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Construction of Cold Rolling Plant for Tin Mill Black Plate -Ton Yi Industrial Corp. in Taiwan-

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The body can be viewed from the next page.

Construction of Cold Rolling Plant for Tin Mill Black Plate —Ton Yi Industrial Corp. in Taiwan—*

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1 Introduction

In March 1993 Kawasaki Steel received an order for the construction of a complete cold rolling plant for tin mill black plate (TMBP) from Ton Yi Industrial Corp. in Taiwan (here after referred to as Ton Yi Industries). The start of operation of all facilities in October 1995, marked the completion of Kawasaki Steel's construction phase of the project.

Ton Yi Industries, which is one of the leading enterprises in Taiwan, is mainly engaged in the manufacturing of tinplate and tin-plated cans. It decided to construct a TMBP plant for producing the materials for tinplate as part of its business expansion program. Kawasaki Steel supplied a continuous electrical tin plating line and tinplate manufacturing techniques when Ton Yi Industries started the production of tinplate in 1986. Since that time, it has worked closely with Ton Yi Industries through the supply of TMBP and operational guidance.

The newly constructed TMBP plant has an annual TMBP production capacity of 600 000 t, making it one of the major TMBP plants in the world. This project involved large-scale construction which comprised simultaneous construction and start-up of the various facilities necessary for manufacturing TMBP, ancillary facilities such as those for supplying utilities, and a production control system. The construction could be completed earlier than originally planned owing to the combination of Kawasaki Steel's immense technical expertise and Ton Yi Industries' capacity to carry out the project.

Since commercial operation was started in October 1995, the output of TMBP has been increasing steadily. This paper describes the method for shortening the construction work and the process in the commissioning stage and presents an outline of equipment specifications.

2 Outline of Project

2.1 Ton Yi Industrial Corp.

Since its establishment in 1969 Ton Yi Industries has been constantly expanding so that it is now engaged in diversified operations including plastic bags, can manufacturing, lithographing of tinplate, tinplate manufacturing, manufacturing of TMBP, and various overseas projects. At present Ton Yi Industries is Taiwan's biggest integrated TMBP and tinplate manufacturing company. At the end of 1993 it became the first foreign enterprise that acquired the JIS authorization of Japan's Ministry of International Trade and Industry.

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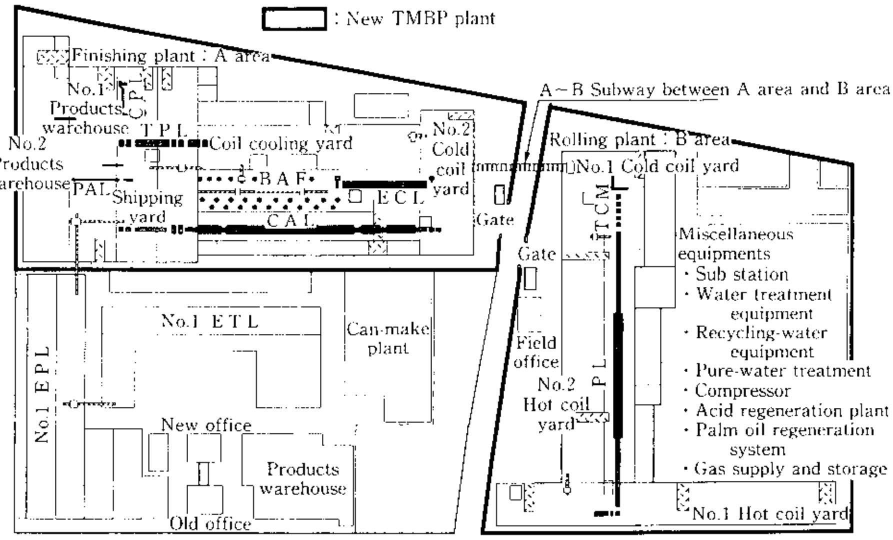

Fig. 1 Ton Yi Industrial Corp.: Plant layout

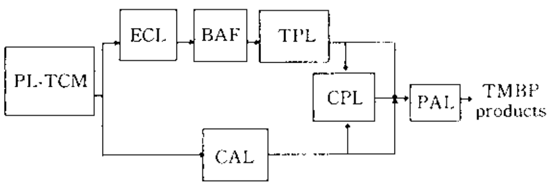

Fig. 2 Configuration of TMBP plant

In recent years Ton Yi Industries has been expanding overseas investments. On the Chinese mainland, this company has brought into operation a canning factory in Si Chuan province Chen Du City and a canning factory and tinplate plant in Jiang Su province Wuxi City. In Fujian province Zhang Zhou City a tinplate plant started commercial operation at the end of December 1996. In Vietnam, the Ton Meng canning factory has been operating in Ho-Chi-Minh City since June 1994.

