Stainless Steel Quarto Plate Productive Capacity Reinforcement

1. Introduction

Stainless steel plates of Nippon Steel & Sumikin Stainless Steel Corporation are currently manufactured at the Plate Mill of Yawata Works in Kita-Kyushu City.

The Plate Mill was constructed in 1957 as the most advanced ordinary steel plate mill of the then Yawata Steel Corporation. Since then, it had manufactured ordinary steel plates mainly for the shipbuilding and construction industries. At one time, monthly production topped 140,000 tons. The mill started production of stainless steel plates in 1963, and has since been manufacturing stainless steel plates for 45 years.

In the wake of a slump in the shipbuilding industry in the late 1970s, several plate mills in Japan were integrated or shut down. In 1988, the Plate Mill reduced its scale of production and specialized in stainless steel plates. At that time, it was producing 50,000 to 60,000 tons of stainless steel plate annually.

In 2003, when the stainless steel business of Nippon Steel Corporation and that of Sumitomo Metal Industries, Ltd. were integrated, it was decided to concentrate the production of stainless steel plates at the Plate Mill. Around that time, the demand for stainless steel plates began increasing rapidly in diverse fields, including shipbuilding, energy and information technology. Under such conditions, there was a growing need to expand the production capacity of the Plate Mill.

The Plate Mill has a surplus capacity for rolling, and its manufacturing structure is such that the capacity for stainless steel plate production can be increased by reinforcing its capacity for conditioning stainless steel plate.

This paper describes the measures we have taken over the past few years to increase the conditioning capacity of the Plate Mill in view of the above situation.

2. Concept of Capacity Expansion and Outline of Plan for Capacity Expansion

(1) Capacity expansion in first phase

Prior to the integration of the stainless steel businesses mentioned above, Sumitomo Metal Industries started in 2002 an extensive review of the production efficiency in production concentration (production increase) at the Yawata Works aimed at dramatically improving earnings. Concerning the conditioning capacity, Yawata Plate Mill was operating almost to capacity. Therefore, it was necessary to take measures to expand the conditioning capacity. The company discussed a plan which would enable it to maximize the benefits of the business integration while minimizing investment in plant and equipment by executing the following measures.

I. Reinforcing facilities with inadequate capacity (heat treatment, inspection, gas cutting)
II. Increasing production of wide and thick plates receiving brisk inquiries from users
III. Improving production logistics taking into account the characteristics of existing equipment.

As shown in the mill layout (**Fig. 1**), the No. 1 finishing line consisted mainly of facilities for narrow and thin plates, while the No. 2 finishing line consisted mainly of facilities for wide and thick plates. The only heating furnace, 3H, could be used only for plates up to 50-mm thick. Since the heat treatment of plates exceeding 50 mm in thickness had been farmed out, there were a number of drawbacks, such as limited production volume and higher production costs. The new heat treatment furnace to be installed was planned so that it would permit treatment of not only thick plates, to resolve the above problems, but also thin plates to eliminate the problem of insufficient total heat treatment capacity.

Concerning wide plates, the cold leveler (CL) of the No. 1 finishing line could only be used for plates up to 3 m in width. Plates exceeding 3 m in width had been handled by the CL of the No. 2 finishing line, since it was capable of threading plates up to 4 m in width. Therefore, the material flow was complicated. Thus, rolling → heat treatment (3H of the No. 1 finishing line) → straightening (CL of the No. 2 finishing line) → pickling (the No. 1 finishing line). It was, therefore, decided to install the new heat treatment furnace (4H) on the No. 2 finishing line in a position where it could be coupled with the rolling mill via a table and where the necessary utilities (water, LNG, etc.) were readily available (see the mill layout in Fig. 1). The installation of 4H has significantly improved the material flow to: rolling → heat treatment and straightening (4H and CL of the No. 2 finishing line) → pickling and inspection (the No. 1 finishing line).

In October 2003, a new company was scheduled to be set up. If the measures to expand the capacity were delayed, there were concerns that the planned shutdown of the stainless steel plate finishing line at Kashima Works would have to be postponed (incurring extra expenditure) and that chances to win new orders would be lost due to insufficient supply capacity. Accordingly, it was absolutely necessary to implement the above measures with the utmost urgency. Therefore, the time required to install the new heat treatment furnace (4H)—the bottleneck process—was shortened by adopting prefabricated piping and large-block components, preventing interference in the scope of the installation work, and so forth. As a result, the installation work was completed in 13 months as scheduled, so that the 4H could be started up by the end of March 2004.

