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History of Integrated Management System of Sales, Production, and Logistics in JFE Steel

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Abstract:

Since 2010, steel sales, production, and logistics have been oriented towards "customer-driven" production in order to deliver high-quality products to customers when they need them with the quantity they need. In addition, it is necessary to respond to unprecedented issues such as the declining working-age population, the growing interest in SDGs and ESG, and the absorption of fluctuations in shipment volume due to changes in market conditions from various perspectives. JFE Steel is currently conducting research and development to solve these problems. In this report, our efforts to address the above-mentioned problems are presented in the area dealing with the decrease in human resources, reducing the environmental load, and improving the flexibility of shipping capabilities by DX.

1. Introduction

During the period of approximately 30 years from the 1980s until 2010, JFE Steel worked to reduce unnecessary inventories and logistics costs based on a linkage of sales, production, and logistics to respond to the needs of a “customer-driven” era. Achieving “customer-driven” production by a form of manufacturing and shipping that not only provides good quality products, but also delivers the required quantity to the customer when needed, rather than the conventional “maker-driven” model of production and shipping that prioritizes the production of high quality products, requires activities that place equal value on sales, production, and logistics and strengthen the linkage among the three, while maintaining an orientation toward integrated management and overall optimization of the system as a whole. As a result of those activities, JFE Steel achieved a large effect, in the form of a 75 % reduction in lead time, over the 30 years from 1980[1)].

On the other hand, the Japanese steel industry faces many logistics-related challenges that must be addressed. First of all among those issues is improvement of labor productivity to cope with Japan’s declining working-age population. The key point here is “automation” of various types of transport equipment, and practical application is progressing, supported by improvements in recognition technologies and communication technologies in recent years. Another issue is reduction of environmental loads, for example, by achieving carbon neutrality, which also responds to the growing interest in the SDGs and ESG. Key points include the development of hydrogen fuel- and ammonia-fueled ships, which is a subject of accelerating efforts by industry, governmental agencies and academia, and promotion of a modal shift to utilize ferries in addition to Roll-on/Roll-off ships. Moreover, astonishing changes have also occurred in the production environment as a result of the COVID-19 pandemic and intense changes in social conditions. Since it is also important to respond flexibly to cost and shipping volume as required by those changes, JFE Steel has launched initiatives utilizing digital transformation (DX) technologies.

The following presents examples of efforts in these respective areas, together with an outline of the results achieved.

2. Efforts to Improve Labor Productivity

2.1 Transition of the Working-Age Population and Labor Productivity

Figure 1 shows the transition and forecast for the

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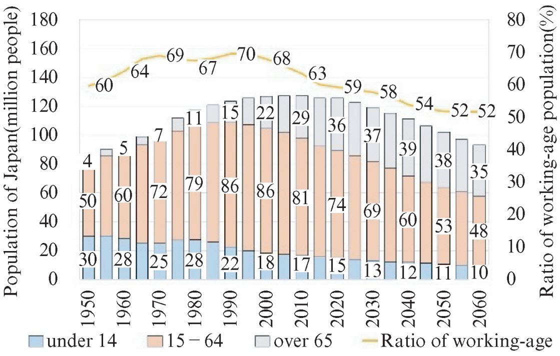

Fig. 1 Changes in ratio of working-age population

working-age population (aged 15 to 64) from 1950 to 2060[2]. In Japan, the problem of low birthrates and a rapidly aging society is becoming more serious. The working-age population began to decrease in 1995, and growth of the total population also turned negative in 2008. According to the national census conducted by the Ministry of Internal Affairs and Communications and the Population Projection for Japan (projection according to the medium-fertility and medium-mortality assumption) of the National Institute of Population and Social Security Research, in 2015, Japan's working-age population was 76.29 million, but is expected to decline to 68.75 million in 2030 and 47.93 million in 2060, which is a decrease of 37 % from 2015. Furthermore, as a result of changes in attitudes toward work among young persons, represented by Generation Z (born in the mid-1990s to early 2010s), young people tend to place higher priority on the meaning of work, rather than on the pay, and there is concern that this may spur labor shortages in the logistics industry, for example, by rejection of the 3-shift system. Thus, we must work toward "Improvement of labor productivity" as a major issue for the immediate future.

