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The body can be viewed from the next page.

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The continuous annealing plant commissioned at Mizushima Works in February 1984 has a number of new automatic devices for material handling developed on the basis of the so-called "mechatronics technology" which has made a prominent progress recently.

The automatic devices mainly consist of the following:

(1) Unmanned crane with electrical non-snaking control and a light weight non-swaying clamp mechanism

(2) Automatic carrying-out system for scrap steel sheets and trimming scraps

(3) Automatic changer of cold coil sleeves

(4) Automatic paper wrapping device

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1 Introduction

It is common knowledge that the technology known as "mechatronics" belonging to the borderline region between mechanics and electrics has progressed rapidly in recent years. On the basis of this technology, precise control in complex, high-speed positioning tasks has become much easier than before, making significant contributions to automation in the iron and steel industry.

In a new continuous annealing plant commissioned at the Mizushima Works in February 1984, mechatronics technology has been widely adopted, with unmanned handling devices for cold coil, shear cut scrap steel sheets and trimming scraps, coil sleeves, and wrapping paper developed.

In particular, in developing an automatic crane for coil transfer, realizing automation at the minimum cost was made a goal. Subsequently, an electrical non-snaking control, a light weight non-swaying clamp mechanism, and others were developed.[1)]

This report describes these unmanned handling devices.

2 Unmanned Crane

The unmanned crane installed in the continuous annealing plant is shown in **Fig. 1**. This crane receives instructions directly from the host computer. Its operation is fully automatic as it conveys cold coils (of up to 50 t) carried in by unmanned car to the address-controlled coil yard or to the entry side conveyer of the multipurpose continuous annealing line (KM-CAL).

2.1 Electrical Non-Snaking Control

Generally, a crane snakes because of unbalanced load or wheel slip. The magnitude of snaking is often so large that the crane is displaced from the predetermined stop point. In conventional unmanned cranes, large side rollers are incorporated to prevent snaking by nipping one of the two rails at two points. However, to avoid damaging side-rollers even if the crane is stopped suddenly in the worst condition, not only are very big side-

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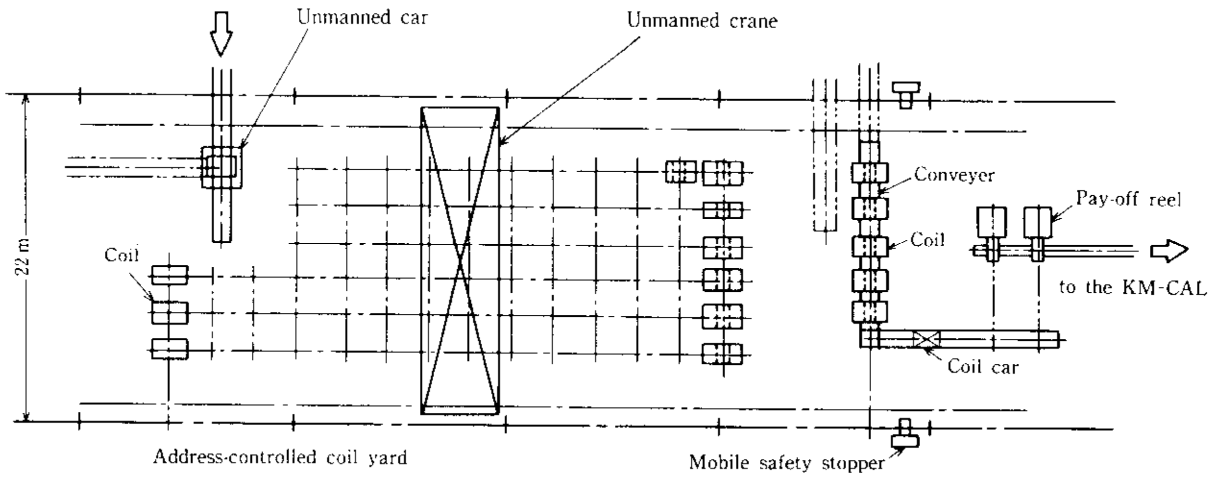

