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High-Efficiency Production Technology at Mizushima Works No. 2 EGL

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Synopsis :
No. 2 electrogalvanizing line at Mizushima Works has been producing zinc-nickel electrogalvanized steel sheets and pure zinc electrogalvanized steel sheets mainly used for automobiles, household appliances, and structural frames since June 1991. No. 2 EGL was installed for the purpose of producing especially exposed panels for automobiles. In order to achieve the purpose for high quality and high productivity, many new high-efficiency process techniques were adopted into No. 2 EGL process, for example, a new horizontal plating cell, zinc oxide dissolving equipment, IrO2-coated anode, new rubber sleeve, and coating weight control system. These effective equipment provide good surface quality and constant coating weight. Owing to these high-level process techniques, No. 2 EGL has been working efficiently and producing high quality galvanized steel sheet on the high levels of yield and productivity.

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1 Introduction

Mizushima Works No. 2 electrogalvanizing line (EGL), which began operation in July 1991, manufactures ZnNi coated sheets and Zn coated sheets for use in the automotive, electric appliance, and construction, and other industries. With special attention to quality assurance for users, especially in sheet for automotive outer panels and chromate materials for electric appliances, No. 2 EGL has adopted a new horizontal plating cell and various automation technologies to manufacture high-grade electrolytic galvanized steel sheets.[1-4]

Recently, the development of high-efficiency production technology has been required in order to meet the growing needs of high quality, labor saving, and international competitiveness, resulting in the introduction of new technologies such as zinc-oxide dissolving equipment,[5] the iridium oxide (IrO_2) coated anode, a new rubber sleeve,[6] and a coating weight control system. With these new developments incorporated into the commercial manufacturing line at No. 2 EGL, this plant is fully equipped to provide customers with high-quality coated steel sheets while maintaining high yield and productivity.

This paper will outline these new production technologies.

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2 Outline of No. 2 EGL

2.1 Equipment Configuration and Main Specifications

Figure 1 shows the layout of Mizushima No. 2 EGL, **Table 1** shows the main specifications of the equipment, and **Fig. 2** shows the equipment setup and new technologies. The receiving of material coils at the entry side and the delivery of product coils from the finishing line are all handled by an automated transfer system. The entry section consists of two pay-off reels and one welder, a precleaning line and looper, all of which are automated. Pretreatment consists of a tension leveller, electrolytic cleaning, and pickling. A new horizontal cell is installed in the coating line. The coating solution recirculation system is optimized with due consideration given to the flow rate requirement and gas removal, etc., during coating. An iridium oxide coated anode and zinc oxide dissolving equipment have also been introduced.

The chemical treatment line consists of surface conditioning tank, a chromate tank, and a sealing tank. The chromate tank is of the vertical-type reaction chromate

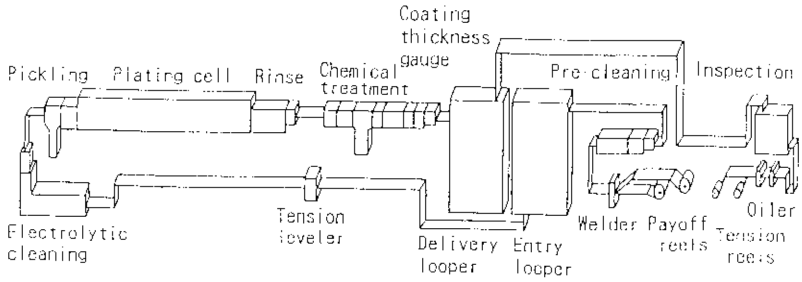

Fig. 1 Layout of Mizushima Works No. 2 EGL

Table 1 Main specifications of No. 2 EGL

Capacity	(t/month)	25 000
Max. line speed	(mpm)	160
Strip thickness	(mm)	0.3~2.3
Strip width	(mm)	700~1 830
Rectifier capacity	(kA)	480
No. of plating cell		16