Ton Yi Industries' principal present facilities related to tinplate are as follows:

(1) Tinplate manufacturing equipment (ETL): 2 lines, 300 000 t/y
(2) Lithographing of tinplate: 120 million sheets/year
(3) Canning plant: 4 lines, 500 million cans/year

2.2 Outline of TMBP Plant

An outline of the just completed TMBP plant is presented given below:

(1) Location: Yung Kang City, Tainan Prefecture, ROC (The site is adjacent to an existing ETL plant) (**Fig. 1**)
(2) Product line: TMBP, T-1BA to T-5CA
(3) Production capacity: 600 000 t/y (products)
(4) Product dimensions: Thickness 0.17 to 0.6 mm, width 600 to 1 220 mm
(5) Destination of products: Ton Yi Industries' ETLs (in Taiwan and on the Chinese main land: Wuxi and Zhang Zhou City)
(6) Line composition: The configuration of the TMBP plant is shown in **Fig. 2**

2.3 Kawasaki Steel's Roles in the Construction of TMBP Plant

Kawasaki Steel, which has acquired the necessary experience and know-how related to the manufacturing of TMBP, contracted to conduct all engineering services ranging from the planning of this project to civil works, construction of facilities and start-up of operation. In particular, Kawasaki Steel, which has many years of experience with TMBP operations and with the construction of overseas facilities, was involved in all aspects of the engineering such as production material flow, plant layouts, equipment design, construction schedule control, preparation of standards related to plant management, manpower requirement plans, training plans, operation plans, hot-coil purchase specifications, and plans to use utilities.

The production facilities entail seven lines, i.e., a fully-continuous pickling and tandem cold rolling mill, a continuous annealing line, an electrolytic cleaning line, batch annealing furnaces, a temper and processing line, a coil preparation line, and a packing line. Kawasaki Steel also supplied a roll shop, an acid regeneration plant, a palm oil regeneration plant, and water treatment equipment as auxiliary facilities. Furthermore, Kawasaki Steel developed and supplied a production control system for the TMBP plant.

In Taiwan rapid progress has been made in infrastructure, and Ton Yi Industries was able to procure the equipment and support available in Taiwan under Kawasaki Steel's guidance.

