KAWASAKI STEEL TECHNICAL REPORT
No.34 (March 1996)
Highly Efficient Production and
Application of sheet Produts,and
Application Development in Open System's Age

Advanced Coil Packaging Line for Tinplates and TMBP Coils

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Kawasaki Steel has developed an automatic coil packaging line in No. 1 Cold Rolling Mill, Chiba Works. This line commenced its operation in 1994. Packaging products are light gauge tin plate and tin mill black plate packaged in various styles. Coil packaging for both domestic (paper packaging) and export (steel packaging) has been automated by developing facilities, such as inside paper wrapping machine and outside steel sheet wrapping machine, and by simultaneously developing new packaging style adequate for automation facilities. Furthermore, preparation of packaging materials is automated and connected to the packaging line, to pursue further efficiency. This line has succeeded to reduce the conventional heavy work load and rationalized coil packaging procedure, and has also contributed greatly to improvement of packaging quality.

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1 Introduction

Mechanization and automation technology in the steelmaking process have made remarkable progress aiming at higher product quality and productivity and greater efficiency. A notable recent event in this connection is the application of automation to the packaging of coil products, which had been considered difficult conventionally due to the numerous technical problems involved.

Kawasaki Steel actively took up the challenge of developing automation for coil packaging, and in January 1994 started up an automated packaging line at No. 1 Cold Rolling Mill and the new hot finishing mill at Chiba Works. Automation was then applied to packaging at the Cold Rolling Mill at Mizushima Works in July 1994, and to No. 2 Cold Rolling Mill at Chiba Works in January 1995.[1,2]

From among these automated coil packaging lines, this report will describe the advanced coil packaging (ACP) line at Chiba's No. 1 Cold Rolling Mill, which handles TMBP and tinplate coils, as these products require particularly complex, heavy packaging work, and will discuss the features of the automated equipment and the development of packaging specifications suited to automation.

2 Background and Aims

Tinplate and TMBP coils are the main products of Chiba Works No. 1 Cold Rolling Mill, with coils for export accounting for more than 80% of the plant's output, as shown in **Table 1**. Because of their thin gauge and the use of light coating oil on these coils, tinplate

Table 1 Products in No. 1 cold strip mill

Product type		Percentage		Packaging requirements
For export use	TMBP[a]	59	84	Steel packaging (interior: paper, exterior: steel)
	Cold	14		
	Tin plate & TFS[b]	11		
For domestic use		16		Paper packaging
Total		100		

[a]Tin mill black plate
[b]Tin free steel

* Originally published in *Kawasaki Steel Giho*, **27**(1995)3, 177–181

and TMBP as principal products of this facility require complex packaging work which emphasizes rust prevention and the prevention of defects due to handling. In addition, steel sheet wrapping is used in packaging for export, which is a heavier packaging specification than that for domestic use.

Conventional packaging work was virtually all performed manually, and packaging yards were located at the delivery end of each coil production line and were thus dispersed over a number of locations. These conditions resulted in poor labor productivity in packaging using many steel sheets, involving a heavy work load, and fluctuations in both work efficiency and packaging quality.

The ACP line was constructed to achieve labor saving in packaging work and higher efficiency, with the following specific targets:

(1) Development of packaging specifications which would make possible mechanization and automation
(2) Automation of complex packaging work up to the steel packaging stage
(3) In-line processing work such as the processing and preparation of packaging materials
(4) Development of mechanization techniques which would enable chance-free packaging

3 Development of New Packaging Specifications

Conventional packaging specification were prepared manually, and packaging was performed by joining a number of packaging materials. Because it was not possible to automate packaging simply by mechanizing the work as it existed at the time, the development of packaging specifications suited to automation and mechanization was necessary. In the construction of the ACP line, new packaging specifications were developed whereby many packaging materials could be integrated by using unitary-type packaging to reduce the number of materials and devising materials suited to automation.

Figure 1 shows the wrapping procedure used with the new packaging specification. In the paper packaging work, the inner diameter (ID) of the coil and the coil side walls are wrapped with paper containing a vaporizable rust-preventive agent. The coil outer diameter (OD) surface is also wrapped with the same type of paper, and both sides of the paper are folded at the edges. As a measure against denting during transportation, cardboard side-wall paper is applied to both sides of the coil. At this point in the packaging process, coils for domestic customers are bound with steel bands for shipment.

