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Past Changes and Future Trends in Distribution Technology

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Abstract:

An overview of distribution improvement technology for the past decade is given, and the future outlook is presented. The technological improvements accomplished in the distribution field have evolved from the optimization of distribution practices within and outside the steel works and the construction of a unit load system. As part of the introduction of such technology, all-weather berths have been built, and warehouses and distribution bases have been augmented. The new technologies that have improved distribution efficiency include artificial intelligence (AI), mobile communications, and automatically-guided vehicles (AGVs). As a result of these innovations, through-process streamlining has made great progress. The steel industry has long been equated with the transportation business and has introduced many advances in transport technology. To create better logistic technology, the production, sales, and distribution divisions will have to work together more closely than ever before.

1. Introduction

This is the first time that technology for improving distribution operations has been featured in an issue of the Nippon Steel Technical Report.

In the steel industry, internal distribution addresses the handling of raw materials at a steelworks and the shipping of products at a product wharf. External distribution concerns coastal shipping, distribution bases, and truck transport.

Jobs in the distribution field fall into the 3-K category: Kitsui (demanding), Kitanai (dirty), and Kiken (dangerous); and are labor-intensive, and low-value added in nature. Given these characteristics, distribution practices must be improved by eliminating the 3-K aspects, improving labor productivity and work efficiency, and saving materials. The technologies required for improving employment conditions in this sector are discussed here.

This report reviews the measures implemented to improve distribution operations in the steel industry in the past decade and describes the future outlook of this technology in the steel industry.

2. Changes in Distribution Improvement Measures (See Table 1)

Nippon Steel has implemented the following measures to improve its distribution operations by reflecting the management environment at each aspect:

(1) Promotion of a comprehensive rationalization program for product transportation

(2) Promotion of comprehensive measures to improve distribution operations.

(3) Development and implementation of an automatic transportation system.

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Table 1 Concepts of distribution improvement measures and changes in main technical measures undertaken

		Before 1983	Comprehensive product transport rationalization program		Comprehensive distribution improvement measures '90-
		Individual rationalization	Optimization of internal through-process distribution — Hardware measures	Software measures	Optimization of internal and external integrated distribution
Internal	① Raw materials	· Enlargement of UL*1 and shovels	· Onboard multifunctional shovel		· Continuous UL*1
	② Railroad	· One-man operation	· Vehicle transport equipment	Comprehensive distribution system (Work load balancing)	
	③ Vehicle transport	· Conversion to T-T*2 · Vehicle enlargement	· Large CP*4 · Large dump trucks and CP*4 for bulk materials		
	④ Warehouse	· Semiautomatic lifting devices · Simple operator guidance*3	· Automatic lifting devices and automatic warehouses · Automatic operation		· Augmentation of semifinished product warehouses · Augmentation of finished product warehouses
	⑤ Shipment	· Semiautomatic lifting devices	· Automatic lifting devices · All-weather berths	· Operator guidance*3	· All-weather berths
External	Truck and ship				· Steel product carriers · Coastal shipping NWS*5
	Distribution bases				· Augmentation of distribution bases in Tokyo area

*1:Unlaoders *3:Operator guidance system *5:Network system

*2:Tractor-trailer combinations *4:Self-elevating transporters

2.1 Implementation of comprehensive rationalization program for product transport

First introduced in 1984, a comprehensive rationalization program for product transport has been implemented throughout the company, doubling labor productivity in the transportation division. (See **Fig. 1**)

Equipment improvements include:

(1) Enlargement of equipment to reduce the number of times the materials and products are transported and handled.

(2) Separation of transport vehicles from pallets to shorten the job cycle time.

(3) Use of general-purpose equipment to make efficient use of equipment.

(4) Introduction of automatic lifting devices and other devices to mechanize and automate material handling tasks.

The following systems were also implemented:

(1) Development and application of a job planning and control system to balance the work load and to achieve comprehensive through-process optimization across the areas of vehicle transportation, warehousing, and product wharf shipping.

(2) Automatic issue of work instructions by an operator guidance system to augment material and product control functions.

2.2 Promotion of comprehensive distribution measures

Although the company recorded low production levels in 1985 and 1986, production increased in 1987, reflecting the beginning of what is now called the bubble economy. With the recognition that suppression of annually rising distribution costs was vital for efficient management, Nippon Steel built a comprehensive distribution system and optimized distribution operations within and outside each steel works by:

(1) Suppressing and reducing transportation costs.