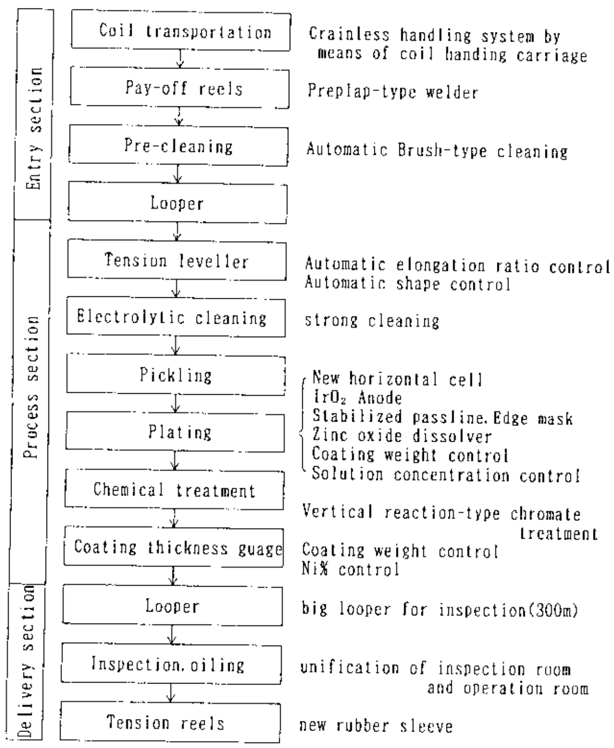

Fig. 2 Equipment composition and new techniques

2.2 Features

No. 2 EGL was constructed as a state-of-the-art line having the following features, with the main aim of securing stable quality in sheets for automotive outer panels and chromate materials for electric appliances:

(1) Development of new all-counter flow, dipping-type horizontal cell to meet strict requirements for surface appearance and uniformity in two-side coating.

(2) Electrolytic solution circulation system with rapid cell cleaning and liquid exchange for two product types (ZnNi and Zn).

(3) Use of vertical-pass reaction-type chromate treatment for improved surface appearance of chromate materials and stable chromate coating weight.

(4) Setting up of pre-cleaning and electrolytic cleaning units for high-level cleaning capacity to secure the cleanness of TMBP before coating and superior coating adhesion.

(5) Installation of tension leveller on the entry side to secure product flatness, reducing the electrode distance and realizing stable in cell passing.

(6) Observation of entry and delivery sections and sheet surface inspection from the operator's pulpit, and automation of each equipment, so as to minimize the manpower requirements of the operation.

(7) Use of high-speed buggies for coil handling and a craneless coil handling system to prevent surface damage and realize unmanned coil handling.

(8) Super-clean production environment by in-line dust prevention covers, and airtightness of building.

Furthermore, new technical improvements such as a zinc oxide dissolving unit, IrO_2 coated anode, new type of rubber sleeve, and automatic control of coating weight have been progressively installed for routine operation to attain higher efficiency.

method for realizing a uniform coating weight on both the top and bottom surfaces, as well as in the width direction. The coating weight gauge performs full-length, full-width inspection. The delivery section includes an inspection room, oiler, shear, and two tension reels, all in automated operation.

3 Plating Cell

3.1 New-Type Horizontal Cell

A soaking-type horizontal cell without dam roll was installed for surface appearance quality improvement, as shown in **Fig. 3**. This type of cell keeps the steel strip

