steel used per unit of production or investment.\(^1\)
Combining all accounts, the global steel demand forecast is shown in Figure 1. With the emerging trends of global climate action and the Fourth Industrial Revolution as already described in other articles, global steel demand will continue on a path of expansion, although the growth rate will moderate. From 2016 to 2025, steel demand will grow at a CAGR of 1.2%, while for the succeeding decade it is expected to remain at 0.9%. By industry, the construction industry will be a main driver for lifting steel demand. Steel demand in the construction industry will increase rapidly to reach 920 million tonnes (Mt) in 2035, accounting for almost 50% of total steel demand. However, steel demand in the automotive and energy industries will just be maintained, while steel demand in shipbuilding will expand moderately after 2025. Steel demand in other sectors such as machinery and domestic appliances is not analyzed in detail. However, as a result of regression analysis using industrial production index forecast, it should rise by around 1%. All in all, global steel demand will reach 1.69 billion tonnes by 2025 and 1.86 billion tonnes by 2035. Therefore, it can be concluded that global steel demand has not yet peaked and will not do so within the next two decades.

Table 1. Forecast of Production and Steel Intensity of Steel-Consuming Industries

<table>
<thead>
<tr>
<th></th>
<th>Automobile</th>
<th>Shipbuilding</th>
<th>Construction</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production (mil. unit)</td>
<td>Steel Intensity</td>
<td>New Orders (mil. GT)</td>
<td>Steel Intensity</td>
<td>Investment (USD Tril.)</td>
</tr>
<tr>
<td>2015</td>
<td>92</td>
<td>100</td>
<td>79</td>
<td>100</td>
</tr>
<tr>
<td>2025</td>
<td>114</td>
<td>89</td>
<td>81</td>
<td>97</td>
</tr>
<tr>
<td>2035</td>
<td>127</td>
<td>80</td>
<td>109</td>
<td>90</td>
</tr>
</tbody>
</table>

Note: Steel intensities are normalized (2015 = 100)

The steel industry will inevitably progress from the quantitative growth of the past twenty years to a future of qualitative growth. The global steel industry must astutely overcome the challenges.

A need for more advanced steel products

The second challenge facing the global steel industry is how it will properly respond to steel-consuming industries’ stricter and more diverse requirements for steel products under the influence of evolving megatrends. Their needs will become more sophisticated mainly in three areas: high strength and high toughness, high corrosion resistance, and high performance. These were of course requirements in the past, but today steel-consuming industries need even higher-strength and more corrosion resistant steel with better performance than ever before.
In the automobile industry, weight reduction has become a central issue due to demanding environmental and fuel economy regulations. High-strength steels are increasingly being adopted in response to stricter collision regulations. To meet such requirements, steel companies have developed and expanded the application of high-strength steels through joint research on minimizing the weight of a vehicle’s body, including the Ultra Light Steel Auto Body (ULSAB) Program in 1994, the Ultra Light Steel Auto Body-Advanced Vehicle Concepts (ULSAB-AVC) Program in 1999, and the Future Steel Vehicle (FSV) in 2008.

Auto steel has continuously improved in strength, reaching 450MPa in ULSAB, 1GPa in ULSAB-AVC, and 1.5 GPa in FSV. GigaPascal steels have already been adopted in Dual Phase (DP),\(^2\) Complex Phase (CP),\(^3\) and Hot Press Forming (HPF)\(^4\) steels for the FSV projects currently underway. Moreover, most flat products used for automobiles are high-strength flat products. However, the stronger the steel becomes, the more its formability is reduced. POSCO has recently mass produced twinning-induced plasticity steel TWIP\(^5\) to provide both strength and ductility.

Ensuring corrosion resistance is one of the ultimate goals of the steel industry. High-resistance stainless steel 409L is used for automotive exhaust systems, including mufflers, in order to withstand thermal oxidation. Its application has recently expanded to exhaust manifolds since the manifold is close to the engine and thus exposed to high temperatures. Heat-resistant products such as 429EM, High Cr, and 310S are being used for manifolds. In addition, demand is rising for steel products with more diverse functions, such as hyper non-oriented (NO) electrical steel for the motors of electric vehicles and bio-shield and vibration damping steel for sensors.