(2) Strengthening nonprice competitiveness by supplying customers with products of good quality while meeting desired delivery dates.

(3) Maintaining and securing stable transportation capabilities.

When implementing the above-mentioned measures, it was necessary to take distribution from production to customer delivery as a single process and to solve problems arising at each step of the integrated process from a comprehensive point of view. The production, technology, and sales divisions at the head office have closely collaborated with the steel works and equipment engineering divisions.

All phases of internal distribution, from receipt of incoming raw materials and shipment of finished products, and of external distribution, from shipment of finished products to delivery of finished products to customers, have been addressed concerning raw materials, semifinished products, and finished products.

The principal measures undertaken were as follows:

(1) Identify bottleneck processes to streamline distribution, and take corrective actions. More specifically, augment semifinished and finished product warehouses for internal distribution, and construct all-weather berths and additional distribution bases in the Tokyo area for external distribution.

(2) Develop and implement an advanced job planning, specifying, and controlling system to more efficiently operate material handling and transporting equipment.

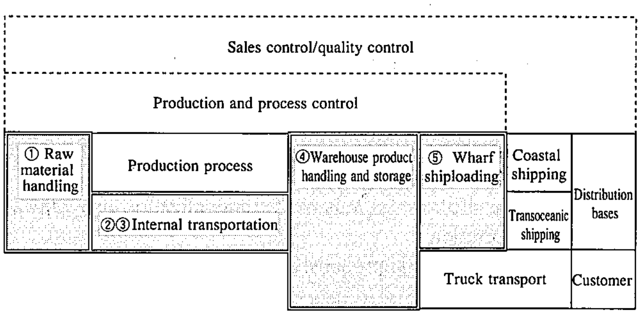

Fig. 1 Subjects covered by comprehensive product transport rationalization program (shaded)

2.3 Development and implementation of automatic transportation system

Since 1990, Nippon Steel has identified needs for technology development in all production processes, and has developed and implemented such technologies as required to:

(1) Cope with aging of workers.

(2) Meet the future shortage of workers, especially young workers.

(3) Improve the working environment for elderly and female workers, and eliminate 3-K jobs.

Faced with similar needs, the distribution division has established a number of aims for technology development, and has developed and implemented necessary technologies.

Of particular interest among these efforts is the progress achieved in the implementation of an automatic transportation system that combines automatically guided vehicles with automatic cranes to eliminate such 3-K jobs as driving coil lift trucks while standing.

3. Technology for Improving Distribution Operations in Specific Areas

3.1. Raw material unloading

3.1.1 Development and introduction of onboard multifunctional shovel

Iron ore, coal, and other raw materials are unloaded from ships with grab bucket unloaders at a rate of 2,000 tons per hour. In the final phase of unloading, workers previously entered each cargo hold and manually collected the iron ore, coal, or other raw material remaining on the shelves and at the corners of the hold.

Particularly in summer, the workers had to toil in dusty and hot cargo holds. An onboard multifunctional shovel has been developed and introduced to eliminate this extremely severe task.

3.1.2 Development and introduction of unloading control system

In line with the progress of ore, coal, or other raw material carrier unloading, it is necessary to move from one cargo hold to another to adjust the load balance of the carrier or to use the previously-mentioned multifunctional shovel onboard. Unloading efficiency depends on whether or not the unloading schedule is properly established. An artificial intelligence-based unloading control system has been developed and introduced to achieve higher unloading efficiency and unloading control efficiency.

3.1.3 Introduction of continuous unloader

Increasing size of ore, coal, and other raw material carriers has made some grab bucket unloaders obsolete. To remedy this situation, continuous unloaders have been introduced that are relatively free from the effects of the cargo condition in ship holds, have small capacity variations from the start to the end of unloading work, have high unloading efficiency, are capable of being enlarged, and are amenable for conversion to automatic operation in the future.

3.2 Vehicle transportation of bulk materials

Vehicle transportation includes the transportation of primary raw materials, scrap, and other bulk materials between yards and of blast furnace slag to a disposal site.

These bulk materials were traditionally carried by dump trucks. Large vehicles, ranging from 50 to 100 tons in capacity, have been introduced to reduce the number of trips made. The bulk materials are stored on pallets to shorten the operating cycle time of the vehicles. An operation control system has been developed and introduced to improve the operating efficiency of the vehicles.

