NIPPON STEEL & SUMITOMO METAL TECHNICAL REPORT No. 111 MARCH 2016

Technical Report

UDC 621 . 771 . 25

Progress of Bar and Wire Rod Rolling Process, and Improvement of Basic Quality

Shohhei SAKIYAMA* Keisuke SAITOH
Takeshi NAKAJIMA Masahiro ISHIMARU
Atsushi AOYAMA

Abstract

After hot rolling, bar and wire rod products undergo various lengthy processing steps in the hands of customers until they are ready to be manufactured as end products. Therefore, to reduce production cost, the omission of certain processing steps is desired. To achieve this, in the bar and wire rod mills of Nippon Steel & Sumitomo Metal Corporation, measures such as improving dimensional accuracy, reducing surface defects, and introducing controlled rolling technology have been implemented. Furthermore, a novel continuous rolling technology has been introduced to multi-strand mills in order to improve productivity and alleviate work load in customers' processing by increasing the unit weight of the coil.

1. Introduction

Bars and wire rods are known for the long subsequent processing they undergo in the secondary and tertiary processors until the final end products are produced. Furthermore, as such end products are used in many cases as vital parts in various industrial fields, efforts for process rationalization in integrated collaborations with customers are incessantly sought for. To date, each rolling mill, belonging to the Bar and Wire Rod Division, has tackled the introduction of in-line heat treatment facilities and development of small-diameter wire rods and controlled rolling with the goal of omitting certain processing steps, improving productivity, and energy saving. In recent years, amid the ever-growing intense competition with overseas suppliers and with the intention of establishing stronger competitiveness in product quality by improving dimensional accuracy and product metallurgical quality, efforts to improve equipment and operations are being promoted. In this article, the following cases of the above performed in Nippon Steel & Sumitomo Metal Corporation are introduced: (1) the new intermediate rolling mill of the wire rod mill of the Kimitsu Works, (2) the high rigidity three-roll-finishing rolling mill of the bar mill of the Yawata Works, (3) endless rolling in the wire rod mill of the Kamaishi Works, and (4) the renewal of pouring reel and its master control system of the bar mill of the Muroran Works.

2. Renewal of Intermediate Rolling Mill of the Wire Rod Mill of Kimitsu Works

The wire rod mill of the Kimitsu Works started operation in 1971 as a mill equipped with a no-twist block mill installed on each of four strands and a highly efficient mill capable of simultaneously rolling different qualities and sizes of steel materials. Recently, in 2008, a new intermediate rolling mill (pre-finish block mill (PFB)) was introduced, and a significant improvement in the dimensional accuracy has been achieved. The mill is currently realizing high quality and efficiency. The outline of the renewal and the technical points are reported hereafter.

2.1 Background

The wire rod mill of the Kimitsu Works started operation as a highly efficient mill consisting of a four-strand parallel-rolling roughing first intermediate rolling mill with 13 stands, two two-strand-parallel-rolling second intermediate rolling mills, and a single strand no-twist-finishing rolling mill with 10 stands installed on each of the four strands.

Since the start of the mills' operation, improvements in both quality and productivity have been promoted through measures such as the renewal of the reheating furnace to a walking beam type in 1989 and realizing reduction in surface imperfections, which was followed by an increase in the rolling speed through the renewal of the finishing mill motors and laying machines in 2001–2004. On the other hand, the rolling mills as a whole had not been renewed since

* Bar & Wire Rod Rolling Technical Dept., Bar & Wire Rod Rolling Div., Muroran Works
12 Nakamachi, Muroran City, Hokkaido 050-8550

the start of their operation, and variations in dimension caused by the change in the number of simultaneous rolling steps that specifically take place in multi-strand rolling continued to remain as a quality problem.

In recent years, customers' needs for dimensional accuracy have been becoming far more stringent, and, to comply with such needs, it was decided to implement a renewal of the wire rod mill at the Kimitsu Works, together with a drastic alteration in its layout. The finally selected layout was to employ one-strand rolling mills for the second intermediate rolling mill on each of the four strands to reduce the influence of change in the number of simultaneous rolling in strands, leaving the layout of the existing one-strand rolling finishing mills unaltered. Furthermore, the plan of employing three-roll-rolling mills appropriate for high precision rolling as the new rolling mill was selected.