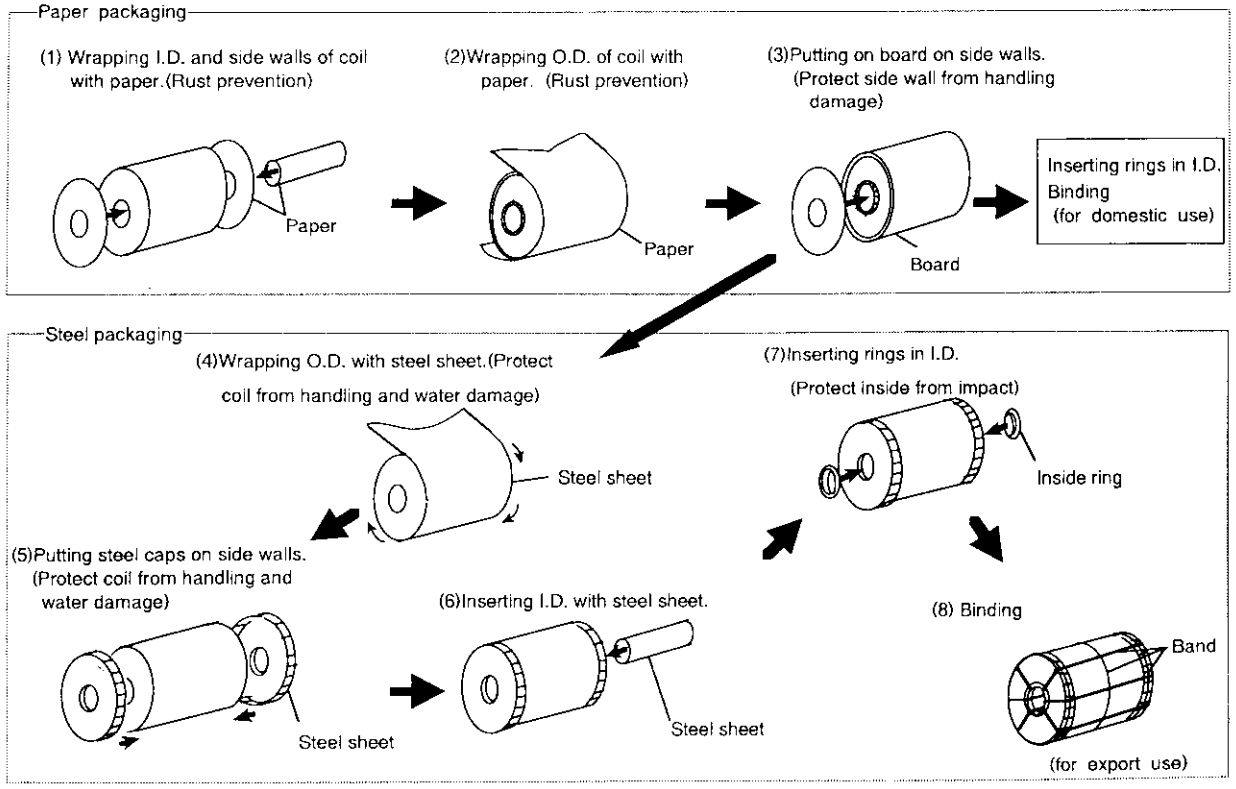

Fig. 1 Packaging procedure for colis

Coils for export are wrapped with a steel sheet over the paper wrapping to prevent damage due to water condensation, seepage of rainwater, and rough handling. The outer and inner circumferences of the coils are wrapped with steel sheets sheared to the size of the outer and inner diameter. The coil sides are also wrapped with disk-shaped steel sheets matching the size of the OD. The portion at the inner diameter is worked with a press machine, and the outer circumference is formed into a cap shape. Rings are then fitted into the inner diameter from both sides to prevent denting by hoisting gear, and the coil is bound with vertical and side bands to complete packaging for export.

4 Line Composition and Transport Equipment

4.1 Layout of ACP

As shown in **Fig. 2**, the ACP line consists of the entry side coil transfer equipment, paper packaging machine, steel packaging machine, binding machine, and the exit side transfer equipment which forwards the packaged coils to the shipping yard. The coil specifications of the line are 580~1 230 mm in width, 762~1 850 mm in outer diameter, and a maximum of 16 t in unit weight. These specifications were set up based on the size distribution of coils produced at No. 1 Cold Rolling Mill.

The packaging capacity of the line is set at a 3-min pitch based on the process requirement of 10 000 coils/month at No. 1 Cold Rolling Mill. Operation of this packaging line is carried out by a four-man crew, which includes materials supply personnel. The work performed includes monitoring of the packaging line, final inspection and acceptance of product coils, and packaging material supply.