Fig. 1 Unmanned crane for 50 t coil

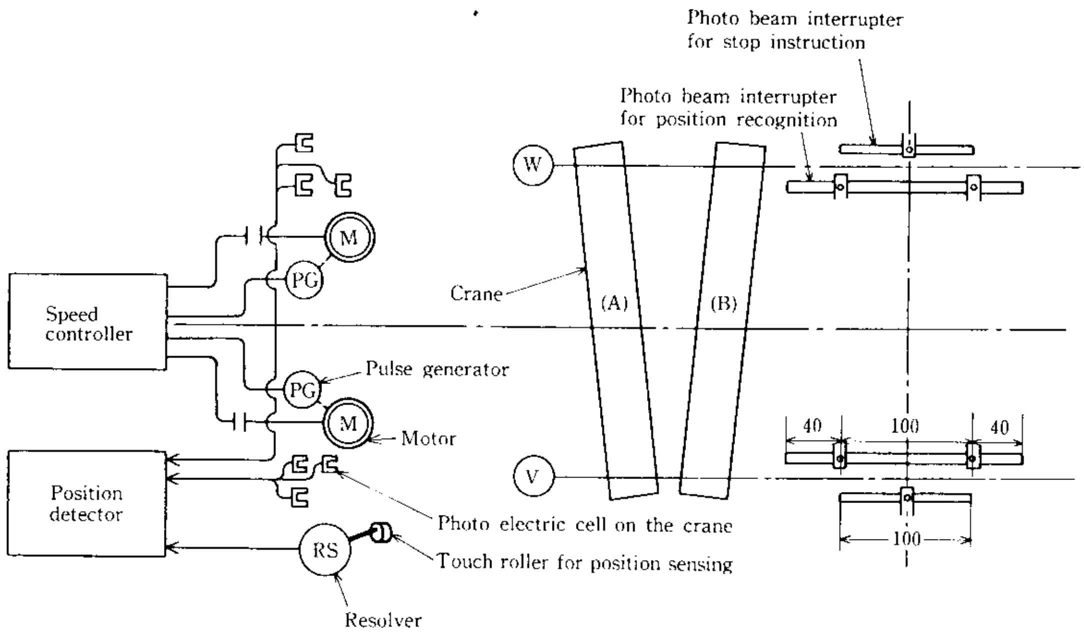

Fig. 2 Electrical non-snaking control of crane without side rollers

rollers necessary, but the crane body must also be rigid to prevent twisting. Increased crane weight, however, is undesirable from the view point of high construction costs for the crane.

Thus, an electrical non-snaking control method, as shown in **Fig. 2**, was developed to make possible the use of a light-weight, flexible-structure crane without side rollers. The principles of this method are as stated below.

2.1.1 Position sensing

Recently, transposition inductive radio cable (address cable) and rack-and-pinion methods have been used to sense the position of automatic cranes. However, relative to the required function, hardware costs for these methods are excessive if only one crane is installed in per lane. Thus, a lowest cost method has been adopted in which a touch roller contacts the rail, the amount of rotation is detected by a resolver, and fixed point wheel slip correction is made at 12 meter interals using a phototube. As a result, a stop precision of ±25 mm has been attained, better by half than the target precision of ±50 mm. The touch roller is of induction-hardened Mo steel to prevent wear.

2.1.2 Non-snaking control method

The wheels on the two sides (right and left) of the crane are driven by separate motors. However, they are controlled by the same speed instruction since the position detector is used to sense the position of only one side. Accordingly, speed is lowered to 5% on the position detector side stop-instruction dog-end, located 50 mm from the stop position.

As shown in Fig. 2, the crane body will be positioned as in case A or B when snaking has occured.

(1) Case A—The Stop Instruction Dog Is Sensed First on the Detector Side.
The wheels on the V rail, which are running faster, is allowed to idle so as to decrease speed naturally by mechanical friction. Then, the trailing wheels, on the W rail, running at 5% speed catch up with the V side wheels. Simultaneously as the trailing side senses the stop instruction dog, the stop control is applied.

