KAWASAKI STEEL TECHNICAL REPORT
No.15 (October 1986)

Automatic Operations of Continuous Pickling Line

Hideo Toyosaka, Hikosaku Matsunaga, Hirokatsu Suzuki, Mitsuyoshi Sonoyama, Haruyuki Nada, Hideaki Katagiri

Synopsis :
At Chiba Works, a new pickling line was installed as an extension to the No.1 hot strip mill and started operation in November 1984. It has a nominal capacity of 112 000 t/month with a rated capacity of 175 t/h. Features which distinguish this line from conventional pickling facilities include a mechanical descaling system, a new pickling tank, a carrousel tension reel and other automatic facilities. This line adopted a mechanical descaling system, in which scale breaking and removal are done by tension leveler and brush to save acid consumption ratio and improve strip flatness. Administration of the entry coil storage yard and the scheduling of pickling commands are automatically controlled and also combined with the pickling line operations. The computer network of a hierarchy system is adopted from the entry of the coil storage yard to the pickling line, which means fully automatic operations, high quality products and high labor productivity.

The body can be viewed from the next page.

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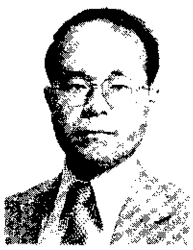
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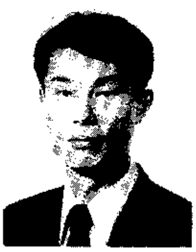
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Synopsis:

At Chiba Works, a new pickling line was installed as an extension to the No. 1 hot strip mill and started operation in November 1984. It has a nominal capacity of 112 000 t/month with a rated capacity of 175 t/h. Features which distinguish this line from conventional pickling facilities include a mechanical descaling system, a new pickling tank, a carrousel tension reel and other automatic facilities. This line adopted a mechanical descaling system, in which scale breaking and removal are done by tension leveller and brush to save acid consumption ratio and improve strip flatness. Administration of the entry coil storage yard and the scheduling of pickling commands are automatically controlled and also combined with the pickling line operations. The computer network of a hierarchy system is adopted from the entry of the coil storage yard to the pickling line, which means fully automatic operations, high quality products and high labor productivity.

1 Introduction

Kawasaki Steel, at its Chiba Works, constructed a new pickling line incorporating mechanical descaling[1] and up-to-date automation techniques with the aim of greatly improving the quality of descaled wide strip to cope with users' demands for higher quality in high-grade surface-treated steel sheets including galvanized and tin-free steel sheets. The new line was commissioned in November 1984.

The new pickling line permits complete descaling and highly-efficient multi-kind and small-lot production, achieving syncronization with plural tandem cold mills in the succeeding process, thereby making possible high quality assurance. For this purpose, all pre-pickling line operations have been fully automated so that coils are processed and supplied on a timely basis in accordance with the subsequent cold rolling sequence. The operations of the pickling line itself were also fully automated by providing the line with DDCs incorporating CRT units having an intelligent function, ensuring satisfactory man-machine interface.

This paper reports on the automated operation of the system and presents an outline of the facilities.

2 Outline of Facilities

2.1 General Layout of Line

2.1.1 Layout of facilities

The general layout of the facilities is shown in **Fig. 1**. At the entry side of the pickling line is a yard where hot coils are cooled and stored. This yard is provided with coil automatic transportation system (CATS), a loop-rail, which has an automatic storage function for receiving and supplying coil. Coils are supplied from this CATS to the pickling line by a loop car and automatic shifter.

2.1.2 Configuration of pickling line

Configuration of the new pickling line is shown in **Fig. 2**. Features of this line include the addition of a

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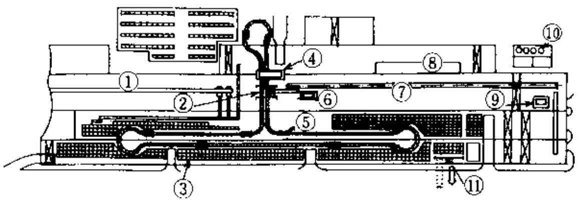
mechanical descaler comprised of a mechanical brush and tension leveler. New devices such as a flying shear and carrousel tension reel have also been adopted at the coil delivery side.