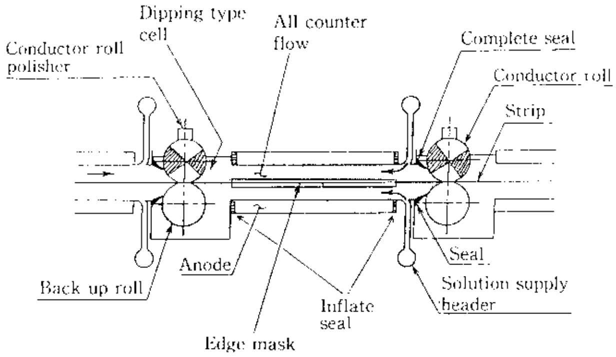

Fig. 3 New type horizontal plating cell

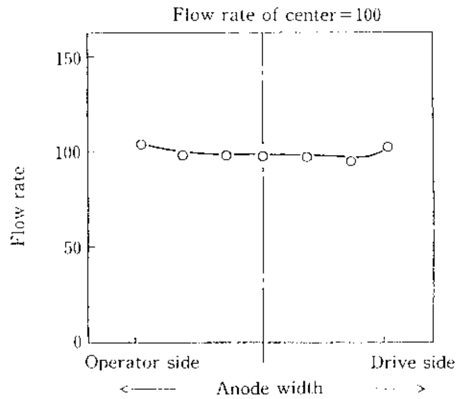

Fig. 4 Distribution of electrolyte flow rate in width direction

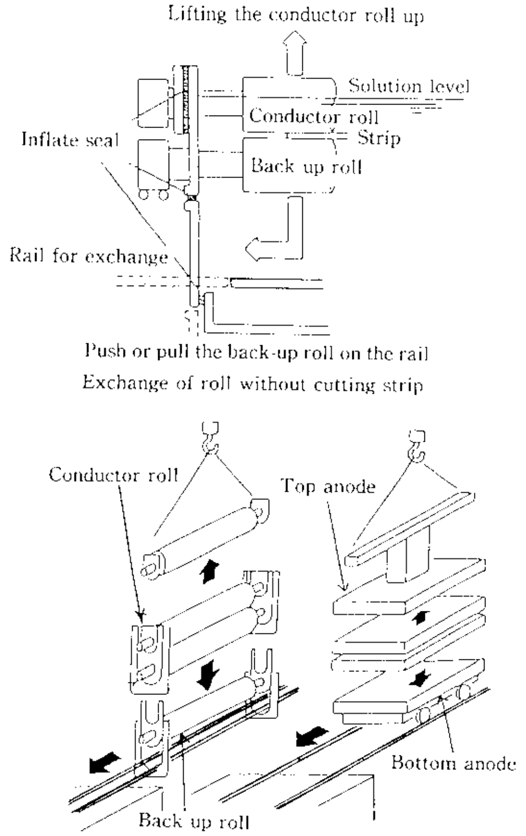

Fig. 5 Plating cell roll and anode changing method

from drying, eliminating the need for keep-wet work, to assure a uniform and attractive surface. In order to attain a high current density/high line-speed operation at a maximum 150 A/dm^2, an all-counter flow method using a rear seal was adopted. This has assured high-speed and uniform electrolyte flow distribution as shown in **Fig. 4**.

To save time in cell cleaning and prevent quality deterioration by contamination caused by mixed impurities, the cell was simplified for improved cleanness, and it is now possible to carry out a solution change from ZnNi to Zn in two hours.

3.2 Development of Roll and Anode Changing Method

To improve production efficiency by reducing the roll and anode changing time and improve the calendar time working ratio and productivity, a method of changing the backup roll and bottom anode with the strip in place was adopted. For rapid changing without removing the strip, an inflate seal is used. **Figure 5** shows the backup roll and bottom anode changing method.

First, the air pressure in the inflate seal used to prevent electrolyte leakage is released. The conductor roll and upper anode are then changed while lifted with the overhead crane. At the same time, the back-up roll and the bottom anode are changed off-line by first lowering them after releasing the air pressure in the inflate seal, and by placing them on the rail for the change and pulling them off the line. This facilitates in-cell inspection and maintenance, not only increasing the production capacity but also improving quality, while reducing repair costs.

3.3 Use of Iridium Oxide Coated Anode

Iridium oxide is used for the anodes. This material is effective in preventing the dents caused by peeling of oxides from the electrode while the electric current is on. The durability of the iridium oxide anode is over 4 000 h.

3.4 Use of Edge Mask and Uniform Zn Coating in Width Direction

Edge overcoat has been prevented almost completely by use of an edge mask technique. As shown by the coating weight profile in **Fig. 6**, the horizontal cell is a new type with all counter flow, and the constant distance maintained between the anode and strip by insoluble anode makes the transverse flow rate distribution both fast and uniform, leading to a superior uniformity of the coating weight distribution in the transverse direction.