(2) Case B—The Stop Instruction Dog Is Sensed First on the Non-detector Side (W Rail Side).
The detector side has not sensed the stop instruction dog; therefore, the speed on this side has not been decreased to 5%. In this case, the speeds of the motors on both sides are immediately decreased to 5%, and stop control is applied to the motors simultaneously when the trailing side (the V rail side) reaches the stop instruction dog. In this case, the snaking is not corrected. However, the crane stops astride the target position, therefore the load is normally within the allowable range of stop positions. In this case, two phototubes, 100 mm apart, are attached at the two sides of the crane to measure the stop position. When either of the side is beyond the 180-mm stop recognition dog installed on the building side, that side only is automatically adjusted to correct the snaking. Finally, both sides of the crane are stopped with ±40 mm precision.

In actual operation, with heavy coils, the crane sometimes goes beyond the allowable range of the aimed position and is automatically returned. However, the adjust time is only several seconds, thus not affecting the operation cycle.

As another method of electrical non-snaking control, consideration was given to attaching position detectors at both sides, allowing separate control of the speeds of the right and left motors. However, in this method, not only would hardware costs increase, but it is also not possible to estimate what stress would be applied by the motor on one side to the other side through the rigid crane body. Therefore, because of the great difficulty in controling a system of this type, this method was not adopted.

2.2 Light-Weight Non-Swaying Clamp Mechanism

Another problem in crane automation is sway control. The electrical non-swaying method is superior to the mechanical method as it does not cause weight increase. Kawasaki Steel has already developed and tested an electrical method, however it is not used in actual operation because the effects of a malfunction would be serious.

A mechanical non-swaying unit, as shown in **Fig. 3**, has conventionally been used. In this unit, the rod fixed to the coil lifter side stops swaying by engaging the guide cylinder on the traverse running car. This unit must stand the shock of emergency stops at maximum speed and maximum load; therefore, it must be rigid and heavy. More over, the lifter, traverse car, crane body, and structural frame work of the building require reinforcement, which results in increased construction costs.

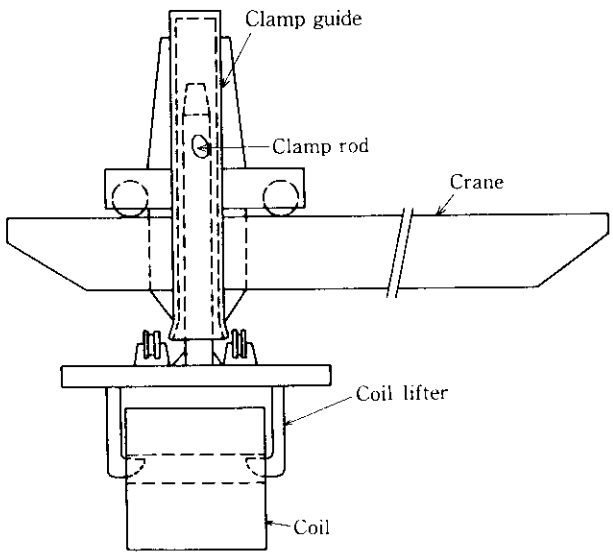

Fig. 3 Conventional Clamp mechanism of coil lifter

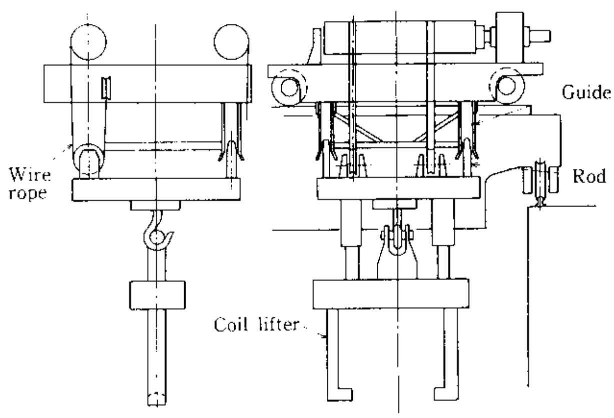

Fig. 4 New clamp mechanism of coil lifter

The present newly developed type of unit is shown in **Fig. 4**. Four non-sway rods are used and are spaced as far apart as possible. The four guide cylinders are made lighter and are interconnected by trusses. The moment of inertia around the horizontal axis is supported by the light-weight frame structure. These features allow significant weight reduction.