① Hot mill line
② Coil shifter
③ Hot coil storage area
④ Yard control pulpit
⑤ Coil car
⑥ Entry pulpit
⑦ Pickling line
⑧ Electric room
⑨ Delivery pulpit
⑩ Acid storage
⑪ Tandem cold mill

Fig. 1 Located layout of new pickling line

2.2 Pickling Line Specification

Main specifications of the line are shown in **Table 1.** The entry-side coil specification is set to 1 400 PIW (pound per inch width; 25 t/m-wide) to permit system expansion from the existing 1 000 PIW. To cope with the current processing capacity, a tank section speed of 260 m/min is sufficient, but to prepare for future increases in the processing capacity, the tank section speed has been set to 330 m/min. The total length of the line is about 50 m shorter than that of a conventional pickling line of the same scale.

2.3 Specification of Coil Transportation System

The specifications of the coil car are shown in **Table 2.** The coil car has been designed to travel on flangeless wheels on two rails without guide rails and have a turning radius of 10 m and a stopping accuracy of ±50 mm.

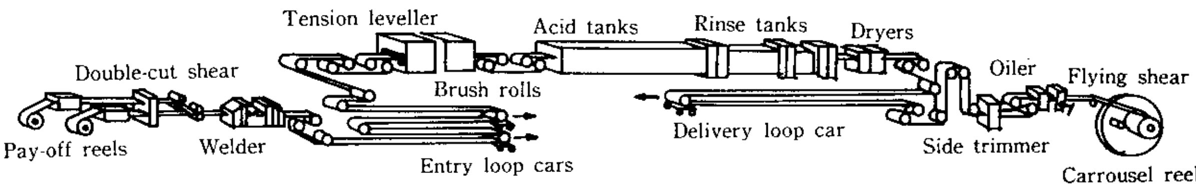


Fig. 2 Schematic diagram of new pickling line

Table 1 Main specifications of new pickling line

Start-up date			Nov. 1984
Capacity (t/month)			112 000 (139 000 max)
Strip	Thickness (mm)		1.8～4.5
	Width (mm)		600～1 310
	Max. yield strength (kg/mm²)		36
Coil size	Entry	inside dia (mm)	762 / 610
		max. outside dia (mm)	2 200
		max. weight (t)	32.5
	Delivery	inside dia (mm)	610 / 762
		max. outside dia (mm)	2 400
		max. weight (t)	28.0
Max. line speed (m.p.m)	Entry section		600
	Tank section		330
	Delivery section		400
Strip accumulator	Entry (m)		500
	Delivery (m)		250
Acid treatment			HCl
Line length (m)			228

Table 2 Specifications of coil car

Coil car	Carrying coil	Max. weight	32.5 t
		Width	600～1 310 mm
		Outside dia	914～2 200 mm
		Max. temperature	700°C
	Running speed		100 m.p.m
	Drive motor		22 kW × 1 AC 400 V 3φ
	Wheel dia		800 mm
	Min. revolution radius		4.0 m
	Dead weight		21 t
	Accuracy of car stop		±50 mm
	Rail gauge		1400 mm
	Rail size		JIS 60 kg/m
	Length of rail circle		738 m
	Numbers		8
Process computer			PFU-1500 II
Coil car controller			CP 320

3 Features of Automated Facilities

3.1 Automation of Coil Handling

3.1.1 Coil handling

A schematic diagram of coil handling flow is shown in **Fig. 3**. Hot coil, which has been transported from the upstream process of the hot strip mill by forklift or trailer, is received by the overhead traveling crane (manually operated) and is temporarily stored and cooled at a specified place in the hot coil storage area shown in Fig. 1. Cooled coil is loaded by crane onto the loop car for transport to the entry side of the pickling line and shifted by the shifter. All these operations are effected fully automatically; the entire system is called "CATS."

3.1.2 CATS system configuration

System configuration is shown in **Fig. 4**. This system consists of minicomputers for information processing, yard control, and main control operations and two DDCs for loop car control. The system performs address control of the coil storage yard, guidance of crane and forklift operators, and scheduling of coil receipt and issuance.