2.2 Outline and features of PFB rolling mill

As the new rolling mill, two stands of the three-roll rolling mill were selected (**Fig. 1**). The major feature of the three-roll rolling mill is its ability to suppress the variations of dimension between the three grooved rolls that roll the entire circumference of a rolled stock and thereby lessen the spread as compared to a conventional two-high rolling mill (**Table 1**).

2.3 Construction of the rolling mill

To introduce the new rolling mill, as the new mills for four strands had to be laid out in a confined space, all the installations between the existing first intermediate rolling mill and the existing finishing mills were relocated (**Figs. 2** and **3**). The direction of the pass lines was changed by 90 degrees between the existing first intermediate rolling mill and the second intermediate rolling mill stands, and an intermediate looper was installed at the bent position of each pass line to absorb speed variation. After the second intermediate rolling mills, the pass line was bent again by 90 degrees to be led to an intermediate water cooling box that was installed to control the property of scale, and then on to the finishing mill. A looper is needed between the newly installed intermediate mills and

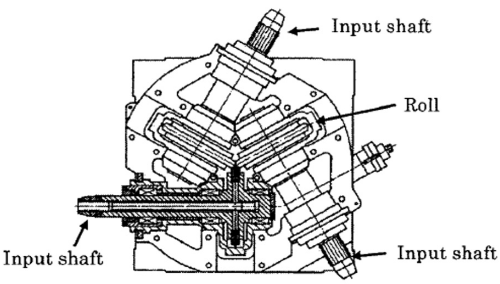


Fig. 1 Three roll rolling mill stand

Table 1 Specification of PFB

Type	Three input drive shafts
Motor capacity	AC 450 kW
Rolling pass	2 pass (reducing 2 pass)
Product size	15–19 mm ϕ
Rolling speed	Max. 9 m/s
Rollong temperature	Min. 920 °C
Roll diameter	215 mm ϕ
Roll gap adjustment	Manually operated
Manufacturer	Kocks GMBH & Co. (Germany)

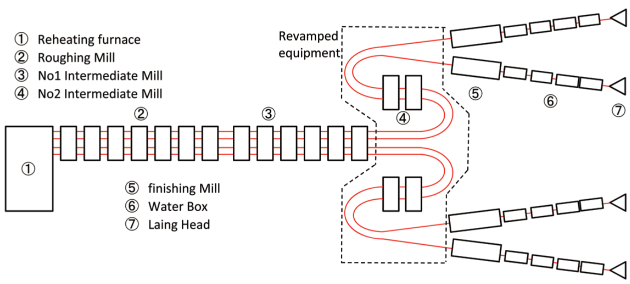


Fig. 2 Layout of Kimitsu Works wire rod mill

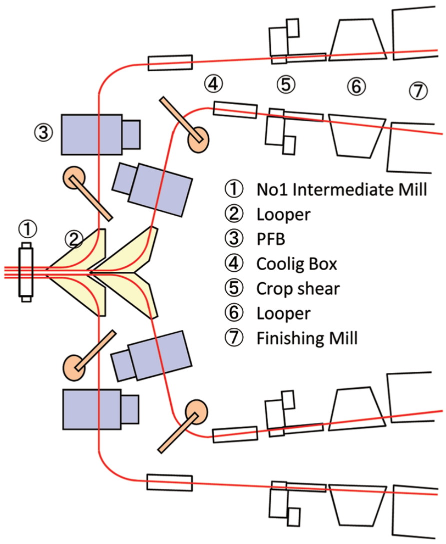


Fig. 3 Layout of intermediate rolling mills after renewal

the finishing mill to absorb speed variation. Since the pass line is set straight, a side looper was installed. An already existing crop shear was relocated for reuse to an upstream position on the pass line to secure a space for installing the finishing mill looper. For stand changing, a method using a jib crane was employed as space for installing the stand changing car was not available.

2.4 Improvement in dimensional accuracy

The majority of small and precision parts for automotive use represented by bolts and the like are formed by cold forging, and high dimensional accuracy is required of the wire rods used to make them.

