Technical Report

# Endless rolling of Wire Rods

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## Abstract

Wire rods are manufactured by rolling billets to predetermined sizes via pluralities of rolling mill stands. Conventional wire-rod rolling causes inevitable losses in productivity and yield due to rolling problems and the improper quality of the unsteadily rolled parts. In the wire rod mill of the Kamaishi Works, endless rolling was introduced to the multi-strand rolling mill for the first time in the world for improving productivity and yield, as well as for reducing customer work load by supplying heavy weight coils.

### 1. Introduction

The wire rod mill of the Kamaishi Works of Nippon Steel & Sumitomo Metal Corporation started its operation in 1961 and is the longest-running wire rod mill currently operating in Japan. Under such a situation, the wire rod mill has promoted improvements in quality and productivity, and has continued to maintain quality and productivity of the highest level in the domestic market. Currently, the mill operates as a multi-strand rolling mill, producing high-quality steel wire rods represented by steel tire cord and cold heading with high efficiency.

The secondary and tertiary wire-rod processors are characterized by several heat treatment and processing stages such as annealing and wire drawing to produce finished products. Therefore, there are requests from customers for improvements in their productivity, cost and reduction in environmental load. By responding to such requests, sophistication of the wire-rod production technologies has been promoted. Among such wire-rod production technologies, the development of endless rolling technology that realizes customers' improvement in productivity by using heavy unit weight coils, and the development of the production technology of small diameter wire rods that corresponds to the omission of heat treatment and the simplification of processing stages are introduced.

#### 2. Development and Practical Operation of Endless Rolling Technology

To improve yield and productivity and enhance the freedom of choice in coil unit weight, the endless rolling technology was introduced to the multi-strand rolling mill for practical operation in 2001 for the first time in the world. The technology is introduced hereunder.

#### 2.1 Background

In the wire rod mill of Kamaishi Works, the edge parts of a

rolled billet need to be cut off during and after rolling to prevent rolling problems due to improper shapes and to remove the unstably temperature-controlled parts. Furthermore, a certain distance needs to be maintained between the foregoing rolled billet and the following rolled billet for the control of rolling operation. These are the factors that inevitably cause losses in yield and productivity. Furthermore, in the rolling of wire rods, two one-ton coils or a two-ton coil are produced from a two-ton billet. However, coils with increased unit weight are required by wire-rod processors like steel cord manufacturers for improving their productivity.

Therefore, to improve yield and productivity, and to increase freedom of choice in unit coil weight, the development of endless rolling technology for endless rolling by weld-joining billets in line was started. Since the wire rod mill of the Kamaishi Works is of the multi-strand type, and is a mill that specializes in the production of high-quality wire rods like those for steel tire cord use, the weldjoining machine system and the product assurance technology for the weld-joined section were newly developed. Thus, endless rolling, the only one of its kind in the world to be applied to a multistrand type rolling mill, was realized.

#### 2.2 Outline of equipment and weld-joining control

**Figure 1** shows the layout of the wire rod mill. The weld-joining machine is installed between the reheating furnace and the roughing mill, and pinch rolls are installed before and after the weld-joining machine. In the present conventional rolling, to prevent problems caused by the contact of the foregoing billet and the following billet during rolling, a constant spacing is maintained between the billets by adjusting the billet extraction timing in the sequential control of the reheating furnace, and by adjusting the feeding speed of the pinch rolls installed before and after the weld-joining machine in the sequential control of the rolling mill.

However, in endless rolling, the billet feeding speed is controlled

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Fig. 1 Layout of Kamaishi wire rod mill

so that the billets come in contact with each other. Then, the speed of the weld-joining machine is synchronized to the rolling speed of the billet and the weld-joining machine welds, and upsets the billet ends (**Fig. 2**). To complete the series of the weld-joining operation within a confined space between the reheating furnace and the roughing mill, the flush-butt welding method is employed and weld-ing within a short time has been enabled. After the completion of the weld-joining, the weld-joined section is deburred by the deburring machine and tracked during rolling. The wire rod is cut in the reforming tub to produce a coil of the prescribed weight. The entire series of the above operation is automated and the endless rolling has been realized without increasing the working load of mill operators (**Fig. 3**).