3.1.3 System operation

A view of the yeard control pulpit is shown in **Photo 1**. Operating instructions for coil handling are given in a unified manner by information from the production control computer. In the control pulpit, only a single operator using graphic display devices is required to monitor the automated operation system.

3.2 Automation of Pickling Line

3.2.1 Coil preparation facilities

Figure 5 shows coil preparation facilities installed at the entry side; these consist of the following units:

(1) Coil center offset detector[2,3] used when a coil on the loop car is loaded onto the walking-beam conveyor by the shifter.
(2) Coil top-end detector used for opening the top and end of the coil on the pay-off reel.
(3) Band position detector for cutting and removing the band binding the coil; a band cutter consisting of a skid shifter, cutter, and reeler.

3.2.2 Automatic coil threading

Opening of the coil top-end on the pay-off reel is performed by controlling the drum rotation angle on the basis of the above-mentioned coil top-end detection signal. A coil with its top-end opened by the coil top-end opener is sent to the pinch roll leveler and then to the crop shear. The No. 1 pay-off reel is provided with a grip transfer-car to prevent the top-end of strip from

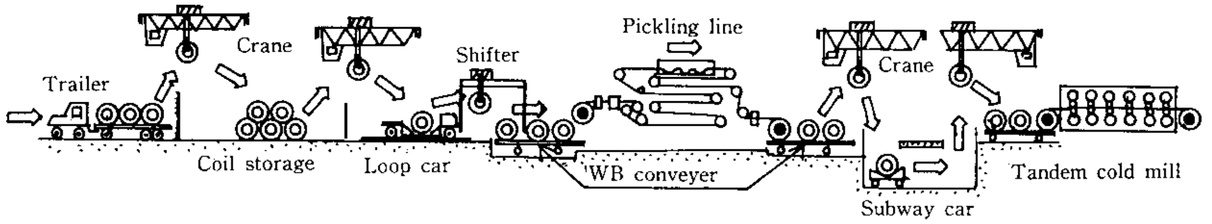


Fig. 3 Material handling flow from coil storage yard to tandem cold rolling

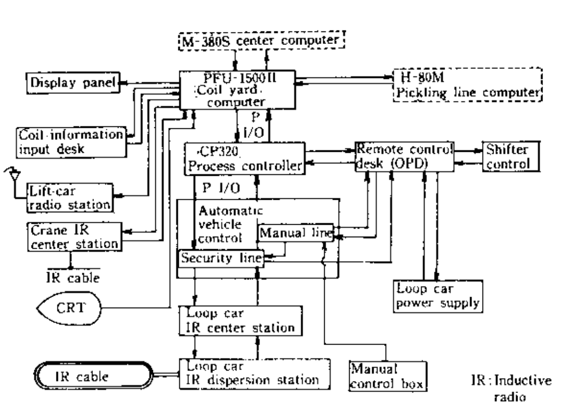


Fig. 4 Configuration of CATS

Photo 1 View of yard control pulpit

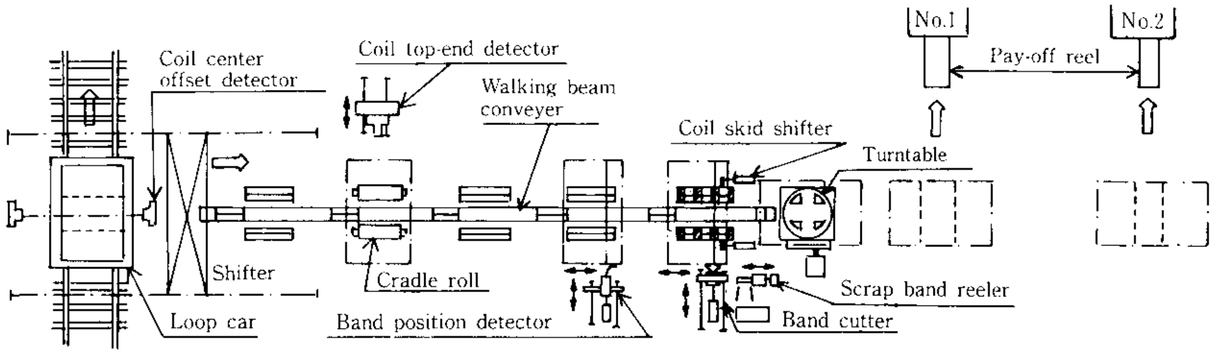


Fig. 5 Facilities for coil preparation on entry side

becoming caught, which may occur due to the long distance between the No. 1 pay-off reel to the crop shear. The crop shear cuts the coil end in a predetermined manner; crops are rejected to the outside of the line by the shifter and conveyor. A series of such operations is performed fully automatically.[4)]