(2) Capacity expansion in second phase

The capacity expansion work in the first phase was completed as scheduled and the new equipment was operating smoothly. In contrast, reflecting economic growth on a global basis, demand for stainless steel plates was recovering remarkably. As the withdrawal and integration of domestic plate mills had been ongoing, it was very likely that stainless steel plates would continue to be in short supply. Therefore, it was decided to implement further measures to expand production capacity of thick plate. There were many chemical plant construction projects and energy-related projects (e.g., LNG projects)

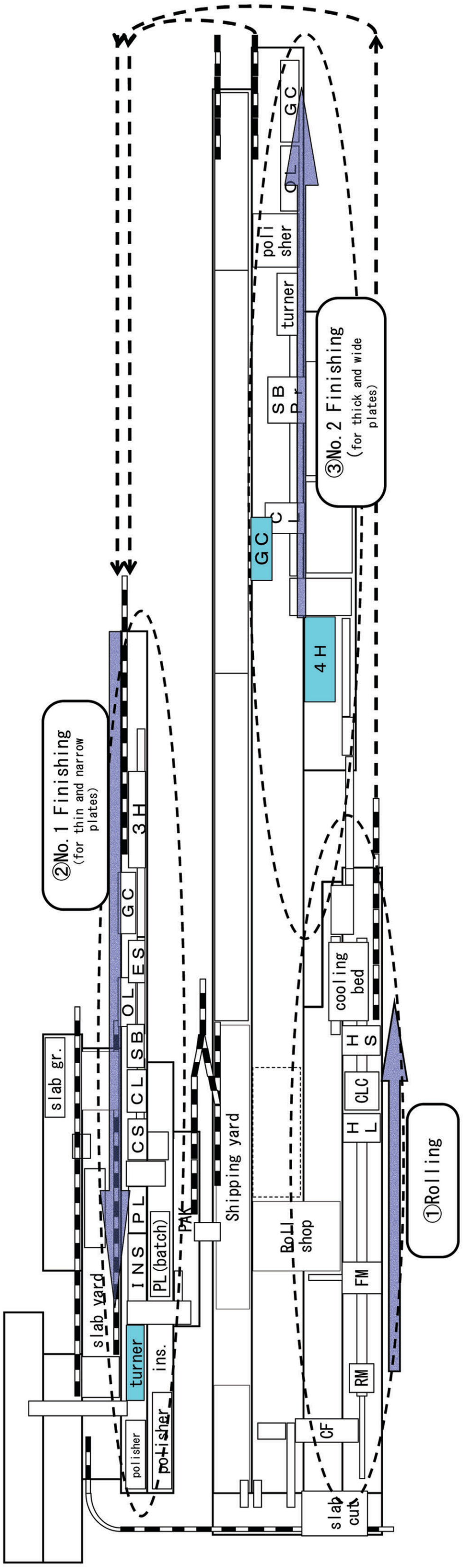

Fig. 1 Mill layout after 1st step reinforcement

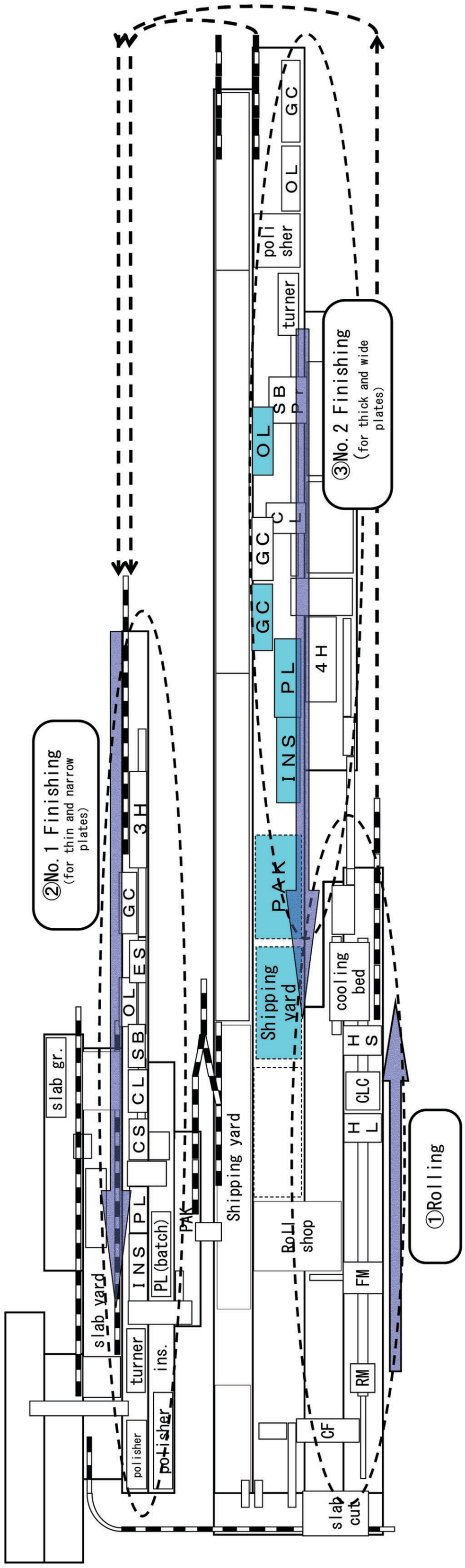

Fig. 2 Mill layout after 2nd step reinforcement

that were underway around the world, especially in the Middle East and Asia. Under that condition, it was expected that the supply-demand gap for stainless steel plates would widen on a global basis. Therefore, it was planned to expand the equipment capacity so as to increase production by 2,500 tons/month to match the estimated increase in domestic demand. The equipment plan focused on the following points.

I. Reinforcing facilities with inadequate capacity (pickling & inspection, straightening, gas cutting, packing & shipping yards)
II. Planning an equipment layout allowing for further capacity expansion in the future
III. Improving the material flow in production taking into account the characteristics of existing equipment

At the time of planning, the pickling & inspection equipment shown in **Fig. 2** was absent in the No. 2 finishing line. Since the heat-treated and straightened plates had to be transported to the No. 1 finishing line by freight cars, the flow of materials was complicated.

Eventually, it was decided to install new pickling & inspection equipment on the No. 2 finishing line, since it had sufficient space for the installation of additional equipment, in order to improve the material flow and permit increasing production sometime in the future. In addition, to take advantage of the characteristics of the facilities of the No. 2 finishing line for wide and thick plates, it was decided that the pickling & inspection equipment to be newly installed should be such that it would even be capable of handling plates up to 150-mm thick and 4-m wide.