Logistics work in a steel works can be broadly divided into conveying/transportation work, warehousing work and shipping work. Conveying/transportation work means transporting finished products to warehouses in the works or transporting the products stored in warehouses to shipping quays. Efficiency is achieved by using dedicated special large transport vehicles. Warehousing work is temporary storage work to absorb the differences between production schedules in the manufacturing process and the timing of shipment to meet the customer's delivery requirements. Here, production loss and shipping loss are prevented by efficiently carrying out product receiving and delivery. Shipping work means loading products on the specified means of transportation for delivery to the customer. Although the main means of transportation is ships, the range of ships applied is wide, from domestic coastal vessels of approximately 700 tons, or so-called 199 ships, to large 30 000-ton export ships, and much know-how is needed when loading each type.

Even in this work, many steel products weigh several tens of tons and in logistics work, large vehicles and cranes are indispensable. Therefore, the basic practice is to assign one or more skilled operator to one piece of equipment. Since it is also necessary to provide direct service to products, such as inspections, exchanges of hoisting accessories, protection to prevent cargo collapse, etc., a large number of personnel must be assigned to work around the product itself. This work is similar to operation of large heavy equipment, and it is difficult to reduce the number of personnel, as this work requires a high skill level, and thus depends on personnel.

2.2 Efforts to Improve Automation Technologies for Large Heavy Equipment

To overcome the above-mentioned problems, JFE Steel is attempting to apply the automated driving technologies which are being developed for ordinary automobiles utilizing recognition, positioning, and communication technologies, all of which have progressed rapidly in recent years, to the special large vehicles used in logistics in the steel works. **Figure 2** shows the levels of automated driving technology[3]. Even at present, driving support-type technologies, such as those shown for Level 1 and Level 2, have already been introduced in many ordinary automobiles and are contributing to reducing accidents and decreasing the driving load, but achievement of Levels 3 and higher, which are currently under development, will be indispensable for solving labor shortages. However, unlike general public roads, where various traffic elements (e.g., passing vehicles, persons, laws and regulations) and many elements of uncertainty must be considered, the traffic routes in a steel works are comparatively limited, and it is possible to set limits on other traffic, taking advantage of the fact that a steel works is private property. Therefore, JFE Steel is grappling with unmanned operation on restricted routes by combining those features of the steel works and technologies that are being developed at present. Considering economic rationality, the target is considered to be between Level 3 and Level 4.

One challenge for automated operation in shipping work is precise control of cranes. When loading products that weigh several tens of tons into a ship from a quay, acceleration is applied to the products, and large load sway almost always occurs due to the effects of wind and the effect of the track of the crane arm transporting the product (in many cases, the product is transported in a concentric circle around the crane body). In order to stack products at the target loca-