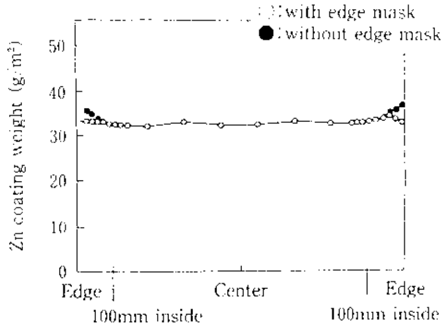

Fig. 6 Zinc coating weight profile

Table 2 Comparison of zinc ion source

Ion source	$ZnCO_3$	ZnO	Metal Zn
Solubility (time dependence)	◎	○	×
Substitute depositon of Ni	○	○	△
Concentration control	◎	◎	△
Source handling	◎	△	○

◎ Excellent ○ Good △ Good ~ Bad × Bad

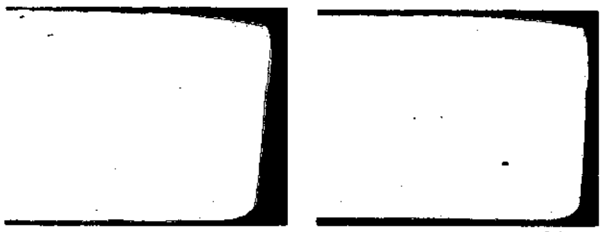

Photo 1 Cross-section of strip edge

Table 3 Comparison of zinc oxide[a]

	Zinc oxide powder	Zinc oxide grain[b]
Compressibility	large (△)	small (○)
Air transportation capability	bad (×)	good (○)
Mass specific weight	0.3 (△)	1.0 (○)

[a]○ Good △ Not so good × Bad
[b]Adopted as Zn ion source in No.2 EGL

Use of the edge mask technique also eliminates edge overcoat. **Photo 1** shows a cross-sectional view of area around the edge, and shows no edge overcoat when edge mask is in use.

4 Zinc Ion Supply

4.1 Zinc Ion Source

In the galvanizing unit using insoluble anode, zinc ion must be supplied from outside. Zinc carbonate, zinc oxide, metallic zinc, etc., are used as the zinc ion source.

No. 2 EGL has used low-cost metallic zinc for zinc coating since startup, but as a zinc ion source of the ZnNi coating solution, the originally used zinc carbonate was changed to a more economical zinc oxide after a series of studies. **Table 2** shows a comparison of zinc ion sources. Zinc oxide was adopted because it does not cause substitute deposition of Ni and offers good control of the solution concentration.

4.2 Zinc Oxide Dissolving Unit

4.2.1 Types of Zinc Oxide and Method of Dissolution

Zinc oxide was used in grain form in order to prevent coagulation of the zinc oxide during dissolving. Zinc oxide in grain form also has better fluidity than powder, as shown in **Table 3** allowing transport by air pressure and automatic handling because grain-type zinc oxide is lower in compressibility than the powder type.

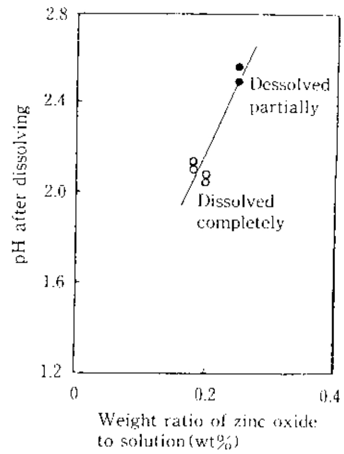

Fig. 7 Relation between dissolved Zn and pH

Figure 7 shows the relationship between dissolved Zn and pH. If the pH is higher than 2.3 after dissolving, some zinc oxide will remain undissolved. This is attributed to the formation of Fe compounds by iron component in the solution, which then cover the zinc oxide and prevents it from dissolving. The maximum input of zinc oxide in this case is 0.2 wt% per unit of electrolyte, with 3 min required for dissolving.