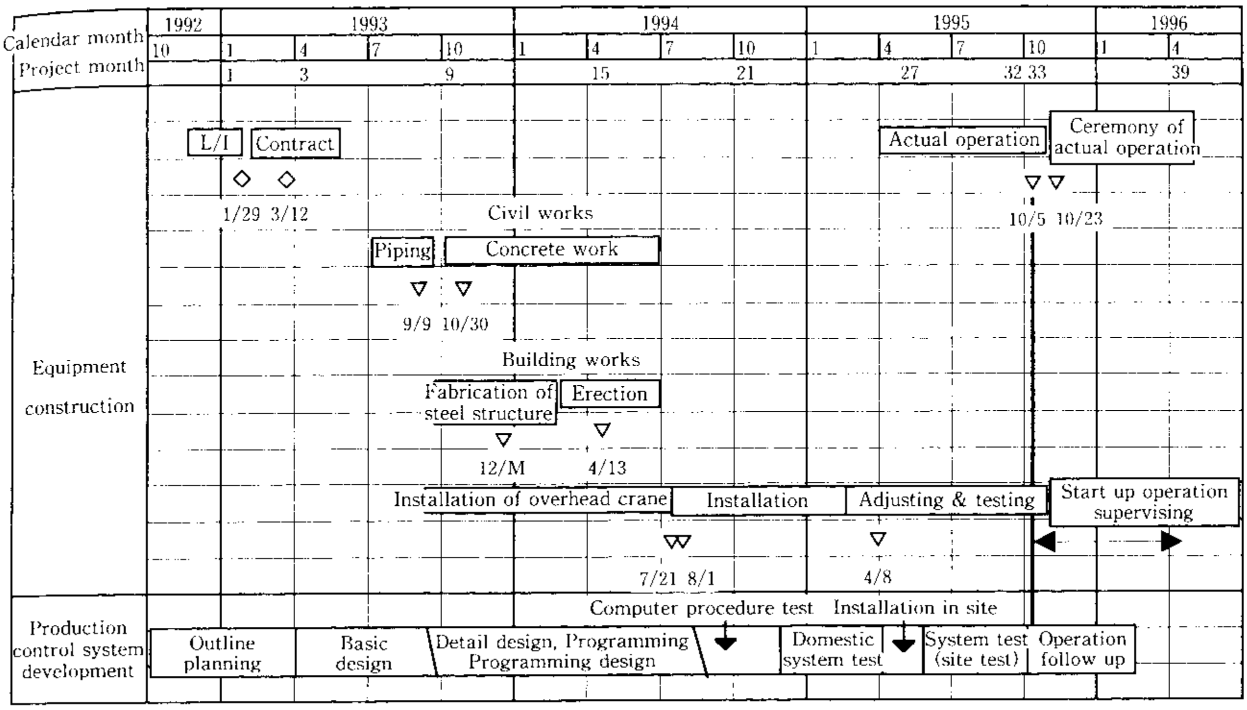

Fig. 3 TMBP plant construction schedule

3 Construction Schedule of the TMBP Plant

3.1 General Construction Schedule

The general construction schedule is shown in **Fig. 3**. Owing to the cooperation of everyone involved, commercial operation could be started 32 months after the issue of the letter of intent (L/I). Following is an outline of the points which were considered to shorten the construction process and ensure smooth start-up.

3.2 Construction Process

3.2.1 Civil works

Prior to construction, pile loading tests were conducted in order to set the pile toe level at the intermediate bearing layer; the results were incorporated into the design and construction. For deep structures such as the entry and delivery equipment, a direct foundation supported by the intermediate bearing layer was used to reduce the number of piles, helping to shorten construction time and lower costs.

Due to the artesian conditions of the intermediate layer, a bloaker was installed by driving steel sheet-piles. These sheet piles were kept buried so that they became anchors against buoyancy. This enabled the construction time to be shortened due to the omission of the removal works and a decrease in the amount of frame work for the wall.

3.2.2 Building work

The fabrication of structural steel was simplified by taking the following measures in the basic design stage:

(1) Making the column span uniform (standard: 15 m)
(2) Adopting full-web girders in the roof trusses and crane girders
(3) Allowing fillet welding in places except those that were the most structurally important

Furthermore, the main columns of yards that intersect each other and the columns of electrical rooms were structurally separated so that they could be erected from any construction zone.

Owing to the above measures taken in the basic design stage, the construction period could be shortened in the preparation of shop drawings for structural steel, fabrication and erection.

3.2.3 Installation work

To shorten the period of installation work, orders for mechanical work (installation, piping, FRP, brick work of PL, insulation work of CAL, etc.) and electrical work were placed with local contractors on a package basis. As a result, the local contractors became keenly aware of the construction deadlines and high efficiency was obtained in the coordination among subcontractors and the smooth execution of the work. Work was further facilitated by securing the storage yards of machine parts according to plan.

The greatest reason why the work could be so smoothly expedited at each stage was that Kawasaki

Steel participated in the project in the initial stage of planning and survey, and permitted designing in which the case of construction was considered. The fact that Kawasaki Steel's great management expertise was fully utilized was another reason.

3.3 Commissioning

As mentioned previously, efforts were made to stick to schedule in each work process, but in reality there was a slight delay.

However, the subsequent cold run and hot run tests were very smoothly undertaken enabling the commissioning process to go forward. As a result, commercial operation could begin earlier than originally planned.

The following are the main reasons for this:

(1) Operational specifications for electrical equipment and control specifications for electrical and instrumentation equipment were established early. The software for the plant was thoroughly debugged.

(2) Detailed plans of individual, interlocking operation, cold run and hot run tests were thoroughly examined and formulated beforehand. Sufficient time was set aside to revise the plans.

(3) The test of process computer (P/C) model was completed during the cold run test.

(4) The interface test of host computer (H/C) for production control, P/C and programmable logic controller (PLC) was conducted in Japan and all bugs were eliminated.

As a result of the above measures, little if any software trouble occurred. For example there was almost no problem with long line stoppages, such as strip breaks. Therefore, the trial run after the cold run test could be carried out very smoothly.

3.4 Development of Production Control System

The computer system development and preparation of various standards for plant management and production control were carried out in parallel with the design and construction of production facilities by making the best use of Kawasaki Steel's expertise with steelworks operation. Although this was Kawasaki Steel's first application of the UNIX* computer to full-scale basic system, an efficient system could be developed using operation tool (K4GL), communication software (VICS) and a central operation support tool in the UNIX computer, which were developed at Kawasaki Steel.

Furthermore, the development and inspection of almost all functions including the test of the interface with the P/C were finished in Japan as mentioned earlier, and the hardware and the developed application software were then shipped to Taiwan. In the commissioning stage after the hot run test, smooth operation was started with the computer systems. These systems contributed greatly to the shortening of the commissioning period after that.