Further, to prevent displacement of the coil lifter during cable take-up, a structure is used in which the four cables are symmetrically placed so as to eusure engagement of the guide rods with the guide cylinders.

3 Automatic Disposal System for Scrap

At the entery side of the continuous annealing line, scrap sheet results when off-gauge portions of coils are cut in lengths, and at the exit side, trimming scraps are cut off by the trimmer. In the new plant, to eliminate manual disposal work, the fully-automated system shown in **Fig. 5** has been developed. At the entery side, the scrap sheets cut in lengths are gathered into an elevator hopper. When several tons of scrap has been collected, the hopper is lowered, the bottom plate is opened and the scraps are transferred to the bag on the underground car without shock.

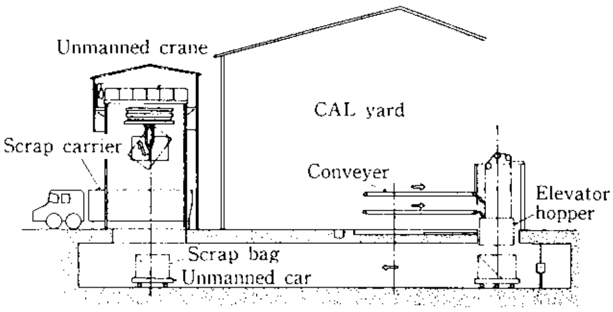

Fig. 5 Unmanned handling system of scrap sheets

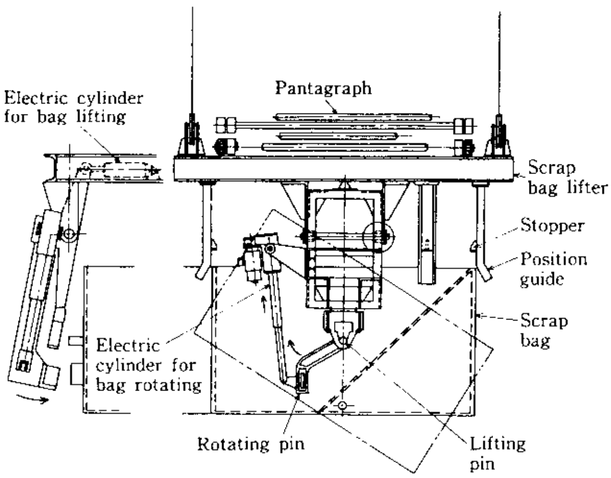

Fig. 6 Automatic lifting and rorating system of the scrap bag

The bag is then transported to the outdoor yard. One problem was how the bag was to be secured by the outdoor unmanned crane in order to carry out the scrap. This was solved by the system shown in **Fig. 6**. This system is characterized by a mechanism which automatically grasps and rotates the scrap bag. First, the bag lifter is lowered and the positioning guide aligns the lifter with the bag. When the stopper touches the bag, the electric cylinder for bag lifting is actuated to insert the two pins for bag lifting and rotation into holes in the lifter. When the bag is lifted and conveyed to above the scrap carrier (also called Dynasore), it is rotated by the electrical cylinder for bag rotation and the scrap is discharged. In this system, a series of operations is reliably performed without human intervention.

