JFE TECHNICAL REPORT
No. 21 (Mar. 2016)

Fully Automated Coil Warehouse†

1. Introduction

Handing of steel coils is generally performed mainly by cranes, and accurate and quick operation is required. Although operators must possess a high level of skill in order to achieve this, considering the low birthrate/aging population of the future, it will be difficult to secure human resources and pass on the requisite skills to younger workers. For this reason, automatic crane operation has become necessary and indispensable.

Many automatic coil-handling overhead cranes have been applied in commercial operations[1]. However, in transport vehicles and loading/unloading, restrictions are frequently applied to the vehicle specifications (structure, shape, etc.) in order to designate the vehicle position. Moreover, in the case of semi-trailers, which are widely used in transportation to customers, intervention by operators was necessary because limitations on the specifications on the vehicle side were difficult, and this was an obstacle to full automation.

In order to achieve full automation in which operator intervention is not necessary, JFE Logistics, in joint work with JFE Techno-Research, developed a measuring system which can respond flexibly to all types vehicles and realized a technology which enables full automation of coil warehouses by combining the developed measuring system with an automatic crane control system of JFE Electrical & Control Systems.

2. Outline of Automatic Crane

One fully automatic overhead crane is installed in the warehouse which was automated this time. The crane comprises the crane itself, which is equipped with various types of sensors and control equipment, ground equipment such as the gate opening mechanism of the warehouse entrance, etc., and system devices which issue coil conveying orders. The main specifications of the crane and a general view of the warehouse are shown in **Table 1** and **Photo 1**, respectively.

Table 1 Specifications of crane

Capacity	23 t
Bridge travel speed	120 m/min
Trolley travel speed	60 m/min
Hoist speed	10 m/min
Lift	9 m
Span	30 m

Photo 1 Automated coil warehouse

The position of the crane is measured with high reliability and accuracy by multiple laser rangefinders.

The positions of all the coils in the warehouse are controlled automatically, making it possible to obtain the target position accurately and transport the required coil, even in case of multi-level stacking of coils with non-uniform sizes.

A shock-less anti-swing control system was adopted. This system performs operation by a pattern which does not cause swinging of the load during crane trolley travel and bridge travel operation, and has realized sensorless, high-speed operation.

Although loading and unloading in the warehouse is all performed by manned vehicles, use of the automatic coordinate measuring system for coil on the car, which is described below, makes it possible to use the vehicles that had been used conventionally as-is, without special improvements on the vehicle side.

3. Automatic Coordinate Measuring System for Coil on Car

3.1 Outline of Measuring System

A system which detects the stopping position of

† Originally published in *JFE GIHO* No. 35 (Feb. 2015), p. 82–83

vehicles that have entered the warehouse and determines the coordinates of the coils on the vehicle was developed. The main specifications of this system are shown in **Table 2**.

In this system, three laser scanners in three dimensions which were designed for dedicated use in the system are installed at equal intervals on the crane main girder, and the surfaces of objects within a range of approximately 5 m × 5 m on the floor surface is detected as a large number of points having three-dimensional coordinates by the respective laser scanners. **Figure 1** shows an example of the measured data of a car and coils captured by one of the laser scanners in this system. The stopping position coordinates and the coil coordinates are calculated by a uniquely developed algorithm from the three-dimensional coordinate data of the numerous points detected by the scanners.

The features of this system are outlined below.

(1) Because a method is adopted in which distance is measured based on the round-trip time of laser reflection, the effect of coil surface properties is minimal. This enables stable measurement of objects ranging from coils packaged with steel sheets, which have high specularity, to unpackaged black coils (coils with mill scale on the surface).

(2) Some reference reflectors are installed on the floor within the measurement range of view, enabling automatic correction of the crane stopping position and inclination by simultaneously measuring the position coordinates of the reference reflector.

(3) Installation of multiple scanner units in a configuration that covers their mutual fields of view secures a measurement area which is free of dead angles.