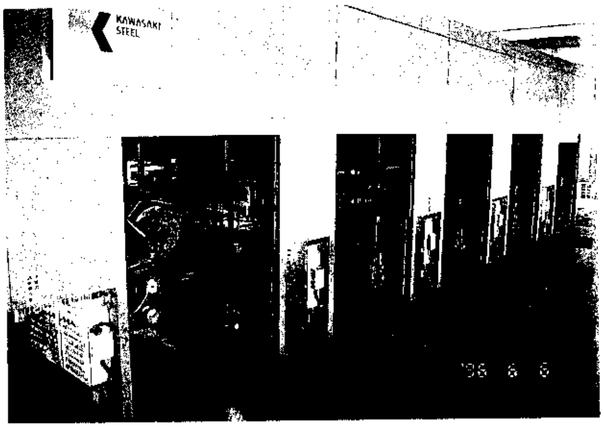

Photo 1 PL-TCM

4 Outline of Equipment at the TMBP Plant

4.1 Fully Continuous Pickling and Tandem Cold Rolling Mill (PL-TCM)

4.1.1 Outline

This line is fully-continuous pickling and rolling equipment and has a capacity for processing 650 000 t/y of high-quality TMBP. In order to produce TMBP products at high speeds, palm oil is used as a lubricant which is supplied by a direct lubricating system. State-of-the-art techniques, such as a shape control system, work-roll shifting for transverse gauge control and roller bearings of backup roll for longitudinal gauge control, are used in both the equipment and the computer control system. Thus this line ensures high quality and high productivity (**Photo 1**).

4.1.2 Equipment composition

The general composition of the PL-TCM line is shown in **Fig. 4**.

4.1.3 Basic specifications

The main specifications of the PL-TCM line are shown in **Table 1**.

4.1.4 System configuration

The system configuration of the PL-TCM line is shown in **Fig. 5**. The H/C (RS 6000/57) has a production control function which will be described later and transmits the information necessary for producing steel coil to the P/C (M 60/600). The P/C determines the computing rolling schedules of the rolling mill on the basis of this information and transmits the tracking information of weld points and operating conditions to various PLCs for electrical control. The roles of the PLCs include such

* The UNIX operating system was developed and is licensed by UNIX System Laboratories, Inc.