3.2.3 Control of acid tank

A schematic diagram of hydrochloric acid and iron concentration control is shown in **Fig. 6**. Successful examples of automatic control of hydrochloric acid and iron chloride in the acid tank are very rare, but the Chiba Works succeeded in controlling hydrochloric acid and iron chloride concentrations by improvements based on the operation records of the No. 5 pickling line of the Chiba Works. For the acid tank, a new, non-strip-lifter type of variant-length acid tank[5)] has been adopted to prevent acid fume leakage and to stabilize catenary control. When the line stops operation, strip in the acid tank is lifted by the tension pad.[6)]

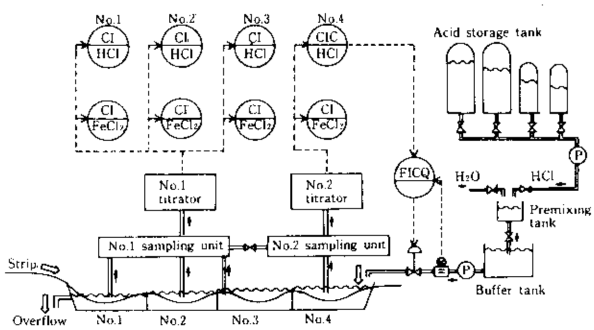


Fig. 6 Control of concentration of hydrochloric acid and iron

3.2.4 Strip guide at side trimmer

The strip centering device at the side trimmer is shown in **Fig. 7**. Conventional pickling lines are frequently provided with a free loop at the side trimmer, but the new pickling line has been equipped with a tight tension system, achieving centering improvement in the trimmer by coordination between the entry guide[7,8,9)] and steering roll. As a result, occurrences of trimming miss and edge problems have become less frequent. The adoption of the high stiffness trimmer has improved the trimmed edge shape, thereby allowing realization of high-speed trimming (400 m/min).

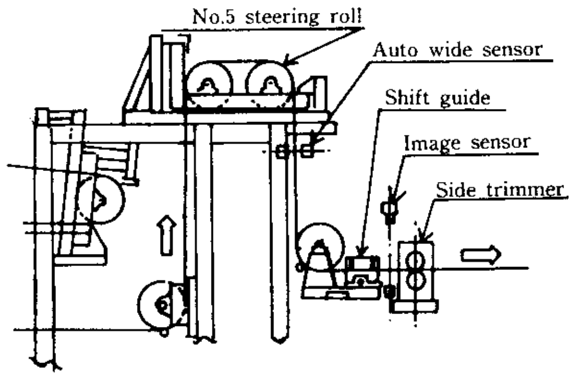


Fig. 7 Guiding of strip at side trimmer

3.2.5 Automatic coiling by tension reel

The tension reel is shown in **Fig. 8**. Through the use of the carrousel tension reel[10)] and flying shear, a series of operations including strip division, crop cutting, sample cutting, and strip-dividing point control has

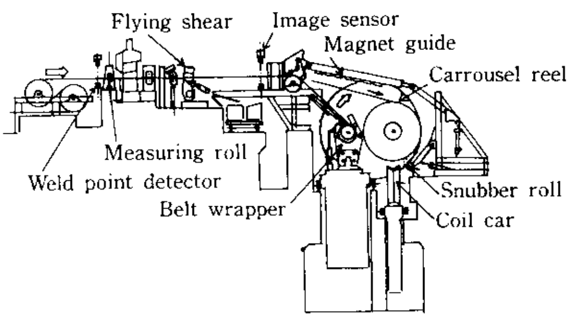


Fig. 8 Automatic coiling

been fully automated.