In the wire rod mill of the Kimitsu Works, a tolerance of ±0.34 mm (for a product diameter of 15 mm) was the producible limit of accuracy, and the mill was unable to comply with the increasingly stringent needs of customers. Since four strand rolling is applied in the roughing and first intermediate rolling mill, a large dimensional fluctuation reaching as high as ±0.74 mm is caused by the influence of the varying number of simultaneous parallel rolling processes. Conventionally, the large fluctuation in dimensions could not have been damped by the second intermediate rolling mill and the finishing mill. After the renewal, in the second intermediate rolling mill where three-roll-rolling mills have been introduced, a drastic reduction in dimensional fluctuation has been successfully achieved, and the production structure for products with a dimensional tolerance of ±0.15 mm (for a product diameter of 15 mm) has been established (**Fig. 4**).

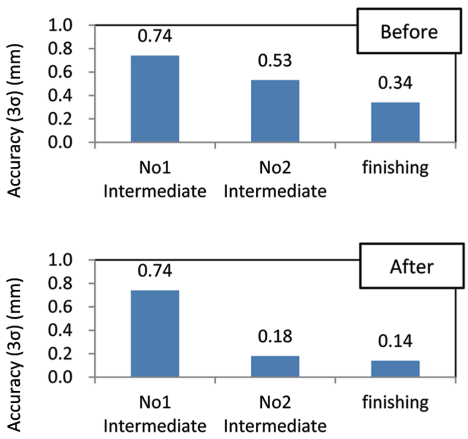


Fig. 4 Result of improvement in dimensional accuracy

2.5 Improvement in productivity

One of the major features of the new rolling mill thus introduced is that pluralities of product size in a wider range have become producible with a single common series of roll passes since the lateral spread is small. By utilizing the feature to the maximum extent possible, further integration of the series of roll passes in the first intermediate rolling mill was made possible. Before the introduction of the new rolling mill, there were three series of roll passes in the first intermediate rolling mill. There had been productivity-impeding restrictions in rolling of different steel quality materials and product sizes in simultaneous rolling. However, upon introduction of the new rolling mills, the series of roll passes was reduced to two, and significant improvement in productivity could be achieved as the restrictions in rolling of different steel quality materials and different sizes in simultaneous rolling were alleviated. With this, a drastic improvement in productivity has been achieved.

2.6 Summary

Improvement in dimensional accuracy has been achieved by the introduction of new rolling mills to the second intermediate rolling mill. The new rolling mills have been in operation since December, 2008.

3. Introduction of a High Rigidity Three-roll-mill to the Bar Mill of the Yawata Works

The bar mill of the Yawata Works started operation in 1976. It is a one-strand fully continuous rolling type mill that produces straight and coiled bars (**Fig. 5**, **Table 2**). In 2009, the three-roll finishing mills were renewed with the goal of improving productivity, reducing production cost, and improving compliance with customers' needs, such as cost reduction in their material, cost reduction in their in-house production, omission of certain processing steps in their production lines, and shortening of delivery time. This article reports the outline and the technical points of the renewal.

3.1 Background

The bar mill of the Yawata Works used to produce commercial grade steel typically used as an architectural material with two high rolling mills (8 stand roughing rolling mill, 4 stand intermediate rolling mill, and 4 stand finishing rolling mill) was built by Morgan-Sumitomo Heavy Machinery Co. Ltd.. In the 1980s, the aimed quality of products was shifted toward high-value-added special steel quality, and, to achieve this, in 1986, a three-roll finishing rolling mill (applied to products of 13–70 mm in diameter) was employed for the first time in Japan in the finishing rolling mill. Later, in 1996, the three-roll finishing rolling mill was renewed with the addition of a stand, intended to give improvements in product quality and productivity and a reduction in production cost.

As customers' needs have been becoming increasingly sophisticated (such as needs for larger-diameter size products and reductions in quality variation), it has become increasingly difficult for the three-roll finishing rolling mill that was installed almost 20 years ago to comply with them. To be able to comply with customers' needs and obtain improvements in productivity and reductions in production cost, it was decided to renew the finishing mill with three-roll rolling mills of the latest design.

The bar mill produces straight bars of 18–120 mm in diameter and bars in coil of 18–52 mm in diameter. After shipment from the mill, these straight bars and/or bars in coil are processed to end products (fasteners, shafts, hubs, cranks, and so on) which are characteristically used as machine parts after various processing steps, such as heat-treatment, annealing, drawing, forging, and cutting in secondary and tertiary processors. Our customers, who carry out such processes, had been demanding improvements such as a reduction in material price, a reduction in production cost in their processing line, the omission of certain processing steps, and a shortening of delivery time and, these demands were growing stronger year by year.