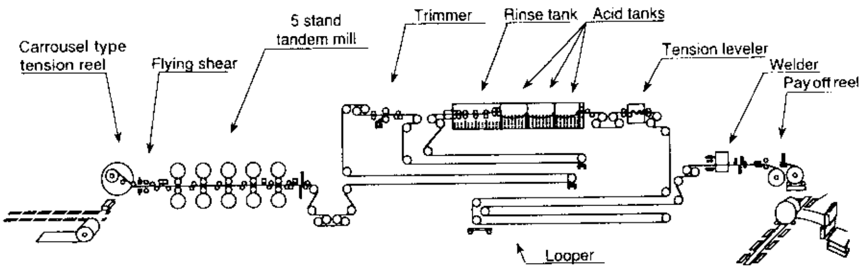

Fig. 4 Outline of PL-TCM

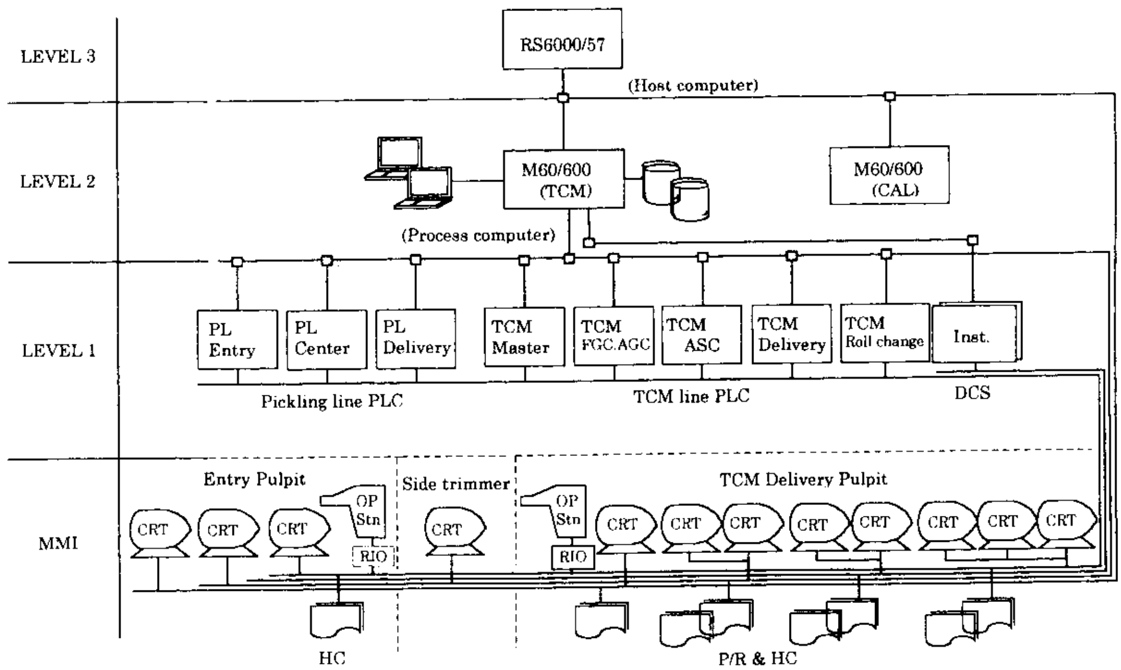

Fig. 5 System configuration of PL-TCM

Table 1 Main specifications of PL-TCM

Item		Specification
Entry strip thickness (hot coil thickness)	(mm)	1.8 ~ 2.6
Delivery strip thickness	(mm)	0.17 ~ 0.60
Strip width	(mm)	600 ~ 1 220
Capacity (entry)	(t/month)	54 000
Entry speed	(mpm)	Max. 500
Acid section speed	(mpm)	Max. 200
Trimmer section speed	(mpm)	Max. 250
Delivery speed	(mpm)	Max. 1 600

functions as the line drive control of electrical equipment, automatic sequence control, automatic gauge control, flying gauge control, automatic shape control, and micro tracking of weld points.

4.1.5 Features of the pickling line

The entry threading and welding are all automated. The descaling equipment is composed of a tension leveler of maximum elongation of 2% and hydrochloric acid tanks 79 m in length. The trimmer has an automatic width setting function and is provided with burr masher rolls, and trimmed portions are of high quality.

4.1.6 Features of the rolling mill

In order to obtain high shape controllability 4-high mills are used in all stands while an automatic shape control system[1], including a spot coolant system, is utilized in the No. 5 stand.

The adoption of K-WRS (Kawasaki Steel-work roll shift)[2] in the No. 1 stand improves the transverse gauge accuracy.

For the longitudinal gauge control, the use of hydraulic screwdown and BUR (backup roll) roller bearings in all stands improves the accuracy of the mechanical system and BISRA AGC, monitor AGC, FF AGC, roll eccentricity elimination control, etc., provide for high-accuracy gauge control.

4.2 Continuous Annealing Line (CAL)

4.2.1 Outline

CAL is a continuous high-speed processing line comprising electrolytic cleaning equipment, an annealing furnace, a skinpass mill and finishing equipment. It has a capacity for producing 426 000 t/y of high-quality TMBP (**Photo 2**).

The strip speed in the furnace is 800 mpm, which is among the world's highest speeds. To achieve this speed, the following latest techniques were introduced.

(1) Arrangement of a tension leveler on the entry side of the furnace
(2) High-accuracy tension control
(3) Optimization of the roll crown in the furnace[3,4]

Furthermore, the furnace composition is such that TMBP of both low and high temper grades can be produced.

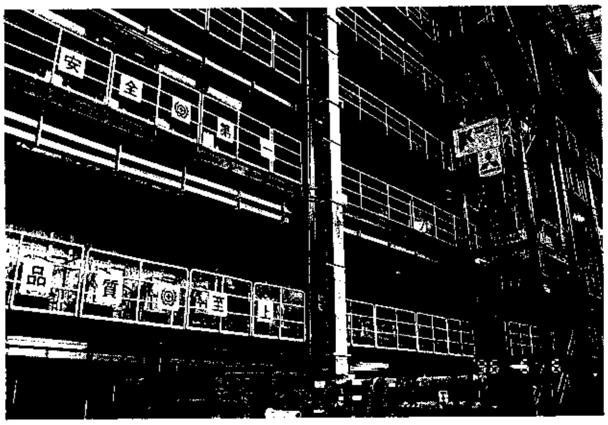

Photo 2 CAL

Table 2 Main specifications of CAL

Item		Specification
Strip thickness	(mm)	0.17 ~ 0.60
Strip width	(mm)	600 ~ 1 220
Capacity	(t/month)	35 500
Entry section speed	(mpm)	Max. 960
Furnace section speed	(mpm)	Max. 800
Deliyery section speed	(mpm)	Max. 1 040

4.2.2 Equipment composition

The general composition of the CAL is shown in **Fig. 6**.

