Equipment of New Ultra-High Speed Continuous Annealing Line for Tin Mill Black Plates*

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1 Introduction

Recently, customer demand for quality of the tinplate and the tin-free steel used for beverage cans, etc., has been increasing. Reduction of the thickness of sheet steel is being enthusiastically promoted as it leads to cost reduction in the can production process and consequently achieves energy conservation. The establishment of a highly effective production technique for thin tin mill black plates, however, is indispensable to prevent decreases in productivity and increases in energy costs which may be caused due to the reduction of the thickness in process lines like the continuous annealing line (CAL). The No. 4 continuous annealing line (No. 4 CAL) was installed in the Chiba Works as a continuous annealing line by which the tin mill black plates of all temper grades can be produced highly efficiently from the single line.[1-3] In this report, the highly efficient production of thin steel sheets using the continuous annealing line is introduced and the economic effect and recent operation results of the introduction of this line are reported.

2 Outline of the Equipment

The characteristics of No. 4 CAL are that ultra thin sheet steel of 0.15 mm can be continuously annealed at the world highest speed of 1 000 m/min and the tin mill black plates of all tempering grades can be made into products (CAL finishing) from a single line by using low and ultra-low carbon steel. The main specifications of No. 4 CAL are shown in **Table 1**. This line is mainly composed of the entry side equiment including electrolytic cleaning and Ni plating equipment, and exit side equipment for finishing including the annealing furnace, the multiple temper mill, the trimmer, and the oiler. **Figure 1** shows the layout of the entire line.

Table 1 Main specification of No. 4 CAL

Strip	Thickness		(mm)	0.15 ~ 0.40
	Width		(mm)	600 ~ 1 067
Coil	Max. weight		(t)	22
	Inner diameter	Entry	(mm)	419, 508
		Exit	(mm)	406, 419, 508
Maximum speed	Entry		(m/min)	1 200
	Furnace		(m/min)	1 000
	Delivery		(m/min)	1 400
Furnace capacity			(t/h)	100

3 High-Speed Stable Threading Technology for Sheet Steel in Furnaces

Mis-tracking of sheet steel on the conveying rolls is a major problem in high-speed sheet steel conveying. Although it can be prevented by increasing the centering force on the roll, i.e. by enlarging the roll crown and increasing the strip tension, this remedy may cause the sheet steel to buckle more easily in the furnace. Especially, troublesome is the buckling of ultra-thin sheet steel and ultra-low carbon steel. The mis-tracking and buckling of the sheet steel were essentially related to antinomy, so the following technologies were developed to solve these problems.

(1) Optimum Design of Roll Crown in a Furnace

A model to forecast accurately the critical conditions of roll crown and sheet steel tension for buckling was developed. **Figure 2** shows the results of actual operation using the mathematical formula of critical tension for buckling derived from this model, which can accurately forecast buckling. The roll crown, which

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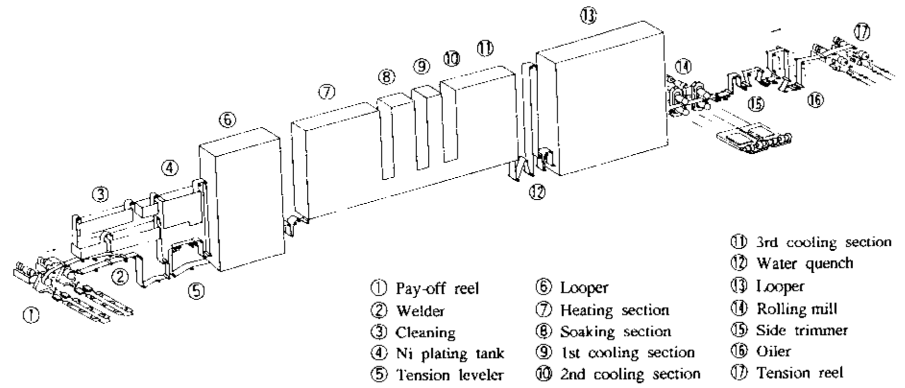

Fig. 1 Layout of No. 4 CAL

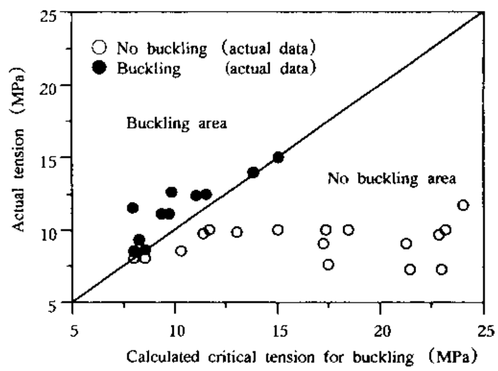

Fig. 2 Relation between actual tension and calculated critical tension for buckling