3.3 Fully-Automated Operation System

3.3.1 Computer network

The computer network, shown in **Fig. 9**, is a hierachy system, consisting of the following units:

(1) Host business computer for production control
(2) Minicomputers for coil yard control and line operation
(3) DDCs for line control[11)]

3.3.2 Minicomputers for line operation

A schematic diagram of functions of the pickling line computer system is shown in **Fig. 10**. The system mainly performs coil tracking in the line and presetting of line control values, together with control, monitoring, and data logging for the general instrumentation and automating equipment.

3.3.3 Line-controlling DDC system

A schematic diagram of DDC system functions is shown in **Fig. 11**. This system automatically controls equipment and facilities ranging from the entry to the delivery side using operational signals from line-operation minicomputers. In this system strip is macroscopically tracked under the division of the pickling line into five zone, and also microscopically tracked with the measurement of strip length from the welder as a point

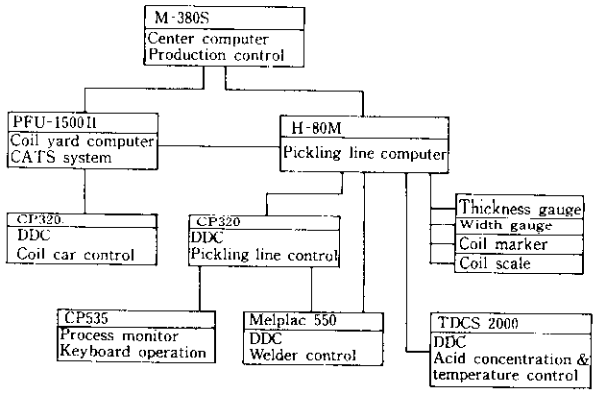


Fig. 9 Block diagram of computer control system

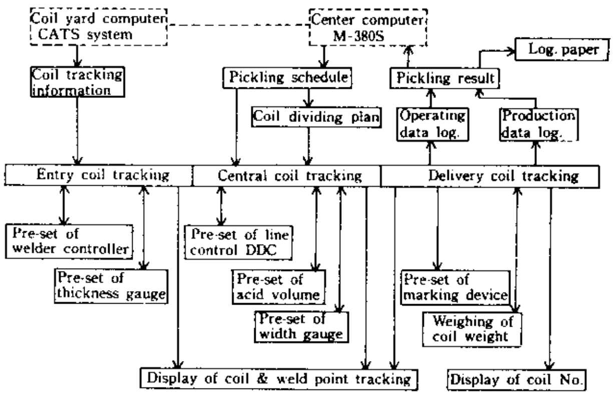
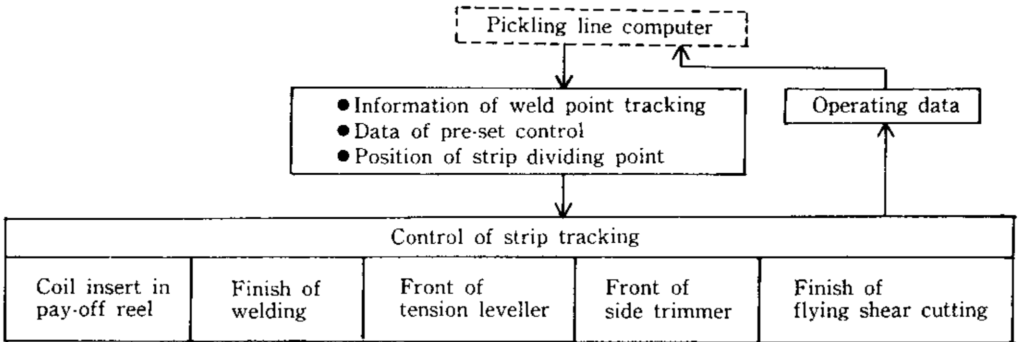


Fig. 10 Function of pickling line computer control system



Position control	● Pinch roll leveller ● Shear side guide	● No.3 pinch roll side guide	● Breaker roll ● Leveller roll ● Mech-brush roll ● Rinse-brush roll	● Trimmer guide & knife set ● Chopper width ● Masher roll width ● Oiler width	
Tension control	Pay-off reel	Entry loop car	Tension leveller	Delivery loop car	Tension reel
Speed control		● Recoiling ● Threading	● Descaling ● Weld point pass		● Coiling ● Threading
Others control	Crop cut number		TL quick open TL elongation		● Shear cut point