In the energy and shipbuilding industries, the development, production, and transmission of oil and gas are increasingly being conducted under extreme conditions such as deep underwater and in the Arctic. High-strength and high-toughness steels are required for standing up to such harsh environments. As offshore structures become larger, they require ultra-thick steels and high-strength steels with yield strengths of over 500 MPa. High fracture toughness steel must withstand extreme cold weather with temperatures below -60°C to be used in the polar regions. In particular, brittle crack-arrest steel is being developed and used to provide fracture toughness in
Table 2. Requirements for Steel Products by Steel-consuming Industry

<table>
<thead>
<tr>
<th>High strength &amp; high toughness</th>
<th>Energy/ Shipbuilding</th>
<th>Construction</th>
</tr>
</thead>
</table>
| Expanded application of giga-pascal AHSS for lighter cars  
• DP, CP, HPF, TWIP, etc. | High strength & low-temperature toughness steel for deep-sea & polar exploration  
• BCA, TMCP, etc. | High strength steel for skyscrapers/ super-long span bridges  
• High strength reinforced bar, section, cable |
| High corrosion resistance | Heat resistant Stainless steels for exhaust systems  
• 429EM, High Cr, 310S | Sour(H2S) resistant steel for extreme conditions  
• API steel for linepipe | High corrosion resistant steel for high temperature, high humidity environ.  
• PosMAC, ZAM, Super Dyma, etc |
| High performance | Highly efficient hyper NO for EV motors, bio-shield steel for sensors, vibration damping steels | Thick plate for offshore wind towers, radiation shield plate for nuclear power plants | High performance steel for interior/ exterior building applications  
• Thermal insulation, self-cleaning, anti-bacterial, sound-proof |

the welded joints of shipbuilding steel.

Line pipe steel also needs to become stronger to withstand increasing pressures and reduce the use of steel; API (American Petroleum Institute) X80 grade steel is consequently being increasingly adopted for line pipes. Furthermore, demand is also rising for ultra-thick and high-deformability steel to improve low-temperature toughness (to -20°C) for the deep-water environment or for resistance to seismic ground movement. For the shipbuilding industry, vessels are increasing in scale and ships such as container ships, tankers, and bulk carriers require high-strength and ultra-thick steel to hone shipping efficiency and high-toughness steel to enhance the safety of structures.

In the meantime, line pipe steel is exposed to different forms of corrosion as oil or natural gas is transmitted from production bases to customers. Particularly in a sour environment in which hydrogen sulfide (H2S) is present as an impurity in oil or gas with water, steel materials become prone to cracking and must be resistant to Hydrogen-induced Cracking (HIC) and Sulfide Stress Corrosion Cracking (SSCC). Radiation shield plates are used in nuclear power plants, and ultra-thick plates are applied in the wind turbine towers that account for more

5 TWIP (Twinning-Induced Plasticity) steel is a class of austenitic steels which can be deformed by both glide of individual dislocations and mechanical twinning.
FUTURE MEGATRENDS
AND THE STEEL INDUSTRY

Steel developed by US Steel, often referred to by the generalized trademark COR-TEN. This material is allowed to rust in order to form a protective coating and improve corrosion resistance. With no need for painting, it is cost-effective and provides a pleasing rustic antique appearance. Recently, titanium is also being used for a coating.

With the rise in the cost of zinc, highly corrosion-resistant but affordable steel materials are gaining prominence. One case in point is hot-dip Zn-Mg-Al alloy-coated steels, such as Nisshin ZAM, NSSMC Superdyma, JFE Ecogal, and POSCO PosMAC. By adding aluminum and magnesium to the coating, hot-dip Zn-Mg-Al alloy-coated steel achieves the same performance while using 50-70% less zinc than conventional hot-dip galvanized steel. It can be widely utilized in housing components, podiums, cattle sheds, shutters, and electronics and automobile components. In addition, steel products with various functions, such as thermal insulating, self-cleaning, anti-bacterial, and sound-proofing qualities,
are being developed as internal and external construction materials.

**Upgrading to eco-friendly and smart steelmaking processes**

The rising megatrend of global climate action will compel steelmaking processes to become more eco-friendly. In the face of environmental concerns, the steel industry has been attempting to advance energy-saving and recycling technologies and develop new steelmaking processes to replace the conventional blast furnace (BF) operations. Such efforts will continue in the future.