3.3 Vehicle transportation of semifinished products and finished products from mill through warehouse to product wharf

3.3.1 Actual situation before improvement

(1) Control systems and control patterns were independent of each other, and entire transport operations were not controlled in an integrated manner. Railroad cars, trucks, trailers, and many other transport vehicles were mixed, which resulted in a lack of versatility and impeded flexible operations. The assignment of operating personnel from one category of transport vehicle to another was also limited.

(2) Transport equipment capacity was small, the loading and unloading waiting time ratio was large, and working efficiency was poor.

(3) Transportation from terminal warehouses to general warehouses and repositioning increased the amount of distribution load.

(4) Each time finished products were transported, they were loaded and unloaded.

(5) Finished products were simultaneously transported from production lines into warehouses and shipped from warehouses to product wharves. These simultaneous transporting and shipping operations were routinely performed below the peak level. The warehousing work load was difficult to balance due to the necessity of assuring synchronicity between the production rate of the manufacturing line and the shipping rate of the product wharf. Warehousing work efficiency also differed with the type and size of finished product, compounding the variability.

The above conditions increased the variations in the required number of transport personnel and equipment and raised the adjustments control personnel had to perform.

3.3.2 Improvement measures

(1) Build comprehensive distribution control functions centering on an integrated plan from the finishing line of each mill to shipping. Augment the comprehensive transport control system. Formulate daily plans and comprehensive through-process plans from the warehouse to the product wharf from monthly plans, and execute the daily plans and comprehensive through-process plans. Use the daily and comprehensive through-process plans to balance the transport work load and to operate the transport vehicles in a flexible and effective manner.

(2) Consolidate transport modes into vehicle transport and switch to a flexible transport system. When selecting transport vehicles, introduce self-elevating transporter and pallet system to reduce the number of transport trips, improve transport efficiency, and synchronize work efficiency of the product warehouse and wharf. These improvement measures are designed to accomplish higher through-process efficiency from the product warehouse to the product wharf.

(3) By making the most of a self-elevating transporter and pallet system, introduce a unit load system to warehouse products on pallets, reduce the handling of products, increase the flexibility of product transportation, and improve not only transportation efficiency but also integrated distribution efficiency from the product warehouse to the product wharf. In other words:

(i) Reduce the handling of products by loading products on pallets at the exit of each finishing line and transporting the products on pallets directly to the product wharf.

(ii) Make use of a product-on-pallet warehouse to balance the warehouse and product wharf operations.

(iii) Facilitate the preparation and execution of comprehensive through-process physical distribution plans

3.3.3 Main physical distribution improvement technologies

(1) Self-elevating transporter allocation and operation control system (See **Fig. 2**)

One important element of the comprehensive distribution control system is a self-elevating transporter allocation and operation control system. When moving pallets on which semifinished