TL: Tension leveller

Fig. 11 Function of pickling line DDC system

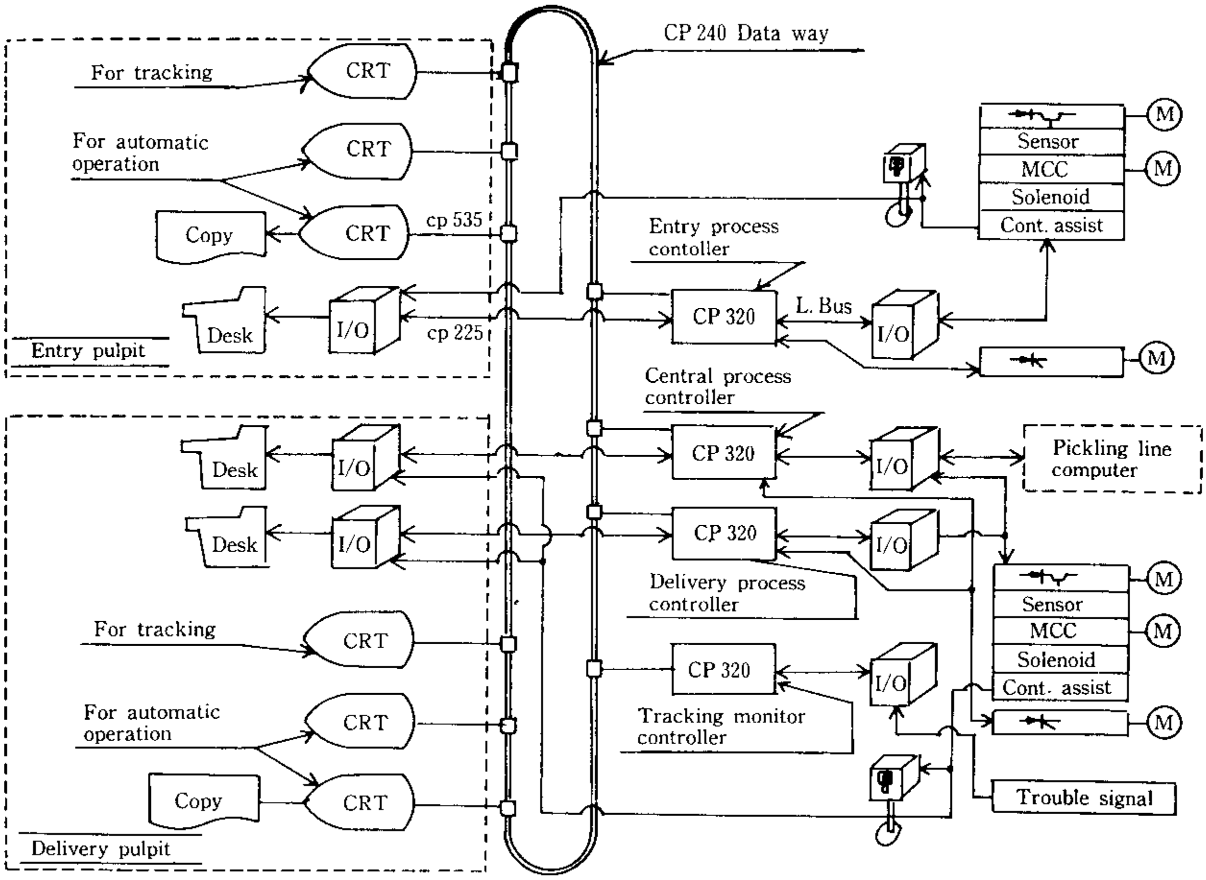


Fig. 12 Control system of pickling line

of reference. In this manner fail-safe, high-accuracy control is ensured.

3.3.4 Improvement in man-machine interface

The CRT operation system is shown in **Fig. 12**. CRT display units installed at control pulpits on both the entry and delivery sides perform operation control and monitoring. CRT operation functions are:

(1) Weld point tracking
(2) Automatic sequence control
(3) Automatic operation interlock
(4) Operation go-stop
(5) Present and actual operation data
(6) Sensor function and sequence control time-overrun checks
(7) Main equipment control condition monitoring
(8) Electric unit malfunction warning
(9) Hydraulic and mechanical unit malfunction warning

CRT display units in the pulpit at the entry side are shown in **Photo 2**.