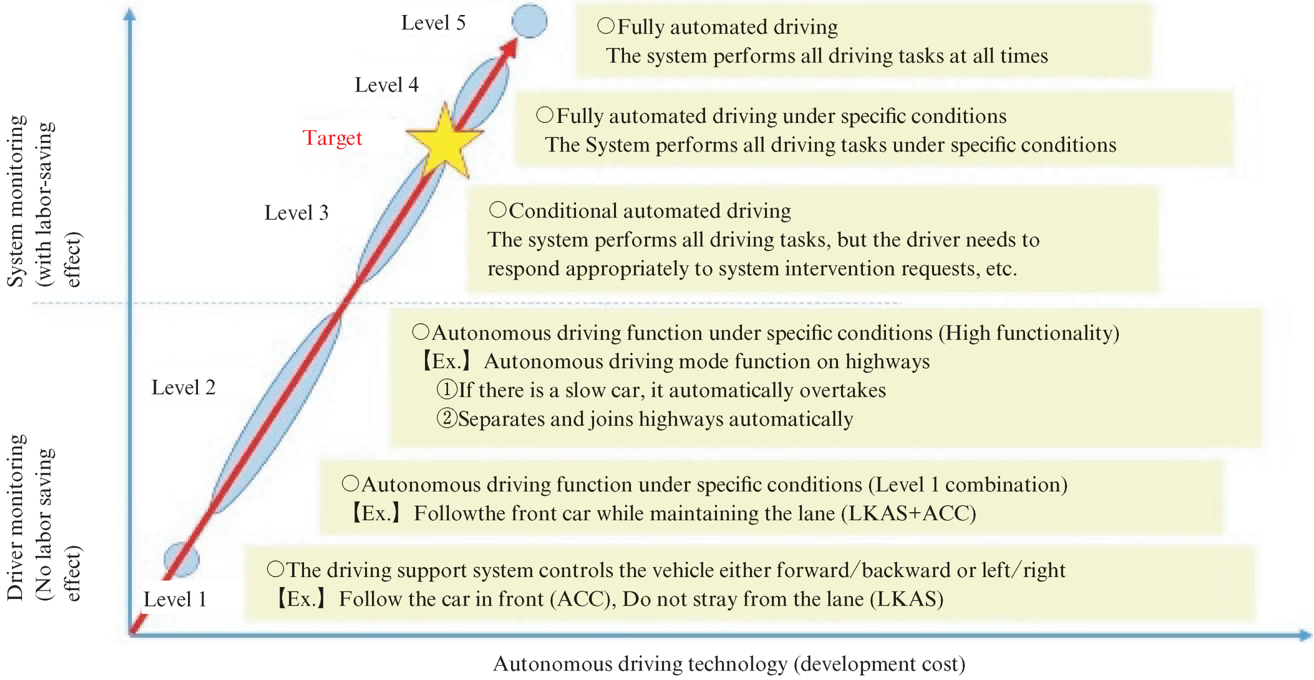

Fig. 2 Level of automated driving

tions, the crane operator makes sensory judgments of this movement and stabilizes the behavior of the product by applying acceleration in the opposite direction. There are also times when the product, which is several meters in size, must be lowered with precision of several tens of mm. JFE Steel is grappling with automation of quay cranes by utilizing a combination of technologies for predicting product behavior, control technologies for controlling swaying, and mechanical technologies for executing precise movements with the crane to achieve the necessary control.

On the other hand, coil storage warehouses are one area where automation technology has already been established and is now being expanded. **Figure 3** shows the automation ratio of coil-form product warehouses in JFE Steel. Between 2017 and 2022, the warehouse cranes of a total of 11 warehouses in the Chiba District (East Japan Works) and Fukuyama District and Kurashiki District (West Japan Works) were automated, and successive automation of other warehouses is also planned in the future. This issue of JFE Technical Report includes a detailed report on automation of warehouse cranes[4].

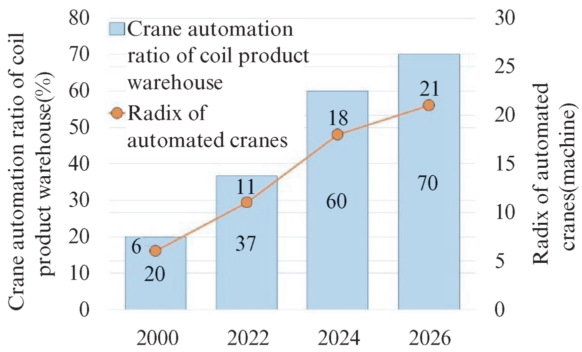

Fig. 3 Transition of crane automation ratio in sheet products warehouse

shapes, and for this reason, together with the fact that no economic effect of rationalization can be obtained due to the small size of product lots, almost no progress has been achieved in automation. At present, local labor-saving is being promoted by automation of the guidance function and improvement of hoisting accessories, such as changing sling wires to lifting magnets[5], but in the future, will be necessary to implement full automation in these warehouses, like that already achieved in coil-form product warehouses.

2.3 Issues of Automation Technologies

Although substantial progress has been made in efforts to improve automation technologies, as described above, the target products have generally been thin-gauge products in coil form. In the case of other steel products, (shapes, wire rods, steel plates, etc.), it is difficult to generalize the movement of cranes and other equipment due to the variations in product

2.4 Target of Labor Productivity

Figure 4 shows the targets for labor productivity, taking the Fukuyama District as an example, when the labor productivity in 2018 is 1.0. Labor productivity is a quantity which is defined as the shipping amount of steel products that can be shipped by 1 hour of labor. JFE Steel's Fukuyama District is conducting activities aimed at achieving increases of 24 % in 2024 and 41 %