To minimize the amount of investment in the new pickling & inspection equipment, it was decided that the pickling tank length should not be too long to prevent the planned capacity expansion. Even so, a sufficient space for extension of the pickling tank to allow for future capacity expansion was secured. In addition, the layout of the pickling & inspection equipment was planned such that it could be directly connected to the shot blast (SB) - CL process during capacity expansion in the future to ensure efficient production operations by, for example, aligning the line centers of the related facilities. For the No. 2 finishing line, new packing and shipping yards were laid out so that the products would flow smoothly from north to south. Since it was expected that the supply of stainless steel plates for a particular big project would start in July 2006, the time in which to complete installation of the new equipment was shortened by adopting large-block components, etc. As a result, the installation work was completed in 15 months and the equipment was started up in July 2006 as scheduled.

3. Outline of New Heat Treatment Furnace (4H)

(1) Furnace body

After comparing the furnace types shown in **Table 1**, the batch type was adopted based on its applicability to wide and thick plates and the amount of investment required.

As the side view of the new heat treatment furnace shows in **Fig. 3**, the batch-type furnace employs an extractor to charge and discharge the steel plate. The heat-treated steel plate is conveyed to the cooling equipment by a roller table. Since it is necessary to maintain the steel plate temperature at 900℃ or higher until the cooling operation starts, a high-speed extractor and a high-speed table were adopted and the extractor traveling speed and table conveyor speed were set at 70 m/min and 120 m/min, respectively, so as to ensure a cooling start temperature of 900℃ or higher.

For a batch-type furnace, the same burner is used to heat the steel plate over the entire temperature region. During soaking, however, the burner combustion rate is decreased to 10% of the maximum rate. In this case, it is necessary to keep the variance in steel material temperature within ± 15℃. In order to secure the required soaking performance while the burner combustion rate is low, a motive air system was installed to the burner as shown in **Fig. 4** to ensure that the burner flames were propelled forward even when the burner load is small.