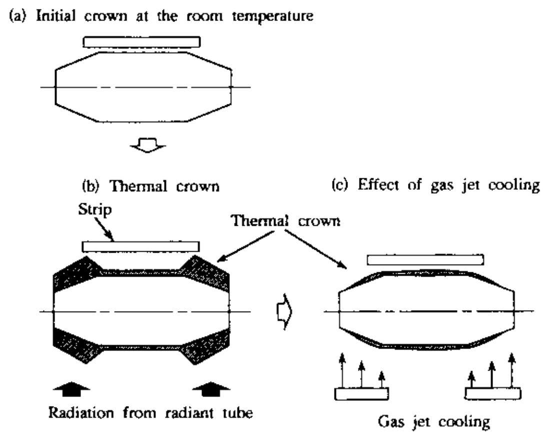

Fig. 3 Schematic diagram of roll thermal crown control in furnace

can maximize the centering force without causing buckling even for the ultra-low carbon steel of 0.15 mm in thickness, has been designed using this model.

(2) The Optimum Surface Roughness Design of the Roll in a Furnace

The floating-up phenomenon of sheet steel with the fluid layer rolled in between the sheet steel and the roll cannot be disregarded since this easily leads to slipping when the threading speed of sheet steel increases. Thus, a suitable roll for high-speed operation in furnace with a roll surface roughness that can negate the influence of the thickness of the fluid layer was developed.

(3) Thermal Crown Control of the Roll in a Furnace

To prevent mis-tracking and buckling by controlling the thermal crown formed by the radiation from the radiant tubes, gas jet cooling equipment for the roll edge was installed in the roll room of the heating section. **Figure 3** shows the basics of the thermal crown control.

(4) High Accuracy Tension Control

Fluctuation of sheet steel tension at the furnace entrance on the de- and acceleration has been decreased to 1/5 compared with past fluctuation by developing a high function vector inverter and a low inertia and high response tension device to thoroughly prevent slipping and other problems caused by this fluctuation of tension, which is one of the major factors causing mis-tracking and buckling under high speed.

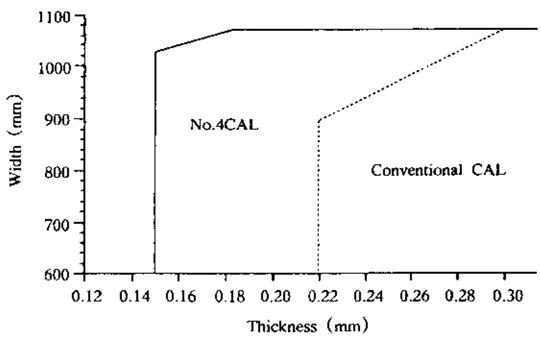

Fig. 4 Stable threading region without buckling for ultra low carbon steel in No. 4 CAL and in conventional CAL

Figure 4 shows that the stable threading region in the furnace for ultra low carbon steel has been expanded greatly as a result of the above-mentioned new techcology introduction.

4 Automation Technology

Intensive automation is indispensable to operate process equipments consisting of electrolytic cleaning, annealing, temper rolling, the finishing which are continuously connected, stably and at high speeds with a small number of operators. Thus, the items shown in **Table 2** including the coil handling and the incidental work which has been especially insufficient, were automated. Moreover, conditions necessary for operating the line are automatically set by organically connecting various controllers including the electrical DDC, the instrumentation DDC, and the shape control DDC with the central process computer as shown in **Fig. 5**. As a result, steady CAL finishing became possible in a single line of multiple connected processes.