4.2.3 Main specifications

The main specifications of the CAL are shown in **Table 2**.

4.2.4 System configuration

The system configuration is basically the same as PL-TCM shown in Fig. 5 and the system is composed of an H/C, P/Cs and PLCs.

4.2.5 Features of Furnace Equipment

The furnace section is composed of the preheating section, heating section, soaking section, No. 1 cooling section, No. 2 cooling section, No. 3 cooling section and water cooling device.

The No. 1 cooling section contains rapid cooling equipment and the No. 2 cooling section is provided with overaging equipment, making it possible to produce TMBP of both low and high temper grades, depending on the heat cycle.[5]

4.2.6 Features of delivery equipment

The delivery equipment is composed of finishing facilities such as the skinpass mill, trimmer and oiler. The main specifications of the skinpass mill are shown in **Table 3**.

The skinpass mill is provided with strong benders to produce the good strip shape required of TMBP. This mill is also equipped with a forced oil lubrication system for backup roll bearings, and water-cooled work-roll

Table 3 Main specifications of skinpass mill

Item		Specification
Mill type		4 Hi 2 stand
Work roll diameter	(mm)	500 ~ 550
Backup roll diameter	(mm)	1 200 ~ 1 300
Motor power No.1 stand	(kW)	600
Motor power No.2 stand	(kW)	900
Rolling force	(t/Stand)	Max. 1 300
Bending force	(t/Chock)	−30 ~ +60

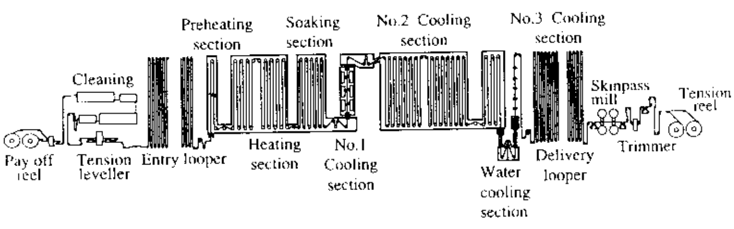

Fig. 6 Outline of CAL

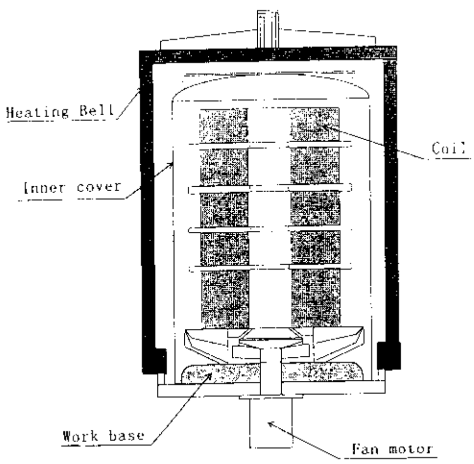

Fig. 7 Outline of batch annealing furnace

Table 4 Main specifications of BAF

Item		Specification
Strip thickness	(mm)	0.17 ~ 0.60
Strip width	(mm)	600 ~ 1 220
Capacity	(t/month)	17 750
Coil stack height	(mm)	4 500
Maximum net charge	(t)	120

chocks to protect against thermal crowns.

4.3 Batch Annealing Furnace (BAF)

4.3.1 Outline

The batch annealing furnace produces TMBP of low temper grade from coils which have passed through the ECL. These furnace are composed of 10 heating bells and 20 bases. The atmosphere in these furnace is 100% H_2 gas and the cycle time from heating to cooling is about half that of conventional HN gas annealing. The adoption of this type is very effective in quality improvement because the temperature distribution toward the circumference is uniform.

4.3.2 Equipment composition

The section of the BAF is shown in **Fig. 7**.

4.3.3 Main specifications

The main specifications of this furnace are shown in **Table 4**.

4.3.4 System configuration

The system configuration is the same as with PL-TCM and the system is composed of an H/C, P/Cs and PLCs. The annealing furnace permits centralized control from the CRTs in the control room. Unlike the systems of PL-TCM, etc., when an abnormality occurs in the PLCs in this new system, the P/C performs the backup functions and continues operation.