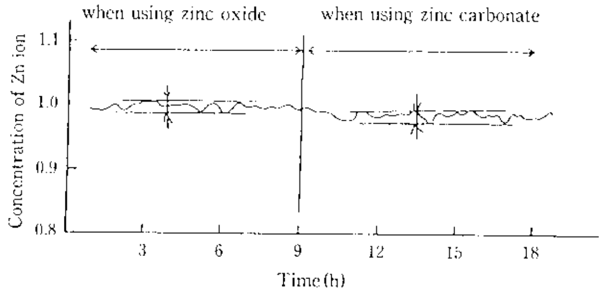

Fig. 8 Concentration trend of zinc ion

4.2.2 Condition of Operation

The zinc oxide dissolving unit is in a smooth operation, and zinc oxide is almost fully used as the zinc ion source for the ZnNi electrolyte. **Figure 8** shows the results of electrolyte concentration control. Zinc oxide and zinc carbonate are identical in terms of fluctuations in electrolyte concentration control.

5 Automation Technology

5.1 Computer System

Figure 9 shows the system configuration of computers. A process computer performs tracking of the line from entry to delivery. The overall automation of the line is made possible by the timely transmission of preset information to the electric DDCs, instrumentation DDCs, and various sensors. Logging of various actual operation data is also performed.

5.2 Automatic Control of Chromate Coating Weight

As shown in **Fig. 10**, a vertical-type reaction chromate method was adopted. To secure a fixed reaction time independent of line speed, the spray zone is divided