4.2 Entry Side Coil Transfer Equipment

The entry side coil transfer equipment consists of transfer cars and a coil transfer machine. As shown in **Fig. 3**, the coil transfer equipment is directly connected to the existing production line by an automated transfer system called the advanced cold-coil express (ACE).[3]

Coils produced in each line are transferred automatically to the entry side of the packaging line, eliminating crane handling and other manual operation when coils are delivered to the packaging line. The entry side coil transfer equipment uses a system which automatically receives actual-product data and packaging specifications from the business computer and ACE and in all cases checks the actual-product data received against the physical coil. The exit side coil transfer equipment is similar to the entry side equipment in using a coil transfer device and coil transport cars, and automatically transfers the packaged coils as far as the shipping yard.

5 Development of Automatic Packaging Equipment

Table 2 shows the status of automation of each coil packaging job. The features can be summarized as follows:

(1) Full integration and automation of the paper packaging and steel packaging work into one line.
(2) In-line automation of material processing work such as cutting of inside and outside paper and outside steel sheets.

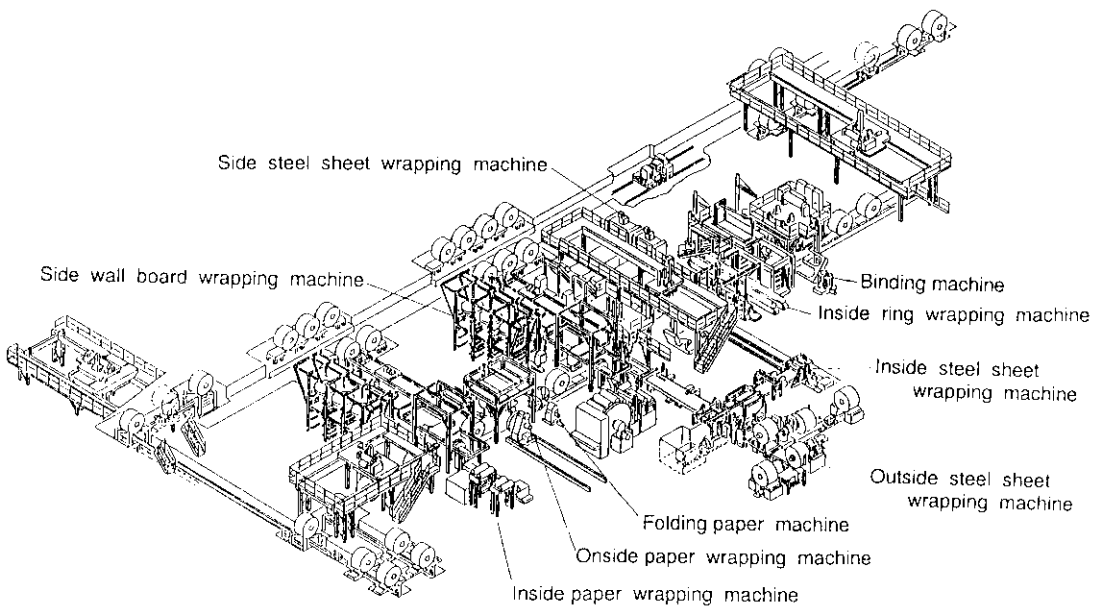

Fig. 2 Layout of ACP (advanced coil packaging line)