4 Automatic Changer for Cold Coil Sleeves

Steel or rubber sleeves must be mounted on the tension reels to prevent mandrel press marking on thin steel sheets. The sleeve changing operation was previously performed manually by operators using an overhead travelling crane. However, an automatic sleeve changer, as shown in **Fig. 7**, has been newly developed. Rubber sleeves of different outer diameters are mounted on rotating cross arms. The handling car clamps a sleeve on instruction and travels to the tension reel to mount the sleeve automatically on the mandrel. Similarly, steel sleeves, which slide onto the steel sleeve feeder, are clamped and automatically mounted on the mandrel. In the tension reel, two mandrels are used alternately and sleeve mounting is performed during sheet passing. Since positioning in sleeve changing is difficult, few automatic sleeve changers are practically used; however, the above system with its simple mechanism ensures reliability by providing a changing station on the extension of the mandrel axis.

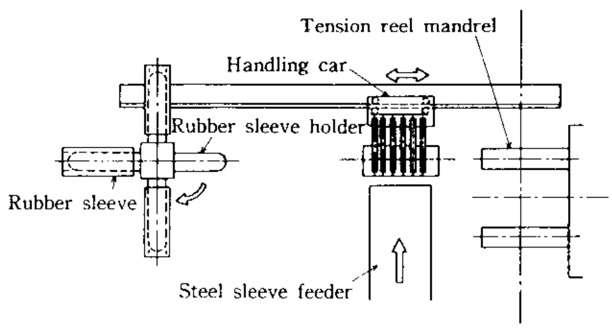

Fig. 7 Layout of an automatic sleeve change device

5 Automatic Paper Wrapping Device for Cold Coil

The paper wrapping device has also been automated using a new method. In response to the instruction of the host computer, this device selects the proper wrapping paper, automatically cutting it to a length corresponding to the coil size, and performs an arc motion according to the coil outer diameter to wrap the paper around the coil. The mechanism is shown in **Fig. 8**. In this device, the clamping car grasps and pulls out the top end of the required wrapping paper and the cutting car automatically cuts it when a length corresponding to the coil outer diameter has been pulled out. The catcher arm, which performs the arc movement according to the outer diameter, then begins to wrap the paper partially around the coil. The top end of the wrapping is fixed to the coil with an adhesive, the paper being wrapped is fully around the coil by the cradle rolls, and finally the tail end is also fixed with adhesive.

The above operation is automatically performed in a short two minute cycle. In particular, the rapid arc movement according to the coil diameter is a typical function that is supported by recent developments in "mechatronics" technology. This function was not possible until a combination of rapid-operation microcomputer, servomotor controlled by the microcomputer, and a ball screw enabling high precision positioning had been realized.

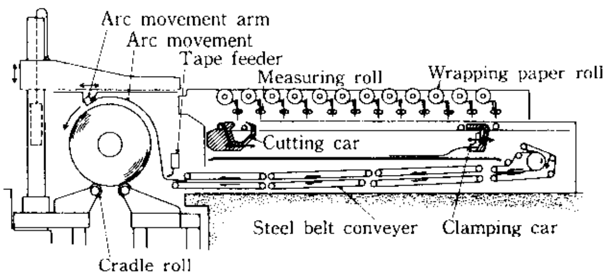

Fig. 8 Automatic paper wrapping device of cold coils

6 Conclusions

This report has described automation technology for material handling using an example of a recent construction at a cold coil continuous annealing plant. Main features of this system may be summarized as follows:

(1) The unmanned crane automatically conveys cold coils of up to 50 t to the multipurpose continuous annealing furnace. The success of this crane in the practical operation was made possible by development of an electrical non-snaking control and lightweight non-swaying clamp mechanisms.

(2) An automatic disposal system for scrap, an automatic changer of cold coil sleeves, and an automatic paper wrapping device for cold coil were also developed and put into practical use.

In recent plant construction, not only automation of main production facilities but also that of the material flow is an important factor in realization of factory automation. Several new types of steel material handling devices have been developed at the Cold Strip Mill. It is intended that total automation of processes including steel material handling be aggressively pursued in order to improve productivity and ensure rapid, dependable processing.

Finally, the authors must acknowledge the cooperation in these projects of the engineers of Kawaden Co., Ltd., Shinmeiwa Industry Co., Ltd., Token Machinery Works Co., Ltd., and Tsubakimoto Chain Co.

References

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