Table 5 Main specifications of ECL

Item		Specification
Strip thickness	(mm)	0.17 ~ 0.60
Strip width	(mm)	600 ~ 1 220
Capacity	(t/month)	17 750
Line speed	(mpm)	Max. 700

Table 6 Main specifications of TPL

Item		Specification
Strip thickness	(mm)	0.17 ~ 0.60
Strip width	(mm)	600 ~ 1 220
Capacity	(t/month)	27 500
Coil weight (entry)	(t)	3 ~ 20
Coil weight (delivery)	(t)	3 ~ 20
Line speed	(mpm)	Max. 1 400

Table 7 Main specifications of CPL

Item		Specification
Strip thickness	(mm)	0.17 ~ 0.60
Strip width	(mm)	600 ~ 1 220
Capacity	(t/month)	27 500
Coil weight (entry)	(t)	3 ~ 20
Coil weight (delivery)	(t)	3 ~ 20
Line speed	(mpm)	Max. 1 000

Table 8 Main specifications of PAL

Item		Specification
Capacity	(coils/hour)	10
Packing conveyor speed	(mpm)	10
Packing conveyor skid	(positions)	16

4.4 Other Production Facilities

The main specifications of the ECL (electrolytic cleaning line), TPL (temper and processing line), CPL (coil preparation line) and PAL (packing line) are shown in **Tables 5** to **8**, respectively.

4.5 Ancillary Equipment

The main specifications of the water treatment equipment are shown in **Table 9** and those of the acid regeneration plant are shown in **Table 10**.

4.6 Production Control System

The scope of the present production control system includes not only the computer system function for operating the ultramodern plant, but also the organizational

Table 9 Main specifications of water treatment equipment

System & main component	Capacity	Specification
Water treatment & supply system	Industrial water treatment (m³/h)	250
	Potable water treatment (m³/h)	50
	Softened water treatment (m³/h)	90
	Demineralized water treatment (m³/h)	160
Indirect cooling water recirculation system	Cooling Tower (m³/h)	2 500
	Supply pump for BAF, CAL (m³/h)	1 500
	Supply pump for others (m³/h)	950
	Supply pump for emergency (m³/h)	250
TCM Direct cooling water recirculation system · Double stage flotation · Cooling tower · Ozone disinfection · Auto strainer filtration	Recirculation water (m³/h)	1 200
Oily/Cleaning waste water treatment system (m³/h) · Flocculation & flotation · Contact aeration		Max. 155
Acidic waste water treatment system (m³/h) · Surface aeration oxidation · Flocculation & sedimentation · Sand filtration		Max. 280 (combined with the above treated water)
Dewatering system	Inorganic sludge dewatering (decanta centrifugal type)	319 kg-DS/h × 2 sets
	Oily scum dewatering (multiple rotating disc type)	465 kg-(DS + oil)/h × 2 sets
Palm oil regeneration system	Palm oil regeneration (m³/h)	4.5
	Fatty acid recovery (m³/h)	2.4

Table 10 Main specifications of acid regeneration plant

Item		Specification
Acid composition after regeneration	Concentration (wt%)	16 ~ 19
	Total-Fe composition (wt%)	Max. 0.7

system, job design, standards for plant operation, etc.

4.6.1 Computer system configuration

The computer system configuration is shown in **Fig. 8**. The basic concepts of computer system design is described below.

(1) The computer system configuration should have good unity with the existing operating computer system (ETL).
(2) UNIX, which is excellent in openness, etc., is used.
(3) Distribution is made to multiple computer systems to increase the processing efficiency and dilute risks.
(4) Hot standby is used in the hardware configuration to cope with hardware problems.
(5) LAN (local area network), which permits high-speed data transmission, is used.
(6) Techniques developed at Kawasaki Steel (K4GL, VICS) are used for development support and communication software.

4.6.2 Computer system functions

The computer system provides a wide range of functions, from order entry to operation and shipping. It is simple and clear so that even newcomers can manage the ultramodern plant. Furthermore, the configuration is such that beginners scarcely make mistakes and can support stable operation. After the appropriate standards were established, computer system development in which maintainability is considered was carried out.

5 Training

The TMBP plant is operated and managed mostly by inexperienced persons although some of the operators do have experience with the operation and management of the ETL. A detailed training program was therefore established and implemented from the start to realize early start-up and stable operation. In order to obtain the maximum efficiency from training in as short a period as possible, well-balanced and timely theoretical and practical training using actual equipment was carried out. The training conducted until just before the commissioning is shown in **Table 11**. The practical training at Kawasaki Steel for 255 man-months and practical training at Ton Yi Industries were completed by the time of commissioning. After the start of the trial run, not only training using actual equipment, but also theoretical training was carried out so that operators could become

Table 11 Outline of training

Training items		man × month
Operation and quality training (to operator)		70
Maintenance training (to mechanical engineer, electrical engineer and instrumentation engineer)		30
Production control system training	Actual production control system	45
	System training	40
Mechanical and electrical training by maker		70
Total		255