(2) Quenching equipment

As shown in **Table 2**, there are three types of quenching systems—roller quenching (RQ), spray quenching and dip quenching. Taking into consideration the applicability to both thick and thin plates and the amount of investment required, it was decided to employ a spray quenching system for thin plates and a dip quenching system for thick plates.

Table 1 Furnace type consideration (for thick and wide plates)

Type	Hearth roll	Walking beam	Batch
Size	×	○	○
Cost	×	×	○
Evaluation	×	×	○

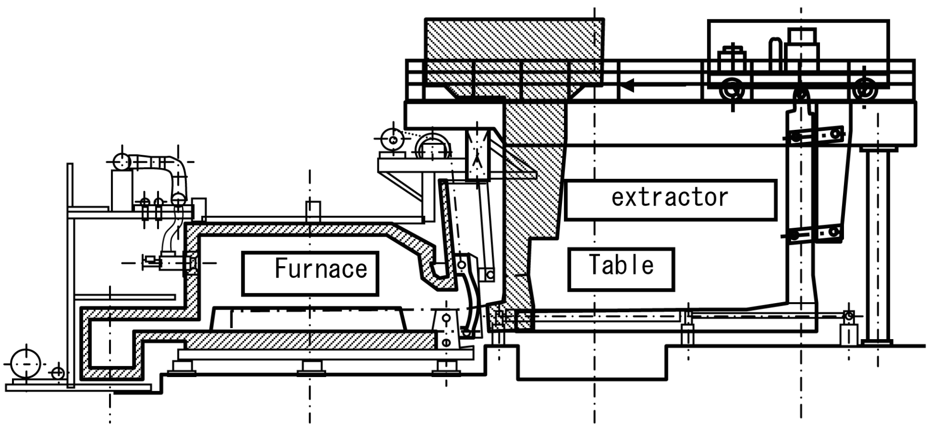

Fig. 3 New heat treating furnace (side view)

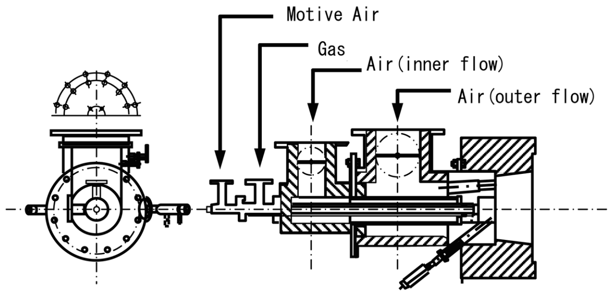

Fig. 4 Burner structure

Fig. 5 shows the spray quenching system. It quenches the steel plate from above and from below. In order to ensure uniform quenching, the spray water flow rates from above and below can be independently controlled. In addition, in order to prevent uneven quenching due to the water flowing over the steel plate, the upper sprays are arranged in an inwardly tilting pattern as shown in **Fig. 6** so that the spray water can easily flow off the steel plate.

Fig. 7 shows the dip quenching system. In order to ensure uniform quenching, nozzles are installed in the system and a piping diameter that minimizes the variance in water flow rate from the individual nozzles is adopted. In addition, the water flow rate at the top and bottom of the steel plate can be controlled independently.

Table 2 Quench type consideration

Type	Roller quench (RQ)	Spray quench	Dip quench
Cooling rate (for thick plate)	○	×	○
Quench start temperature	○	○	× (handling time)
Cost	×	○	○
Evaluation	×	○	