#### 2.3 Features

#### 2.3.1 Application to multi-strand mill

Endless rolling in a single-strand mill has already been applied in other companies. However, since the wire rod mill of the Kamaishi Works is of the multi-strand rolling mill type, study of a new machine configuration was required. Since the space between the strands is confined, installation of a weld-joining machine on each strand like in a single-strand mill is difficult. Therefore, a weld-joining machine shiftable across the rolling strands and applicable to plurals of rolling strands was developed in order for a weld-joining machine to enable weld-joining on each strand. During the weldjoining operation of billets, the weld-joining machine travels at a speed synchronized to the rolling speed, and after the completion of weld-joining, the weld-joining machine returns to the starting position. Then it is shifted sideward to the adjacent strand position to stand by for the next weld-joining. By repeating this cycle of operation, the endless rolling has been realized in the multi-strand type rolling mill.

Other subjects in applying the endless rolling to a multi-strand mill concern deburring and the countermeasure for sputtering during welding. The weld-joining method of the endless rolling is flushbutt welding and sputtering takes place during weld-joining. There is a concern over the sputtering causing equipment and/or quality problems on the wire rod being rolled in the adjacent strand. There-



Fig. 2 Operation flow diagram of welding procedure

fore, to realize problem-free operation, it is necessary to suppress sputtering.

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To solve the problem, for the purpose of minimizing the adverse effect of sputtering to the extent possible, shutters to enclose sputtering within the strand and scrapers to deal with the sputter adhering to shutters were developed (**Fig. 4**). Both the shutters and the scrapers are designed so as not to exert influence on the weld-joining operation, and the shutters are used only during weld-joining operations. This development has greatly contributed to the stable operation of the weld-joining machine.

Furthermore, as burr is produced at the weld-joined section, the development of a deburring machine was necessary to prevent problems after rolling. However, in the confined space between the weldjoining machine and the roughing mill, a space has to be secured for allowing the weld-joining machine to travel until the completion of weld-joining at a speed synchronized to the rolling speed of the billet. The deburring machine must be essentially compact as deburring has to be applied to the four sides of the billet and a wide space is required when the machine is of the travelling or driven type. To solve the problem, a compact deburring machine was developed wherein the cutting tools are pressed onto the billet surfaces vertically and the pushing force of the billet in rolling is utilized. Furthermore, the deburring operation timing was determined, being synchronized to the tracking based on the rolling speed. The structure of the deburring machine could be made compact.

2.3.2 Application to high-quality steel

Adoption of the weld-joined section as salable products has al-

ready been practiced for commercial quality steel in other companies. However, as the application to steel tire cord was unprecedented, it is vitally important to establish the welding condition that guarantees an acceptable quality of the weld-joined section. To solve the problem, in the experiment conducted on the actual equipment base, the welding power, the welding time and the disrupting displacement in weld-joining were adjusted so that the nonmetallic inclusions are entrapped in the burr and discharged from the weldjoined section. Then, a welding condition that realizes breaking-free wire drawing even for steel tire cords was established. With the application of the technology, the uniformity in quality along the entire length of a wire rod has been secured (**Fig. 5**).

Furthermore, by fully utilizing the technology, the production of 2.5-ton coils has been realized by dividing into four the wire rod of the five weld-joined 2-ton billets. The production of the 2.5-ton unit weight coil realizes the improvement in productivity on the part of customers as the frequency of the preparation of the material coil and welding in the wire-drawing is reduced. Thus, by producing 2.5-ton unit weight coils from 2-ton billets, the production of large unit weight coils without investment in equipment on a large scale for applying large weight billets has been realized (**Fig. 6**).



Fig. 3 Welding procedure





Fig. 4 Schematic of shutter and scraper

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## 3. Conclusion

I contributed to the improvements in yield, productivity and the freedom of choice in unit coil weight by the application of endless rolling to a multi-strand rolling mill for the first time in the world, the development of technology that guarantees quality in the weld-joined section of the wire rods for steel cord use, and its application to actual production.



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