Taking into account such customers' needs, the following items were projected as targets for the introduction of three-roll rolling mills of the latest design.

1) Achievement of high productivity
- Integration of a series of roll passes (pass schedules) by taking

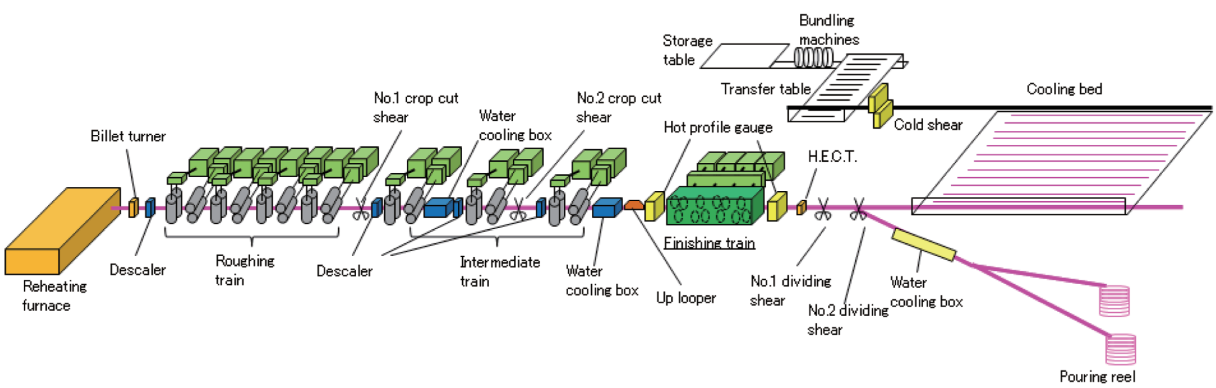


Fig. 5 Layout of Yawata Works bar mill

Table2 Specification of RSB

Type	Three input drive shafts
Motor capacity	DC 1 200–2 100 kW
Rolling pass	4 pass (reducing and sizing)
Product size	18–120 mm ϕ
Rolling speed	1 300 rpm
Roll diameter	435 mm ϕ
Roll gap adjustment	Remote control
Manufacturer	Kocks GMBH & Co. (Germany)

advantage of free-size rolling
- Shortening of size changing time by the integration of a series of roll passes
- Reduction in material cost like rolling rolls and so on by the integration of a series of roll passes

2) Effect in reducing variation of quality
- Enlarging the range of application (up to 120 mm in diameter) and improvement in dimensional accuracy of all products.
- Stabilization of controlled rolling
- Compliance with production of middle size products by taking advantage of free-size rolling

3) Shortening of delivery time, compliance with small-lot production
- Adoption of multi-cycle rolling schedule by taking advantage of improved productivity
- Compliance with small-lot production by taking advantage of improved productivity

3.2 Features of three roll rolling mill of high rigidity

The following three items are the major features of the three-roll rolling mill of high rigidity.

1) Products of 18–120 mm in diameter can be rolled.
2) Free-size rolling is possible.
3) Products with improved variation in quality are obtained.

In particular, "free-size rolling" is a method capable of rolling and producing products of different sizes by simply changing the roll gap of the same rolls and is a very effective method in complying with such subjects as the shortening of the size changing time, production of middle size products, adoption of multi-cycle rolling, production of small-lots, and reduction in material cost. Though production had been carried out by the old three-roll rolling mill by taking advantage of these features, because of the complexity of its mechanical structure, the mill rigidity was poor, imposing restrictions on controlled and precision rolling of large-diameter bars. Furthermore, as stated above, the applicable size range was limited. In the renewal, the achievement of world top-level competitiveness was aimed at by removing such restrictions.

3.3 Effects obtained by introduction

3.3.1 Achievement of high productivity

Owing to the enlarged size range of application, a finishing roll pass groove that had been arranged for each size of the large diameter bars has become unnecessary, and furthermore, as a result of the integration of feeders by free-size rolling, pass schedules have become simplified, (series of roll passes) and the number of pass grooves required in the two-high roll mills has dropped to 31 after remodeling from 57 before remodeling.