Table 2 Main automated items

Section	Item	Contents
Entry	Coil handling	Band cutting Coil insertion in reel Diameter change of reel Top/end reject and threading
	Sleeve handling	Drawing out and removal
	Scrap handling	Conveying to outdoor scrap bag
Furnace	Strip temperature control	Furnace temperature calculation Cooling condition calculation
Mill	Rolling condition control	Rolling force and tension calculation Flatness control
	Work roll handling	Shuttle transporter Automatic crane Work roll changer
Delivery	Side trimmer	Flying width change Reject of width changing portion
	Oiler	Change of kinds of oil
	Products finishing	Coil dividing Quality assurance Coil tail end stopping Weld marker insertion Sleeve handling and insertion in reel Diameter change of reel Drawing out of coil ID marker Coil insertion at inspection line
	Scrap handling	Conveying scrap to outdoor scrap bag

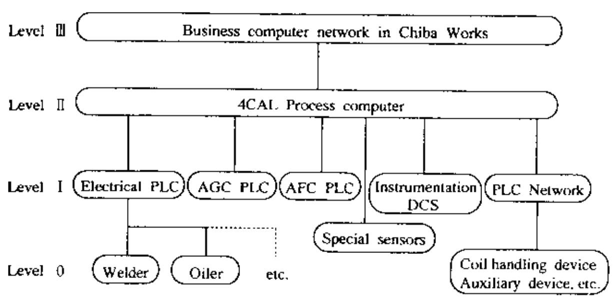

Fig. 5 System configuration of No. 4 CAL

5 Operation Record

Figure 6 shows the changes in production since operation started and **Table 3** shows the operating record and the strip break frequence in 1995. Moreover, **Fig. 7**, which compares the production yield with the conventional process, shows the yield has been remarkably improved as a result of integrating the production process.

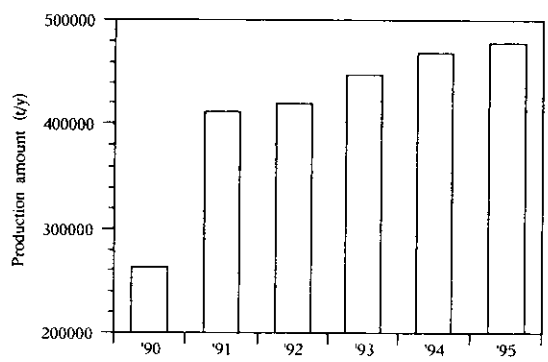

Fig. 6 Production record of No. 4 CAL

Table 3 Operation record of No. 4 CAL in 1995

Item	Record
Operating ratio	96.2%
Strip break in the furnace	0.2 times/month
Strip break out of the furnace	1.8 times/month

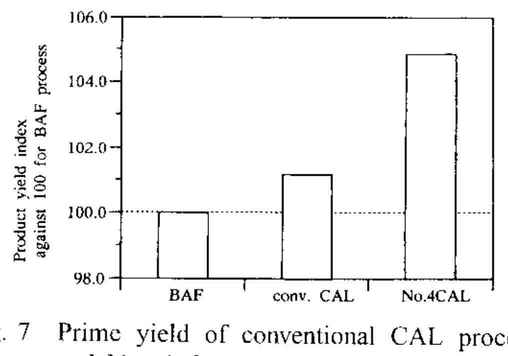

Fig. 7 Prime yield of conventional CAL process and No. 4 CAL in comparison with batch annealing furnace process

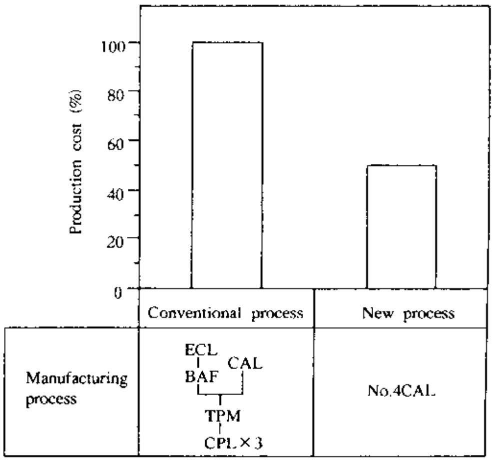

Fig. 8 Comparison of production cost in conventional process and new process

6 Economic Effect

Figure 8 shows a comparison of the costs of the new system with the conventional costs. Production costs from electrolytic cleaning to the finishing process have been reduced by 50% due to the improvement of the production yield, the reduction of the number of workers and the reduction in maintenance and energy costs, etc., by consolidating the line. Moreover, the automation of the can production process which results in uniform product quality and thinning of the can wall, is able to help customers save resources.

7 Conclusions

The equipment of the new ultra-high speed continuous annealing line for tin mill black plates provides the newest and most powerful process to satisfy customers' increasing demand for quality. Many new technologies were developed for this construction and operation and their success has been enormous.

References

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