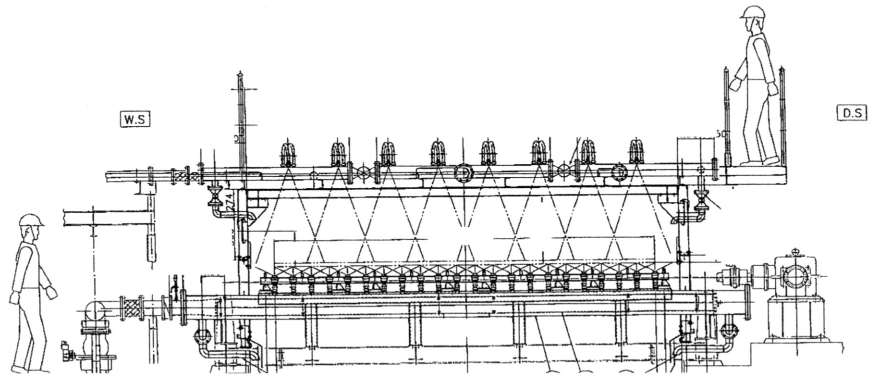

Fig. 5 Spray quench

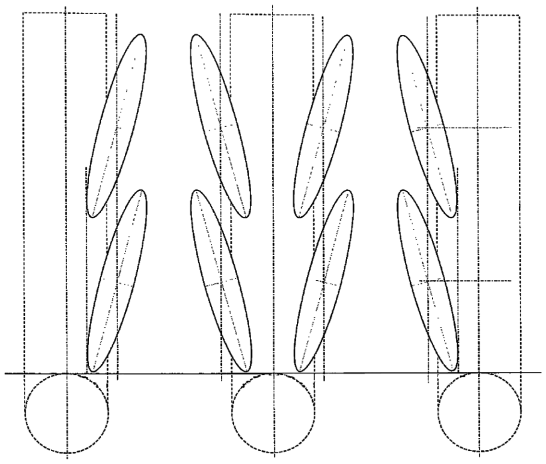

Fig. 6 Spray pattern

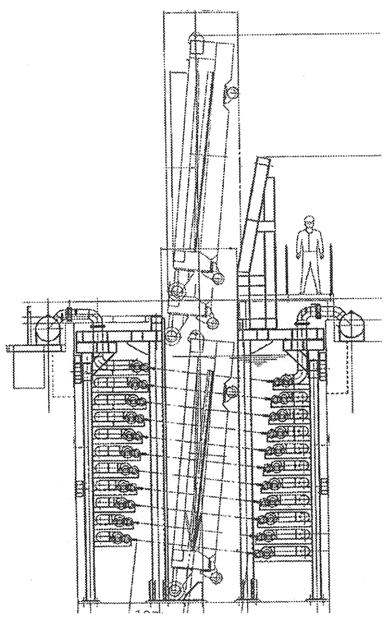

Fig. 7 Dip quench

4. Outline of New Pickling Equipment (No. 2 Pickling Equipment)

(1) Equipment layout

Fig. 8 shows the layout of the new pickling equipment. Space to extend the pickling tank is secured to allow for future capacity expansion. In addition, a space to install an automatic ultrasonic flaw detector and automatic thickness gauges is secured to allow for future improvements in work efficiency. Thus, the amount of investment in the new pickling equipment was minimized while providing for expandability of the equipment in the future.

(2) Details of pickling equipment

Fig. 9 shows a plan of the pickling equipment. To ensure efficient pickling operation, a spray pickling system is employed. The pickling solution is a mixture of nitric acid and fluoric acid. Iron is removed from the waste solution and recovered. Undiluted nitric acid and fluoric acid are replenished as required. Thus, the unit consumption of nitric acid and fluoric acid and the amount of waste solution are minimized.

To prevent the clogging of spray pickling nozzles and ensure the safety of maintenance personnel during repair of the piping, equipment to flush the pickling piping system is installed. All the related devices can be monitored and remotely operated from the operation room. Thus, the pickling equipment is designed so that it can be operated quite safely.

During pickling, NO_x is generated from the nitric acid as the acid reacts with oxygen. However, the generation of NO_x is minimized by feeding a small amount of hydrogen peroxide into the piping for spray pickling.

5. Summary of Capacity Expansion Results

The Phase I capacity expansion work was completed in March 2004 while the Phase II capacity expansion work was completed in July 2006. Since then, all equipment has been in good operating condition. As shown in **Fig. 10**, the reinforcement of the plate finishing line has made it possible to meet brisk demand for stainless steel plates and maintain a higher level of stainless steel plate output than originally planned.

6. Conclusion

In this report we describe the reinforcement of the finishing lines that has been conducted over the past few years. Demand for stainless steel plates continues to increase, mainly in the fields of energy and information technology. There is also growing demand for stronger and more corrosion-resistant stainless steels, as well as for wider, thicker stainless steel plates. The present situation is such that the existing facilities will soon be insufficient to fully meet market needs. It is considered necessary to further reinforce the finishing lines in the near future.