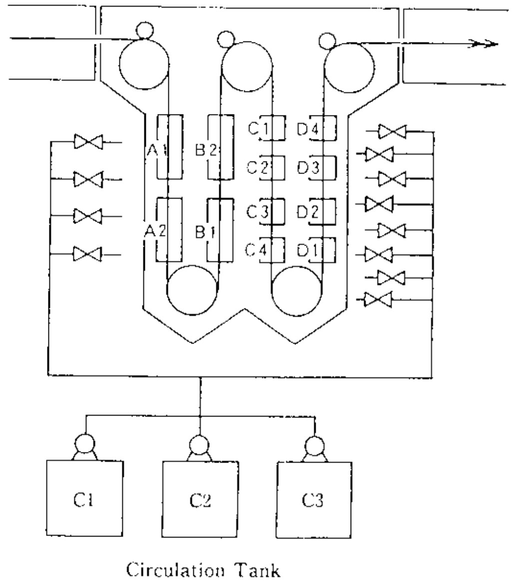

Fig. 10 Chemical treatment equipment

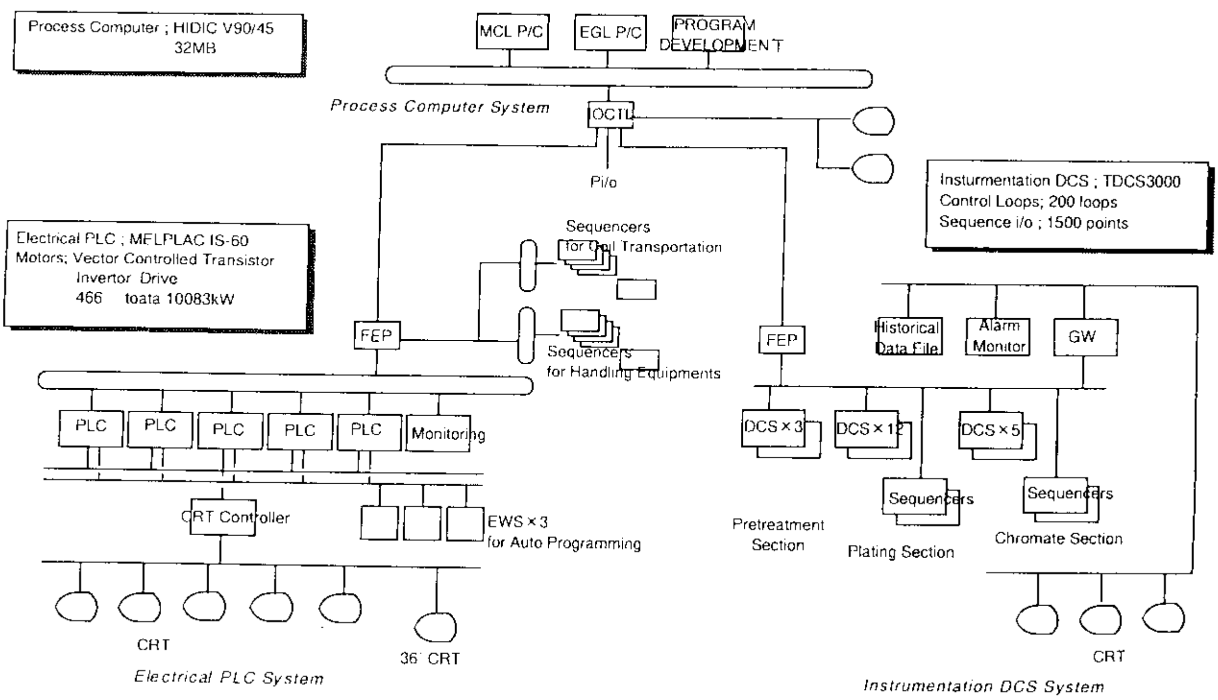

Fig. 9 System configuration of No. 2 EGL

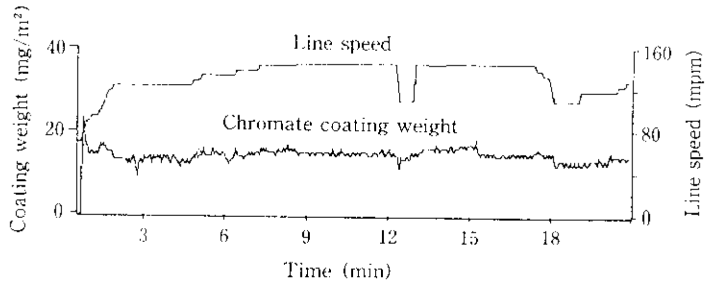

Fig. 11 Trend of chromate coating weight

into 12 zones, and a zone control system is used. With the horizontal method, it was difficult to equalize the reaction time between top and bottom surfaces because of the presence of chromate solution riding on the upper surface of the steel sheet. However, in the vertical-pass spray zone coating system, the reaction time between the top and bottom surfaces can equalized because the effect is less than with the horizontal-pass type. Consequently, there is no difference in coating weight between top and bottom surfaces.

Since an increased number of zones can be set up, more accurate coating weight control was possible. **Figure 11** shows the results of chromate coating weight control. Control of the zone number makes it possible to maintain a uniform chromate coating weight constant even when the line speed changes.

6 Condition of Operation

6.1 Production Control

No. 2 EGL made a smooth startup after being commissioned in July 1991, and is continuing to show a high level of operation, especially with the critical ZnNi and chromate products, which are being produced smoothly and fully demonstrating the required functions.

6.2 Yield Improvement and Laborsaving

The particularly noteworthy points with regards to No. 2 EGL are as follows.

6.2.1 Yield improvement by reel-mark defect prevention

The typical response to the problem of reel marks at the end of strip, which occur during tension reel rewinding, is the use of rubber sleeves. However, reel marks occur with round rubber sleeves of the conventional shape, because this type of sleeve is inadequate to absorb the step difference at end of heavy-gauge strips. A newly devised "heart-shaped" rubber sleeve was introduced to reduce the occurrence of reel marks, and has improved yield as shown in **Fig. 12**.

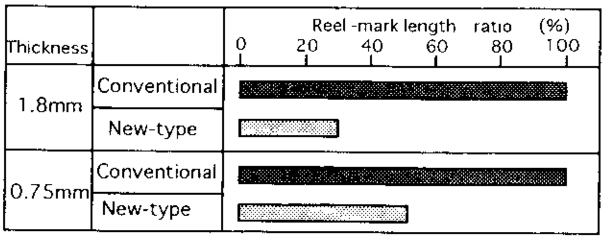

Fig. 12 Reel-mark length

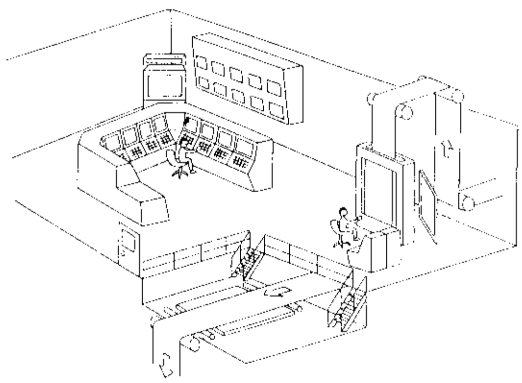

Fig. 13 Pulpit (operation and inspection room)