As for the size changing time for large diameter sizes, for instance, the size change time required for the two high rolls from 85 to 83 mm diameter products was 5 minutes before the remodeling, but the size changing time has been shortened to below one minute as only remote-controlled three-roll rolling mill gap adjusting is required after the remodeling. Furthermore, the total size changing time before and after the remodeling is shown in **Fig. 6**. As an effect of the remodeling, a shortening of the total size changing time by 31% as compared to before the remodeling has been achieved.

3.3.2 Effect in reducing quality variations

As for the dimensional accuracy of products of 18.0–120.0 mm in diameter, with the application of precision rolling in the new three-roll rolling mills, high accuracies such as the following have been obtained; within ±0.1 mm for products of sizes below 70.0 mm in diameter, within ±0.15 mm for products of sizes between 70.0 and 100.0 mm in diameter, and within ±0.20 mm for products of sizes above 100.0 mm in diameter (**Figs. 7** and **8**). Furthermore, as for the dimensional accuracy when free-size rolling is applied, high accuracy of products as follows have been obtained; within ±0.2 mm for products of sizes below 70 mm in diameter and within ±0.3 mm for products of sizes over 70.0 mm in diameter.

Based on these results, it has become possible for the bar mill of

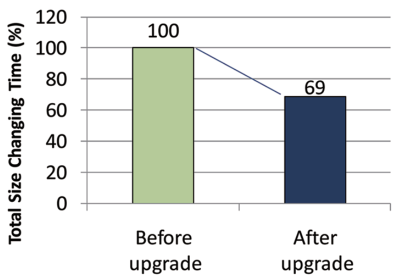


Fig. 6 Total size changing time (total in a month)

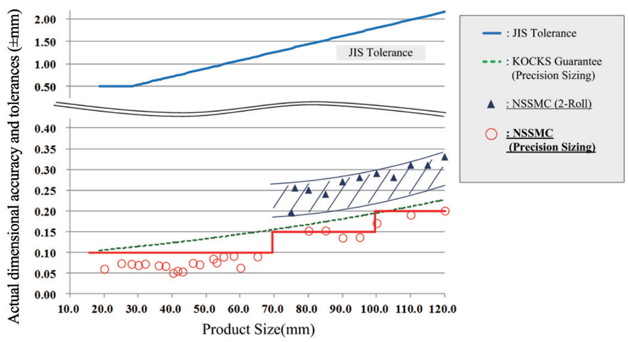


Fig. 7 Actual dimensional accuracy data of products between 18.0 mm–120.0 mm in diameter

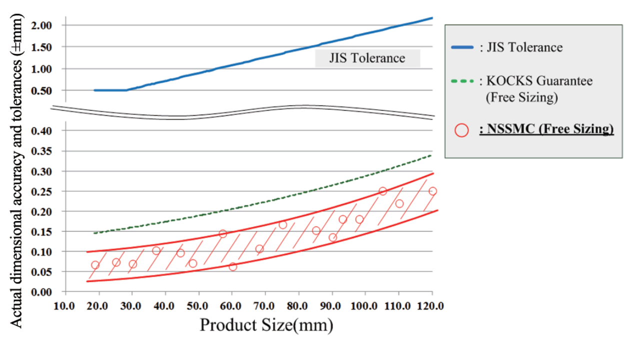


Fig. 8 Actual dimensional accuracy data of products between 18.0 mm–120.0 mm in diameter rolled by free-size rolling

the Yawata Works to produce any middle size products in the production range 18.0–120.0 mm in diameter by applying free-size rolling technology. With this, a production structure realizing great contribution to the omission of certain processing step(s) and an improvement in yield in customers' processing lines has been established. Furthermore, concerning the controlled rolling practiced in the bar mill, micro-metallurgical structures equivalent to the one at the level before renewal have been obtained, controlled rolling maintaining the dimensional accuracy of the same level with conventional rolling as mentioned above in the size range of 18.0–120.0 mm in diameter has been proven to be possible, and continued production of controlled-rolled products having higher accuracy has been realized. As a result, in addition to the effect of omitting heat treatment processes realized by controlled rolling, omission of drawing processes and/or improvement in yield in machining processes are also possible. Thus, the renewal has contributed greatly to the reduction in production cost for our customers.