Table 2 Specifications of measuring system

Measuring principle	3D Laser scanner
Number of scanners	3
Scanner height	9 m
Measuring area	5 m × 15 m
Measuring time	Approx. 30 seconds
Measuring accuracy	20 mm (X, Y, Z-Direction)

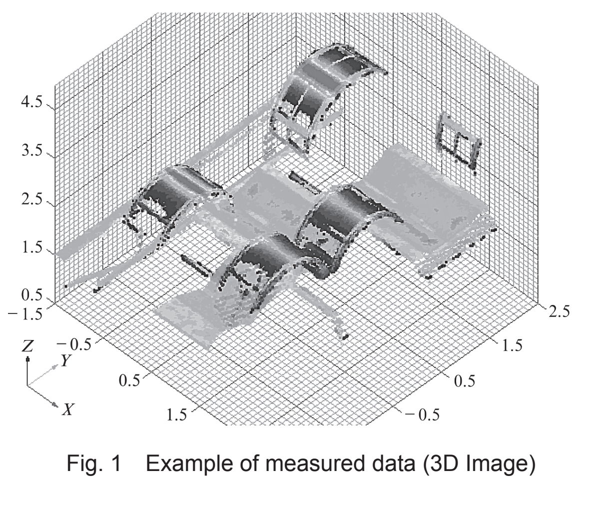

Fig. 1 Example of measured data (3D Image)

3.2 Measurement of Coil Coordinates on Car

3.2.1 Application to coil-transport vehicles

Coil-transport vehicles are vehicles in which fixed coil stands are installed on loading platform of the vehicle. The position of coils on these vehicles is controlled by matrix address, and the shape and dimensions of the vehicle are registered in the system by a unique vehicle number. The dimensions of the vehicle and coil and the address on the vehicle where a coil is to be loaded/unloaded are received from the upper level computer, and the coil coordinates are calculated by combining this information and the results of an analysis of the vehicle shape by this system.

3.2.2 Application to semi-trailers

Unlike coil-transport vehicles, the shape and dimensions of semi-trailers are unknown. Furthermore, because there is no concept of address on the vehicle, the target position when unloading coils must be designated by some method.

In this system, the above-mentioned problem was solved by providing a positioning reference point near the loading/unloading point. The reference point is recognized automatically from the measurement data of the laser scanners, and accurate measurement is possible, even though the dimensions of the vehicle are unknown, by analyzing the vehicle shape, limited to the area around the reference point.

Photo 2 shows an example of semi-trailer loading work. Loading without causing collapse of the cargo during transportation has been realized in automatic

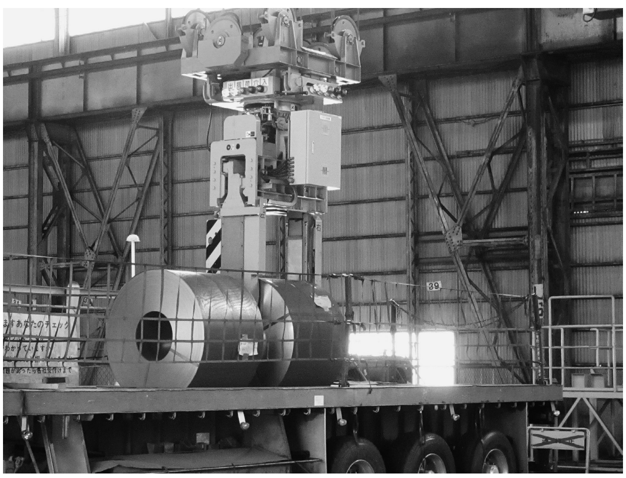

Photo 2 Loading to general-purpose semi-trailer

operation by combining this method and a dedicated loading logic which was developed at the same time.

4. Conclusion

This development enabled fully automatic loading and unloading in the warehouse with diverse types of vehicles without depending on intervention by manual operation. A shorter transportation cycle time exceeding the results of manual operation could also be achieved.

For the future, efforts to develop new technologies to achieve even higher efficiency in logistics and to solve the problems of securing human resources and transferring skills to younger personnel are planned.

References

1) Uemura, Akira; Shirai, Masaaki. New Technologies for Steel Manufacturing Based upon Plant Engineering. NKK Technical Review. 2003, no. 88, p. 37.

For Further Information, Please Contact:

Logistics Solution Dept., JFE Logistics
Fax: (81)3-6214-9742
Sales Div., JFE Techno-Research
E-mail: jfetecsalesmarketing@jfe-tec.co.jp
Website: http://www.jfe-tec.co.jp/en/