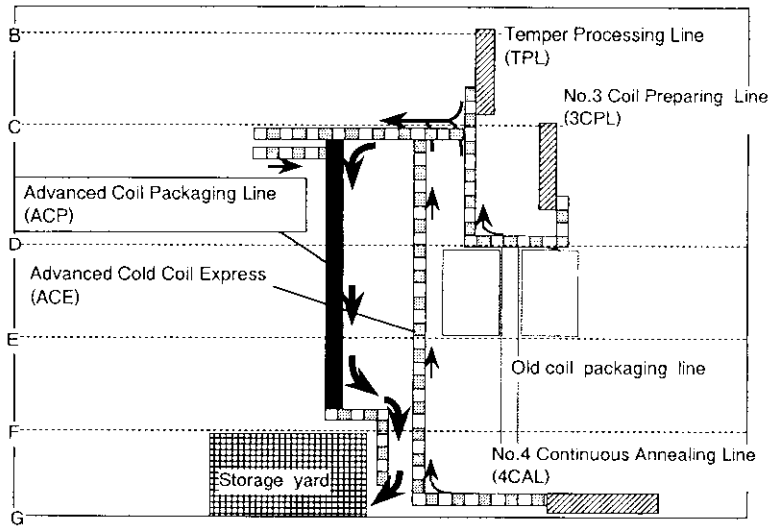

Fig. 3 Location of ACP

Table 2 Automated packaging process

	Packaging process
Paper packaging	Inside paper preparing
	Inside paper wrapping
	Side wall paper wrapping
	Outside paper preparing
	Outside paper wrapping
	Paper folding
	Side wall board wrapping
Steel packaging	Outside steel sheet preparing
	Outside steel sheet wrapping
	Inside steel sheet preparing
	Inside steel sheet wrapping
	Side steel sheet forming
	Side steel sheet wrapping
	Inside ring inserting
Binding	Vertical and side band binding

(3) Chance-free operation of packaging work by automating the processing of packaging material and actual packaging work up to steel packaging.

These measures have resulted in a marked increase in efficiency in packaging work, together with improvement in the efficiency of material processing and a large reduction in the amounts of storaged materials, making it possible to package coils in the order of their arrival at the entry side of the ACP.

As examples of automated packaging equipment, the two following sections will describe the inside paper wrapping machine as an example of paper wrapping, and the outside steel sheet wrapping machine, as an example of steel wrapping.

5.1 Inside Paper Wrapping Machine

As shown in **Fig. 4**, this equipment consists of the inside paper processing and wrapping machine, the device which supplies the side-wall paper from the automatic rack and applies the paper to the coils, and the device which connects and bonds the inside papers and side-wall papers. In this arrangement, the technical problems when placing the inside paper in the inner circumference of the coil were how to spread the inside paper so as to secure a good fit to the inner circumference of the coil and how to join the inside paper and side-wall paper tightly enough to secure airtightness.

In placing inside paper in the inner circumference, the inside paper is wrapped around an expandable, segmented coiling reel, improving the air-tightness between the inner circumference of the coil and inside paper by the expansion/contraction and the turning action of the reel.

Next, in joining the inside paper and side-wall paper, both edges of the inside paper are notched at fixed intervals in the inside paper preparation process, and tape is applied to the notched portions. At the same time, side-wall papers on which an adhesive has been automatically coated are pressed against both sides of the coil. The inside paper is passed through the inner diameter of the side-wall paper and set against the inner circumference of the coil. The notched portions of the inside paper are then spread outward, and the inside paper and side-wall paper are joined and bonded by the adhesive. At this time, the notched portions are covered with tape to secure air-tightness.

The development of this equipment completed the full automation of a series of jobs which includes the processing and placing of the inside paper and the supply and placing of the side-wall papers, which were for-

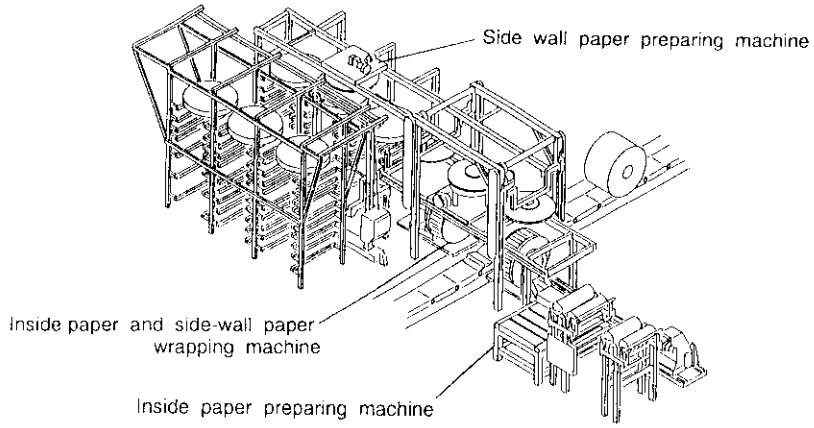

Fig. 4 Inside paper wrapping machine

merly only possible as manual tasks.

5.2 Outside Steel Wrapping Machine

As shown in **Fig. 5**, this unit consists of the outside steel sheet processing and supply equipment, and wrapping device, and the device which tapes the outside steel sheet corners. The technical problems with this equipment were securing a tight wrap of a 6-m-long outside steel sheet around the outer circumference of the coil, applying the tape from the edge to the side at the outside diameter corners, and continuous tape supply.