3.3.3 Shortening of delivery time, compliance with small-lot production

When multi-cycle rolling is applied, frequent size change work was necessary with the former series of roll passes. Therefore, in case attainment of production amount is prioritized, only one rolling chance was provided for a size in a month, and two rolling chances in a month were provided for sizes with a large amount of production and production lot was also made large, being concentrated. After renewal, as the time spent for size change has decreased, compliance with multi-cycle rolling like two roll chances/month and/or three roll chances/month has become possible while maintaining the past productivity. Furthermore, compliance with small-lot production has been made easier compared to before the renewal, enabling compliance with shorter delivery times and small-lot production required by customers.

3.4 Summary

The following effects were obtained by three-roll rolling mills of high rigidity that started operation in August of 2009.

- Integration of series of roll passes (pass schedules) by taking advantage of free-size rolling
- Reduction in cost of materials like rolling rolls by the integration of series of roll passes
- Shortening of size changing time by the integration of series of roll passes
- Improvement in dimensional accuracy of all round bar products produced in the bar mill
- Production of middle size products in the entire production range by taking advantage of free-size rolling
- Stabilization of quality of control-rolled products
- Adoption of multi-cycle rolling and compliance with small-lot production by taking advantage of the integration of the series of roll passes

The authors are determined to establish the top-ranking bar mill in the world by complying with customers' ever more stringent and sophisticated needs, fully utilizing the capability of the new mill, and making incessant efforts to improve productivity and reduce production cost.

4. Development and Application to Actual Operation of Endless Rolling Technology in the Wire Rod Mill of the Kamaishi Works

The wire rod mill of the Kamaishi Works is the wire rod mill having the longest operation life among mills currently operating in Japan. During its operation, the mill promoted improvements in quality and productivity and continued to secure top level quality and productivity. Currently, the mill is under operation as a multi-strand mill, producing mainly wire rod steels of high quality represented by steel tire cord and cold heading use with high efficiency. The endless rolling was introduced to the multi-strand mill in 2001 for the first time in the world, intended for improvements in yield and productivity and for enhancing freedom in choice of coil unit weight. The details of this technology are introduced in this section.

4.1 Background

In the wire rod mill of the Kamaishi Works, billets are rolled continuously to designated sizes through 28 rolling stands. The end part of a billet has to be cut and removed during and after rolling to prevent the occurrence of rolling troubles due to defective shape and to remove the unstably temperature-controlled part. Furthermore, a certain spacing has to be secured between billet ends to control the rolling operation. These factors lead to inevitable losses in yield and productivity. Furthermore, in the rolling of wire rod, two-ton or one-ton coils are produced from two-ton billets; however, wire rod processors such as steel tire cord producers require increased unit weight coils to improve their productivity.

To obtain improvements in yield, productivity, and increasing freedom of choice of weight of a coil, the development of endless rolling technology wherein billets are weld-joined on-line and rolled continuously was started. Since the wire rod mill of the Kamaishi Works is multi-strand mill and has been producing high quality steel mainly for steel tire cord, the construction of a weld-jointing system and new technology for developing the quality of the weld-joined section to a commercially acceptable product quality were newly developed, and an endless rolling operation, the only one among multi-strand mills in the world, has been realized.

4.2 Outline of equipment

Figure 9 shows the layout of the wire rod mill. The joining machine is installed between the reheating furnace and the roughing mill, and pinch rolls are installed before and after the joining machine. In conventional rolling, a constant spacing is always provided between billets by adjusting the billet extraction timing in the sequential control of the reheating furnace and/or by adjusting the transfer speed of the pinch rolls before and after the joining machine in the sequential control of the roughing mill. On the other hand, for joining billets in the endless rolling, the billet transfer speed is controlled by the front and rear side pinch rolls. Then, after that, the speed of the joining machine is synchronized with the transfer speed of the billet, and welding and upsetting are applied to billet ends.

Owing to the development of the technology, joining without lowering the rolling speed was realized. Furthermore, to complete welding within a confined space between the reheating furnace and the roughing mill, a flash-butt welding method was employed, and welding within a short time has been enabled. After the completion of joining, the burr produced at the weld-joined section is removed by a deburring machine. After rolling, the weld-joined section is tracked, and the coil is cut in the reforming tub to supply a coil of prescribed weight. The entire series of the above operation is done automatically, and the endless rolling has been realized without increasing the work load of operators.