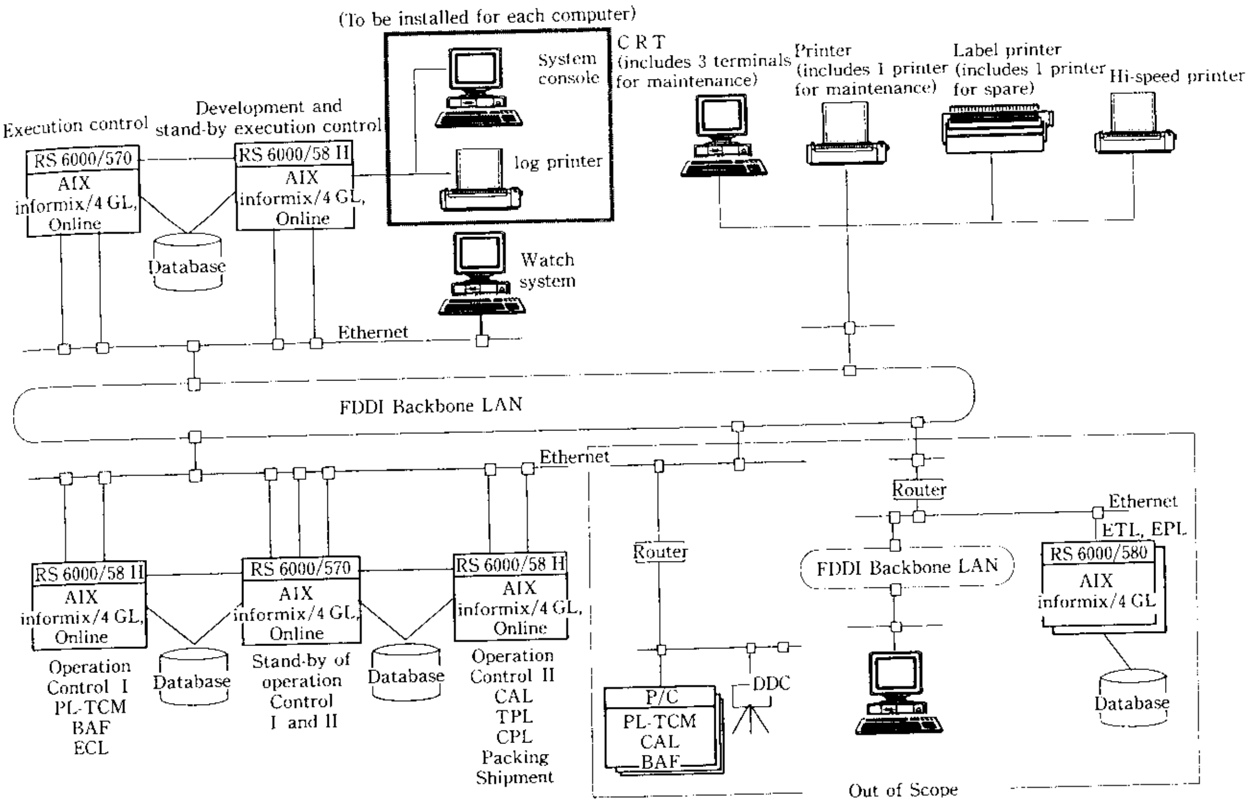

Fig. 8 Hardware configuration

skilled more quickly.

6 Conclusions

TMBP is one of the most difficult cold-rolled steel strips to manufacture because strict dimensional accuracy, high strip surface cleanliness and good strip flatness are required in its applications. This TMBP plant, which produces only TMBP, was completed in a very short period of 32 months after the issue of a L/I and 30 months after the start of construction. The main reasons for this short construction period of such a large-scale plant of high-quality TMBP are summarized below:

(1) Optimum plant layout and equipment design were achieved based on a high level of expertise.

(2) Efficient construction work was executed owing to the total engineering capability in which overall technical capability for construction work was combined with the technical capability related to equipment.

(3) The commissioning period was shortened by increasing the quality inspection accuracy of equipment and software before shipment.

(4) Ton Yi Industries' excellent staff was thoroughly trained in Japan and Taiwan.

(5) Kawasaki Steel was able to work closely with Ton Yi Industries.

7 Acknowledgments

This project was carried out with guidance from Mr. Shing Chi Liang, president of Ton Yi Industrial Corp. and the eagerness and cooperation of the staff of Ton Yi Industrial Corp. There was also backup and careful consideration given by Japanese and foreign equipment suppliers and local companies in Taiwan. Therefore, we would like to extend our sincere thanks to all of these companies and people.

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