6.2.2 Laborsaving by integration of strip surface inspection room and central operating pulpit

A operating pulpit layout was adopted which commands a full view of operation at the entry and delivery sections and sheet surface inspection, as shown in **Fig. 13**. This layout has made line operation possible with the minimum number of crew members.

6.2.3 Automated coil transfer system

Figure 14 shows a schematic diagram of the flow of materials. **Figure 15** shows the typical equipment configuration. The coil handling carriage shown in Fig. 15 is a two-level car, which transfers coils at high speed (max. 200 mpm) over a relatively long distance. A three-level car type is used to transport coils within

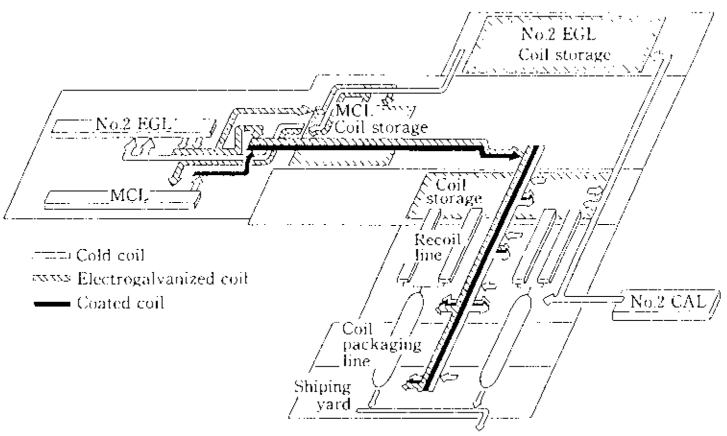

Fig. 14 Schematic diagram of material flow

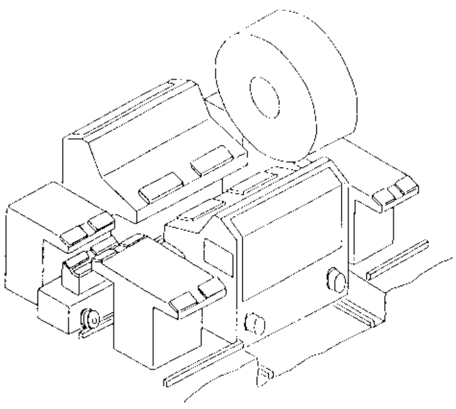

Fig. 15 Coil handling carriage

the storage area.

7 Conclusions

This report has described the new horizontal plating cell developed to meet the sophisticated surface quality requirements of sheets for auto outer panels and chromate materials for electric appliances produced at Mizushima Works No. 2 EGL, together with an outline of the new technologies recently incorporated in routine production lines. These results can be summarized as follows:

(1) The development of the new horizontal plating cell has resulted in improved surface appearance quality, high-current/high-density operation, quality improvement through the prevention of contamination, roll and anode change without strip cutting, dent prevention by the use of iridium oxide anodes, all contributing to the stable manufacture of high-quality EGL products at high-speed and high productivity.

(2) The zinc oxide dissolving unit is in smooth operation, supplying almost all ZnNi coated products with a zinc ion source from low priced zinc oxide.

(3) Coating weight control and various other automated control functions have been realized, enabling operation with a minimum number of personnel.

(4) The use of a new-type rubber sleeve has resulted in a marked decrease in reel mark occurring at coil ends during tension reel rewinding.

As a result of these improvements, the products of this EGL enjoy the confidence and good evaluation of customers. However, we will continue to make further efforts to establish operation technology with a higher level of quality, productivity, and efficiency.

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