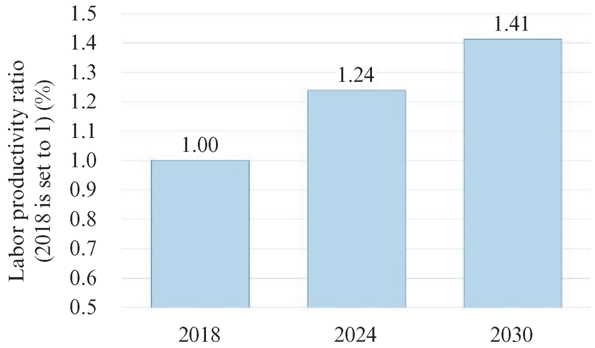

Fig. 4 Target of labor productivity ratio in the Fukuyama district

Photo 1 All-weather type (rainy weather cargo handling) shipping berth

Photo 2 Special ship which can stow cargo pallets in the ship hold by using a mobile loading machine

Photo 3 Loading operation for a special ship which can stow cargopallets in the ship hold by using a special vehicle

in 2030 in comparison with the conventional level by capital investment centering on expansion of warehouse automation.

3. Efforts Related to SDGs and ESG

JFE Steel mainly produces iron sources by the blast furnace process, which uses coal as a reducing agent. With the current technology, carbon dioxide (CO_2) emissions cannot be eliminated because it is still not possible to substitute other alternatives. However, since reduction of environmental loads is unavoidable in sustainable business management, efforts related to the SDGs and ESG are positioned as essential elements for creating a management foundation for sustainable enhancement of corporate value[6]. The JFE Group Environmental Vision for 2050 states that the problem of climate change is "an extremely important concern for the JFE Group from the perspective of business continuity." Because a response to global-scale climate change problems such as the emerging challenge of abnormal weather is an urgent issue, the JFE Group has positioned 2020 as a "landmark year" for further reinforcing its response to climate change, and is promoting CO_2 reduction activities as a top-priority issue in the Medium-term Business Plan with the aim of achieving carbon neutrality in 2050[7]. As concrete targets, the JFE Group aims to reduce CO_2 emissions in its iron and steel business by 18 % from the FY 2013 levels at the end of FY 2024, which is equal to a CO_2 reduction of 58.10 million tons/year, and is also targeting carbon neutrality in 2050, including the contribution to CO_2 reduction of its engineering businesses.

CO_2 emissions from product distribution activities are approximately 450 000 t/y. Since these emissions are due to the use of fuels, it is necessary to grapple with reduction of CO_2 emissions from various perspectives. "Realization of ammonia-fueled ships" may be mentioned as one such effort. Because ammonia has attracted attention as a next-generation fuel which does not emit CO_2, the development of ships that use ammonia as a fuel is being promoted[8]. JFE Steel is targeting the use of ammonia as a fuel for ships, focusing on the fact that it is a zero-emission fuel, and is participating in a council for joint study of common issues (Joint Study Framework on Ammonia as an Alternative Marine Fuel)[9].

On the other hand, "Modal shift" can also be mentioned as one effective means of achieving carbon neutrality. "Modal shift" means changing freight transportation by truck to maritime or rail shipment, which have smaller environmental loads and enable transportation of larger volumes of products. Since the 1990s, JFE Steel has promoted this modal shift by introducing all-weather type shipping berths (**Photo 1**) and Roll on/Roll off (RO-RO) ships (**Photo 2**, **Photo 3**)[10]. At present, the modal shift ratio is 94 % or more in transportation of steel products with shipping distances of 500 km or more. In more recent years, JFE has also implemented a new type of modal shift using ferries, which are general ships. This issue of JFE Technical Report includes a separate report of one example[11].