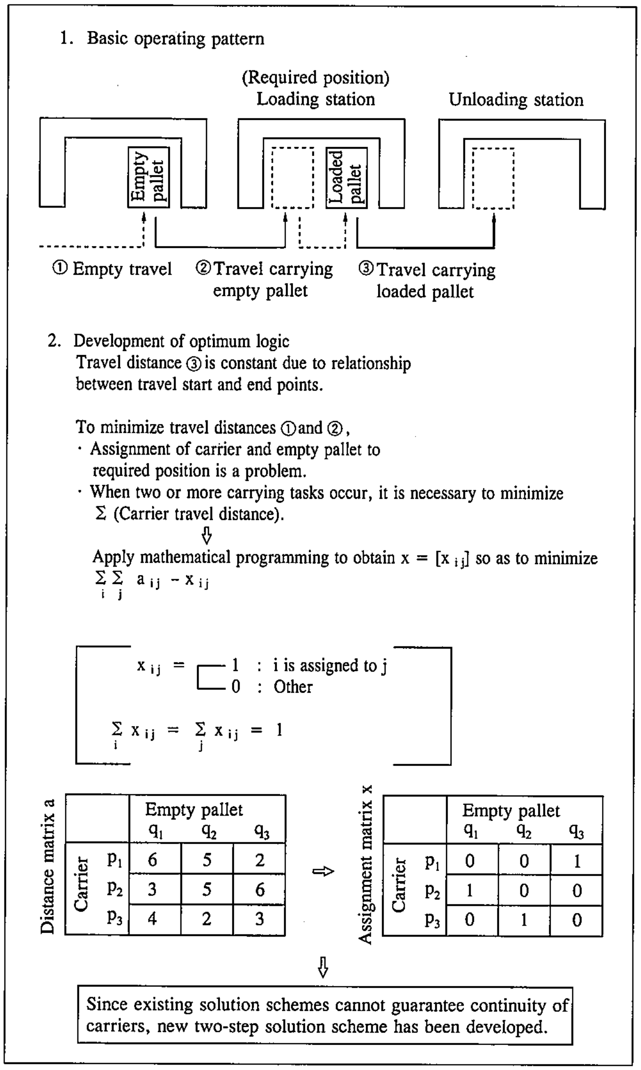

Fig. 2 Self-elevating transporter allocation and operation control system

products, finished products, or other materials are loaded and supplying empty pallets, this system optimally assigns empty or loaded pallets to carriers to minimize the time during when carriers travel alone and the time during when self-elevating transporters transport empty pallets. This is an important function that governs the transportation efficiency of each steelworks.

The development of the system obtained optimum solutions by mathematical programming, an operations research technique. Recently, an automatic vehicle monitoring (AVM) system has been introduced that combines advanced communications and multimedia technologies to locate and display the position of each carrier in real time by using an satellite navigation system. In other words, the AVM system shows the operating position of each carrier on the map displayed on the CRT screen and assigns an optimum carrier to each pallet.

(2) Development of automatic stowage plan preparation system (See **Fig. 3** and **4**)

The accurate prediction of shipping time is indispensable for efficient distribution from the product warehouse to the product wharf. For sea transportation, loading procedures determine the ship departure time. The following duties are vital in the comprehensive distribution control system:

(i) Judging whether or not all the steel products to be shipped can be loaded onto one ship.

(ii) If this is possible, graphically display the position of each type of steel product to be loaded on the ship and issue loading instructions accordingly.

Conventionally, the sequence in which to load respective types of steel products into a ship was determined by veteran operators relying on their experience and intuition. This manual work took considerable time, was not fast enough to accommodate frequent shipping time predictions, involved personal differences, and often resulted in inaccurate predictions.

An automatic stowage plan preparation system has been developed and implemented. By making use of AI, the system is so flexible that anyone can produce a standard ship load plan at any time.

(3) Development and implementation of automatic transportation system

Particularly at the mills and warehouses where sheet steel products are produced and handled, the products are manually transported via coil lift trucks and cranes in the mill building and are moved by self-elevating transporter and pallet system from the mill to the warehouse. Workers engaged in the handling and trans-

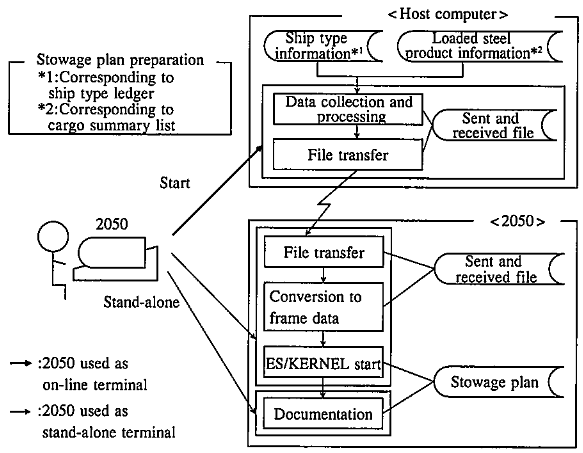

Fig. 3 Configuration of automatic ship load plan preparation system

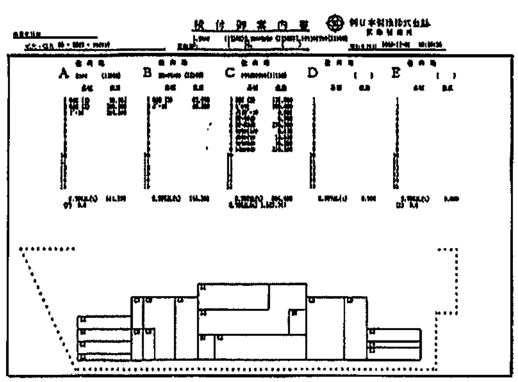

Fig. 4 Example of stowage plan prepared

porting of coils and other products account for the majority of the internal transport personnel. The lift trucks used to carry coils and the operators who drive the coil lift trucks are both aging. This situation calls for remedial action.

The main operations performed in this division are mainly loading, transporting, and unloading. If an automatic system is introduced to perform these functions without operator intervention, it can reduce the number of low-value added jobs and can be applied to other areas throughout the company. Recognizing this fact, the personnel concerned have worked on the development of such a system.