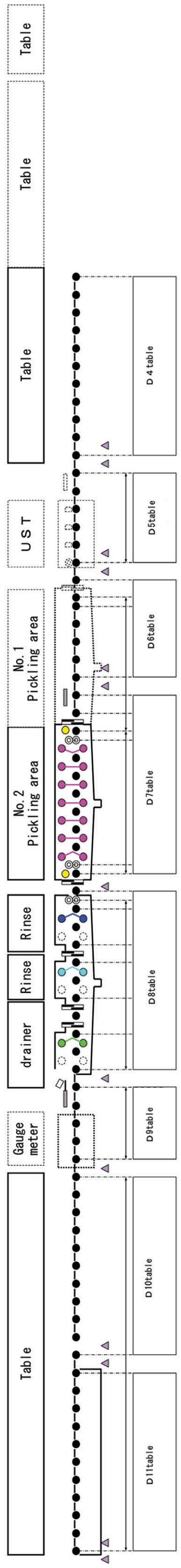

Fig. 8 New pickling line layout

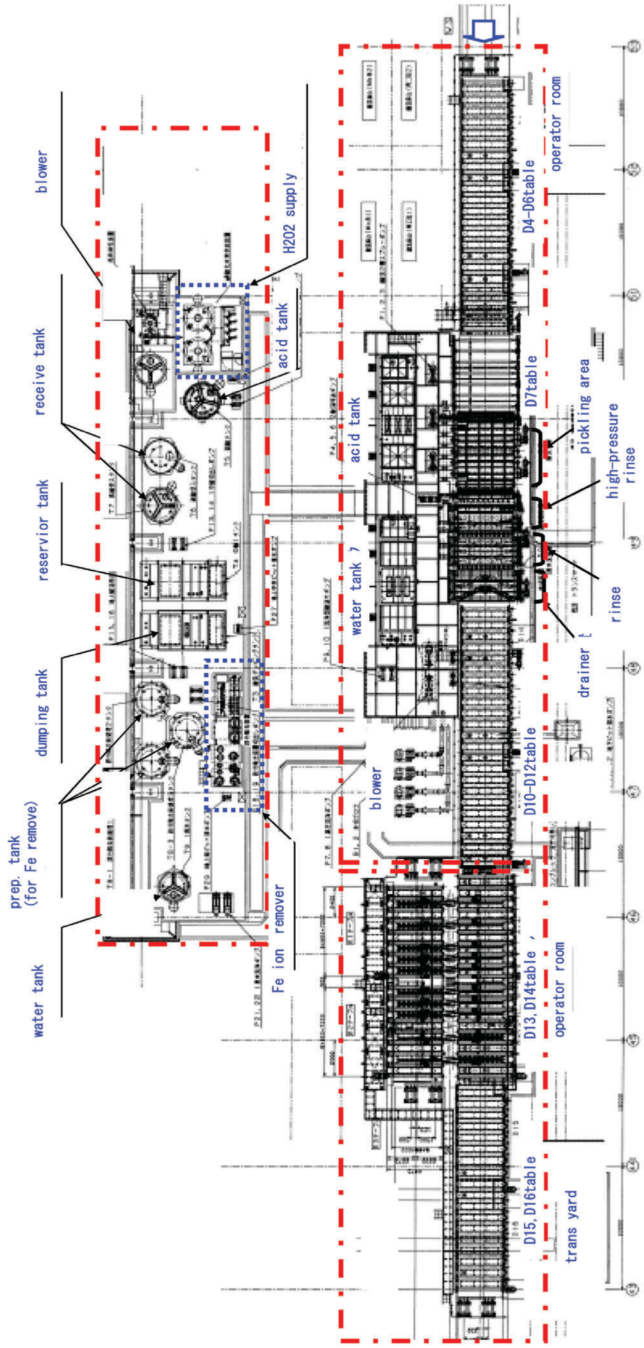

Fig. 9 New pickling line floor plan

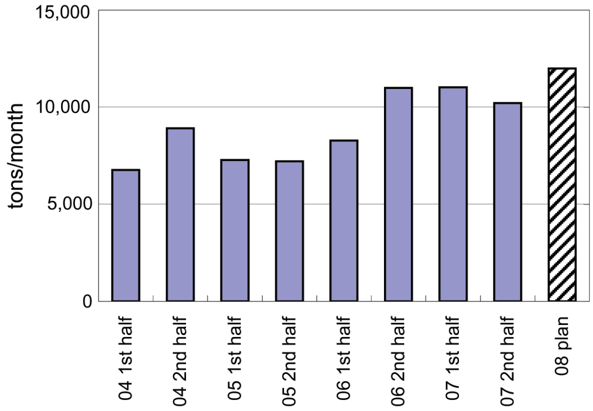

Fig. 10 Quatro plate output

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