4. Use of Digital Transformation (DX) Technologies in Sales, Production, and Logistics

4.1 Response to Sudden Changes in Supply and Demand and Related Issues

Figure 5 shows the changes in consumption of automotive steel products from FY 2017 to FY 2021. Indexed to steel consumption in FY 2017 as 100, consumption declined substantially in FY 2020 and FY 2021, falling to approximately 80, due to the effects of stagnation of the global economy caused by the novel coronavirus (COVID-19) pandemic. Consumption also failed to return to the past level in FY 2022, remaining at less than 90 level during that year, when the response to COVID-19 was being completed, but this was due to reduced production in the automotive industry and many other fields caused by supply chain disruptions, beginning with a global shortage of semiconductors. Thus, in order to maintain operation of blast furnaces under an environment of remarkable changes in fields where production was decreased accompanying economic stagnation and shortages of various parts due to the effects of pandemic-related lockdowns in China, it was necessary to secure a volume of crude steel production corresponding to demand changes in a timely manner.

Conventionally, the effects of changes in the product mix had been judged based on experience, so it was impossible to predict the effects on capacity and cost and the details of the optimum logistics plan, and as a result, there was concern that it might not be possible to ship products to customers at the proper timing.

Therefore, JFE Steel is promoting the use of digital transformation (hereinafter, DX) as a solution to these problems. Concretely, the company opened the JFE Digital Transformation Center (JDXC) in the Head Office as a base for promoting company-wide DX utilizing data science and state-of-the-art ICT, and has created an environment in which operational data from all steel works and other plants within JFE can be used in an integrated manner. Optimization and simulation technologies have developed rapidly in recent years, the DX technologies using those technologies have also been applied to production planning and logistics planning[12]. JFE also newly established the Data Science Project Department in 2017 and the Cyber-Physical System R&D Department in 2019, and is working to solve logistics problems by actively introducing and utilizing data science and related technologies.

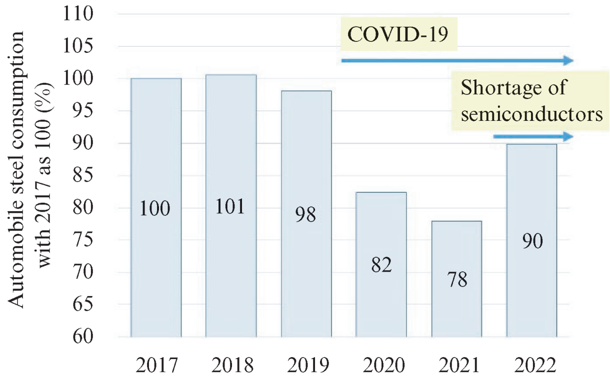

Fig. 5 Automobile steel consumption trends (FY 2022 figures are estimates)

4.2 Improvement of Delivery Efficiency by Utilization of Unified Dispatching System for Thin-gauge Products

This section introduces an example of application of optimization and simulation technologies in logistics planning. A system for optimizing delivery routes, which creates unified delivery plans for thin-gauge products shipped by the three bases of East Japan Works (Chiba District, Keihin District, Tokyo Logistics Center), was developed[13]. Because customers are concentrated within a certain range from the logistics bases, the volume of land transportation from East Japan Works by trailers and trucks occupies large percentage, at 10 000 t/d, and each base created its own logistics plans separately, which resulted in reduced logistics efficiency due duplication of loaded and empty vehicles. To solve this problem, vehicle dispatching was unified by creating a metaheuristics-based algorithm. Metaheuristics is a technique which obtains optimum solutions in a short time and with a certain degree of precision by repeated simulation of improved conditions from a defined initial condition. Since it was found that an average logistics improvement effect of 4.9 % and a CO_2 reduction effect of 3.2 % can be obtained by applying this system, the system was applied to the actual work of vehicle dispatch planning.

In addition, we are also developing a scheduling technology for shipping work, which is the subject of a separate report in this issue[14].

5. Conclusion

The development of an integrated management system of sales, production, and logistics in JFE Steel is summarized below.

(1) Improvement of labor productivity is necessary to cope with labor shortages which are feared accompanying Japan's declining working-age population. Equipment automation is an effective means of solving this problem.

(2) At West Japan Works Fukuyama District, equipment automation is being promoted, targeting improvement of labor productivity by +24 % in FY 2024 and +41 % in FY 2030 in comparison with FY 2018.

(3) To achieve carbon neutrality, JFE Steel is participating in a council on the use of ammonia as a fuel for ships, and is promoting a modal shift in product transportation.

(4) JFE Steel has also launched initiatives that utilize DX technologies to respond flexibly to changes in production and shipping volume.

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