Among the important technical problems to be solved with respect to the development of AGVs are reducing their size, improving stopping accuracy, and achieving full-mode travel to minimize travel area.

Among the important technical problems to be solved with respect to the development of automatic cranes are the development of appropriate lifting devices, position sensors, a coil recognition system, a coil swing control system, a control system for avoiding the operational interference of two or more cranes in the same building, and a system for the priority assignment of cranes to specific jobs to optimize the overall efficiency of the AGVs, and cranes to move the coils into and out of the product warehouse and to reposition the coils within the product warehouse.

The development of this technology is bringing an automatic transportation system, composed of AGVs and automatic cranes, closer to reality. (See **Fig. 5**)

3.4 Distribution from product wharf through distribution base to customer

Both equipment and system improvements have been carried out to drastically enhance the efficiency of external distribution.

Among the specific measures are the construction of an all-weather berth at each steelworks to load steel products into ships, improvement of distribution bases, especially in the Tokyo area, building of all-weather berths, and modification of holds in existing ships to carry steel products. To enhance these measures, a coastal shipping network system was built to raise the efficiency of coastal shipping as an important mode of external distribution.

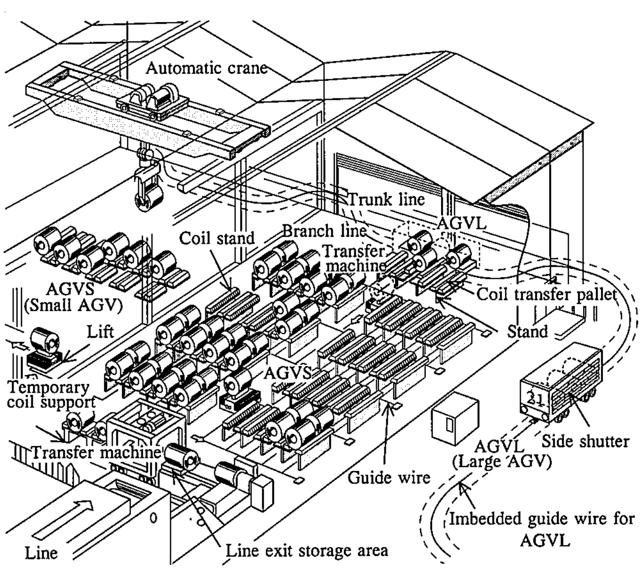

Fig. 5 Schematic illustration of automatic transportation system

3.4.1 Introduction of steel product carriers

As a result of the reduction in the number of the steelworks where crude steel is produced, the proportion of semifinished steel product transactions between the steelworks in the form of coastal shipping tonnage has increased.

To boost the efficiency of large-lot transportation, including internal transactions, steel product carriers have been introduced in to raise coastal shipping tonnage.

Steel product carriers have holds fitted with special-purpose supports to load semifinished steel products without dunnage, and aim at higher handling efficiency at loading and unloading points and higher overall navigation efficiency.

Steel product carriers have improved the efficiency of distribution operations from terminal warehouses at loading works to reheating furnaces at unloading works.

3.4.2 Installation of all-weather berths

Nippon Steel has all-weather berths for barges already installed at Yawata, Muroran, Hirohata and Kimitsu, but not at the other works yet.

The increase in the percentage of steel products that must not be exposed to rain has raised the waiting time of coastal ships at loading and unloading points due to such weather conditions as heavy rainfall and rough waves, and decreased the operating efficiency of coastal ships.

The type of all-weather berth for a particular works is determined by considering the weather and other conditions peculiar to the works.

4. Future Outlook and Conclusions

The measures implemented by Nippon Steel to improve its distribution operations in the last decade have been reviewed. Ensuring integrated material flow is essential for raising distribution efficiency. Pursuit of overall streamlining and load balancing makes it necessary to improve distribution efficiency in each of the processes concerned.

The steel industry is said to be a "transportation business". When we look back on the measures undertaken in the last decade, it is a fact that our industry still has transportation industry characteristics.

The production, sales, and distribution divisions will have to collaborate more closely than ever in improving distribution in terms of both stock and flow and in streamlining distribution channels. More specifically, the inventories of semifinished and finished products will have to be lowered, and the amount of distribution performed, including nonroutine distribution, will have to be reduced. On top of that, the distribution division itself will have to enhance the efficiency of each process involved.