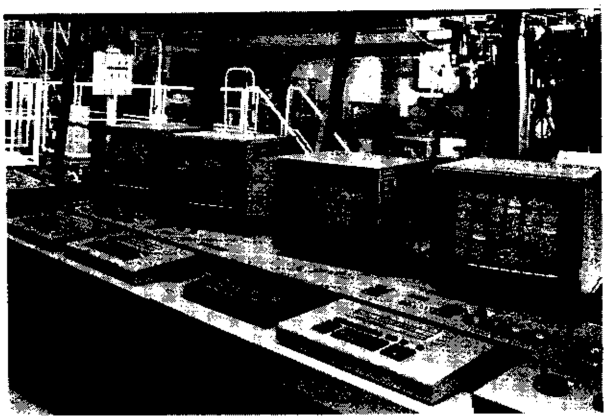


Photo 2 View of entry pulpit

4 Operation Records

Since its commissioning at the Chiba Works in November 1984, production at the new pickling line has smoothly expanded and the manufacture of high quality products at stabilized high efficiency levels has been realized, operation records as described below concern production results and the benefits of automation.

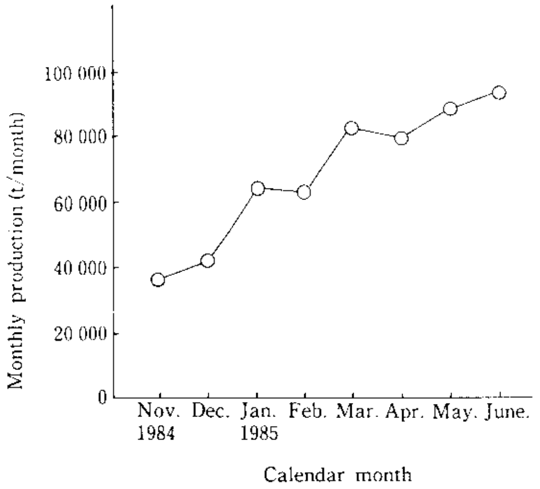


Fig. 13 Start-up performance of monthly production

4.1 Production

Monthly production at the new pickling line, shown in **Fig. 13**, reached a level of 100 000 t/month in June 1985, achieving the initially-planned target. The mean size of processed materials, 2.2 mm t × 870 mm W, and operation efficiency, 154 t/h, are among the best for Japanese steelmakers.

4.2 Results of Automation

Adoption of automation has greatly contributed to manpower rationalization and improvement of product quality. The number of operators at a conventional pickling line was 7 to 10 per shift, but the new line is operated by 3 per shift. In terms of quality improvement, the following favorable results have been obtained:

(1) Decrease in the number of surface defects as a result of coil handling automation.
(2) Decrease in micro-slip defects, due to stabilization of tension balance by ASR control and non-slip control of the bridle roll.
(3) Improvement in descaling and flatness through the use of tension leveler and mechanical brush equipment.
(4) Improvement in sectional shape of the strip edge through the use of the high-stiffness trimmer and improvements in strip centering.

5 Conclusion

The system and facilities for automation of the new continuous pickling line have been reviewed. Both system and facilities for automatic operation demonstrated their effectiveness immediately upon commissioning and production has smoothly increased, resulting in highly-efficient, stabilized manufacture of high-quality products with a smaller number of operators. In the future, efforts will be made to further improve the automation ratio, and 2-man-per-shift operation will be introduced. Because customers' demands for surface treated steel sheets will become ever more diversified and quality-oriented, even if multikind and small-lot operation is introduced, it is foreseen that functions for stabilized production in good time and at minimum cost will be essential. Accordingly, the authors intend to continue efforts for further technical development and operational improvement in the future.

Finally, the authors express their deep appreciation to concerned staff of Hitachi, Ltd., Yaskawa Electric Mfg. Co., Ltd., and Kawasaki Heavy Industries, Ltd. for their design and manufacture of main components of the present facilities and for their valuable cooperation in the course of the facility construction.

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