In outside steel sheet processing and supply, steel sheets of the specified width are selected from three reels based on material data transmitted from the business computer and sheared automatically to the proper length for the outer diameter so that the outside steel sheet will be ready for use. An adhesive is applied to the top surface at the head end of the outside steel sheet, and a cloth tape is pasted on the bottom side so that about half the width of the tape protrudes beyond the sheet edge as a tape stop for the tail end of the sheet.

This type of preparation of the outside steel sheet material made it possible to simplify the outside steel wrapping machine and realize extremely easy wrapping of the sheet. The head end of the outside steel sheet which has been prepared is pushed against the coil for adhesion, the long outside steel sheet is automatically wrapped around the full outer circumference simply by rotating the coil, and the tail end is stopped with tape.

Taping of the outside steel sheet corners was mechanized by using the expandability of the tape. Folding at the sides of the coil and pasting are performed simultaneouly using the back tension and pressure of the roll from above the tape. As a feature of this method, it may be noted that wrapping of the outside steel sheet and taping of the corners can be performed simultaneously since taping makes use of the turning of the coil while the outside steel sheet is being wrapped.

When tape is applied to the outer circumference of the coil, tape consumption is extremely fast because the

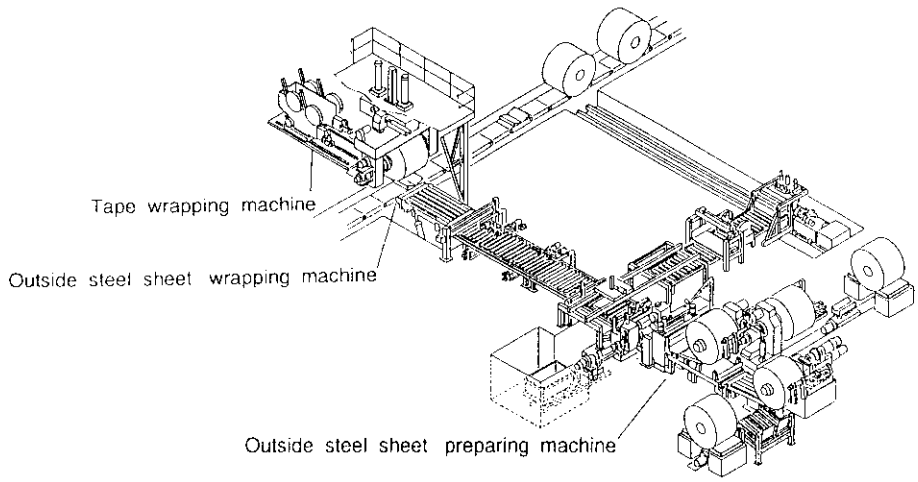

Fig. 5 Outside steel sheet wrapping machine

outer diameter is being wrapped, and the frequency of tape replacement is therefore high, requiring a continuous automated supply of tape. Continuous tape supply was realized by providing spare tape on a stand-by reel, in addition to the tape in use, and flying connection of the tape ends without stopping the tape-wrapping work.

Thus, full automation was made possible in the processing and wrapping of the outside steel sheet, which requires an extremely complex operation.

6 ACP System Configuration

The ACP line has the following system configuration using an FA controller:

(1) Integration of various packaging machines and issuing of instructions on the selection of packaging materials and size changes in response to product information and packaging specifications.
(2) Packaging progress control based on information on coils-in-process in the upstream lines in coordination with the production control system, using the existing business computer.
(3) Operator guidance when breakdowns or trouble occur, warning signals, balance of packaging material information, etc.
(4) Transmission of packaging completion indication of each coil to the production control system.

7 Conclusions

This paper has described the advanced coil packaging (ACP) line developed at Chiba Works No. 1 Cold Rolling Mill for the packaging of TMBP and tinplate product coils. The features of the development are summarized as follows:

(1) Development of packaging specifications which make mechanization and automation possible.
(2) Automation of complex packaging work up to packaging with steel sheet wrapping.
(3) In-line processing work such as processing and preparation of packaging materials.
(4) Development of mechanization technology making chance-free packaging possible.

These measures have enabled full mechanization of operations which were formerly done manually, realizing complete automation of packaging work.

Based on study of the line discussed in this paper, Kawasaki Steel successfully constructed automated packaging lines for hot rolling and other cold rolling processes. These automated packaging lines are all in smooth operation, achieving rationalization of packaging work and improvement of the working environment, with a notable effect on the improvement of packaging quality.

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