Various types of energy-saving technologies are being developed for BF, which consume the largest share of energy in the steel-making process. Hot oxygen injection is a technology in which oxygen is directly injected into the BF to improve productivity by 15% compared to a conventional BF. Developed by the U.S. Department of Energy (DOE), the technology is currently in the pilot stages. Blast furnace heat recovery recycles the BF exit gas at a temperature of 250°C into a burner to preheat stove combustion air. This technology reduces fuel costs and heightens fuel efficiency, although the effects differ with the scale of the BF. Research into this technology began in the 1980s and a demonstration plant has been developed. In addition, plasma blast furnaces apply plasma, which is widely used in the chemical and metal industries, to the BF process to minimize metal losses. The technology was primarily developed by the European Steel Association and has already completed validity testing.

One of the major themes of research into the steelmaking process is recycling slag, dust, and other surplus oxides generated as waste materials during steelmaking. The U.S. Department of Energy (DOE) and the Massachusetts Institute of Technology (MIT) have conducted joint research on methods for increasing the iron recovery rate from slag. Japan’s JFE Steel has performed research on technologies for recycling steelmaking slag into “marine blocks.” These two
research on technologies to separate iron and zinc from the dust generated in a rotary heat furnace. The DOE and Advanced Industrial Science and Technology (AIST) are developing technologies to reduce waste oxides in the steelmaking process and improve the iron recovery rate.

Furthermore, new iron-making technologies are being developed to replace the conventional BF, including POSCO’s FINEX, Siemens VAI’s COREX, the TecnoRed process, and Kobelco’s ITmk3. These processes use fine iron ore or pulverized coal to reduce energy use and minimize hazardous substances such as SOx and NOx.

To address environmental concerns, the steelmaking process must not only adopt energy-saving and recycling technologies and new alternative technologies, but also focus on reducing carbon dioxide emissions. In the short term, carbon dioxide capture technologies can be applied to each process to reduce CO₂ emissions, but for the long term the steel industry is gearing up to develop carbon-free technologies such as the hydrogen reduction process.

Creating value through a smart transformation using IoT, Big Data and AI

Another emerging megatrend is Industry 4.0. This refers to the Fourth Industrial Revolution, which succeeds the First Industrial Revolution triggered by the advent of steam engines in the 18th century, the Second Industrial Revolution characterized by mass production in the early 1900s, and the Third Industrial Revolution brought about by plant automation in the 1970s.

The key characteristic of the Fourth Industrial Revolution is the digitalization of manufacturing using advanced ICT technologies, including big data and AI. It involves a more gradual evolution compared to the past industrial revolutions that brought about more sudden and radical shifts. The advancement of ICT technologies will in the future convert steel plants into smart factories. Smart steel plants collect data on-site using IoT (smart sensing), analyze and predict the status of production processes based on big data (smart analytics), and optimize production while using AI.
The smartening of the steel industry will be most effective in three areas: advanced factory automation, smart manufacturing system, and internalization of know-how.

• Advanced Factory Automation: Wireless measurement and monitoring, including temperature measurement using sensors, robot scarfing, and autonomous cranes using location recognition sensors and software.
• Smart Manufacturing Systems: Prediction of potential production defects and facility malfunctions using big data, effective production scheduling using AI, and integration of facilities and systems at steel plants via IoT (current manufacturing execution systems are separately operated by plants).
• Internalization of Know-How: Converting implicit knowledge into explicit knowledge in the form of manuals, and improving work styles through the realization of smart workplaces.

Smart Factories are anticipated to bring about a great number of benefits: reduction of product error rates and decision-making time, inventory minimization, enhancing facility maintenance, reduced number of accidents, and quicker response to errors. Such positive effects will immediately result in cost reductions.

The concept of smart factories in the steel industry will develop from automation to smartening. Smart factories will have to integrate each smart process at the enterprise level in order to maximize efficiency and develop new profit-making models using smart solutions to create value for customers. The steel industry will inevitably progress from the quantitative growth of the past twenty years to a future of qualitative growth. To this end, the steel industry needs to boost capabilities for smart transformations and continuous product and process innovation; and build a sound steel ecosystem by strengthening partnerships with steel-consuming industries and seeking open innovation in the development of steel products and solutions. The global steel industry must astutely overcome the challenges of the future in order to remain a key industry.