4.3 Features

4.3.1 Application to multi-strand mill

Endless rolling in a single-strand mill has been already practiced in other companies. However, since the wire rod mill in Kamaishi Works is of multi-strand mill type, new construction of equipment

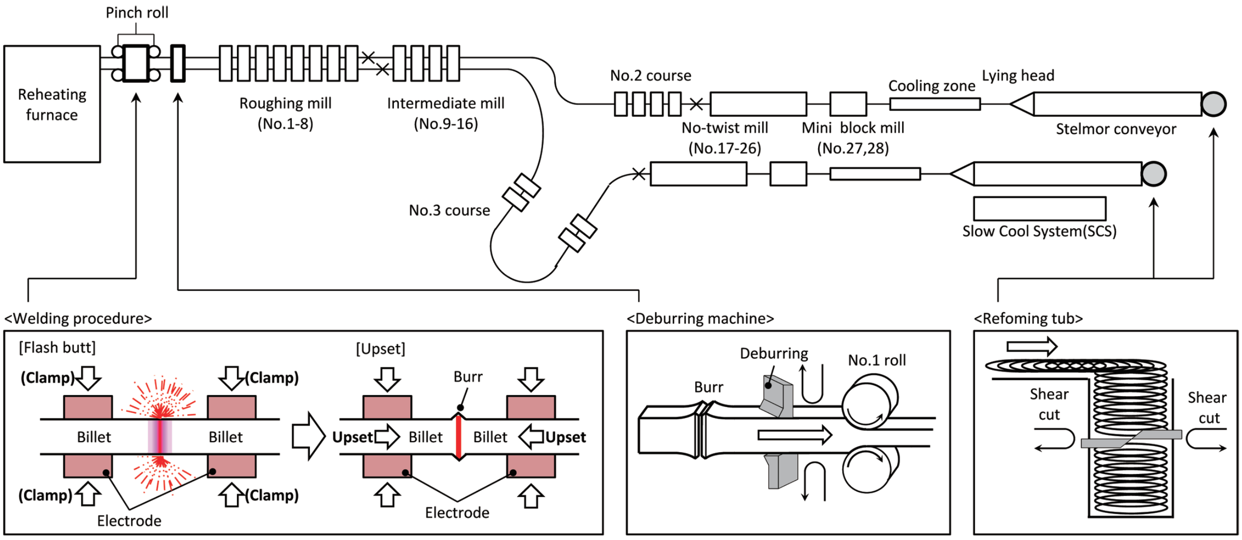


Fig. 9 Layout of Kamaishi Works wire rod mill

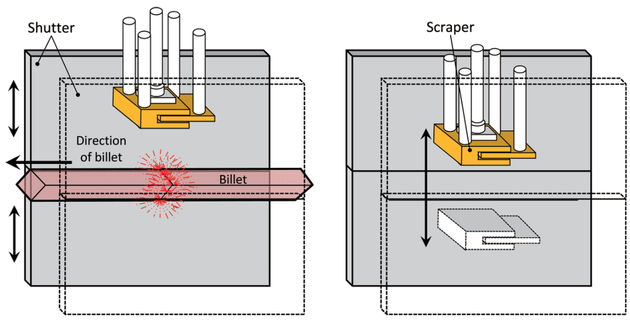


Fig. 10 Schematics of shutter and scraper

had to be studied. Since the space between the strands is confined, the installation of a joining machine on each strand as in the case of a single-strand mill is difficult. Therefore, a joining machine that can be shifted across the rolling strands and applicable to multiple rolling strand mill was developed in order for a joining machine to enable joining on each strand. During the joining operation, the joining machine travels at a speed synchronized to the rolling speed, and, after completion of joining, the joining machine returns to the joining-starting position, shifting sideways to the adjacent strand position to stand by for the next joining operation. By repeating this cycle of operation, endless rolling was realized in the multi-strand mill.

Other subjects that existed were the countermeasures for sputtering that takes place in joining and deburring. The joining method in the endless rolling is flush-butt welding, and sputter is generated during joining. There is a concern over the sputtering causing equipment troubles and/or quality problems on the wire rod being rolled on the adjacent strand. Therefore, to realize trouble-free operation, it is necessary to suppress sputtering.

To solve these problems and to minimize the effect of sputtering to the greatest extent possible, a shutter to enclose sputtering and a scraper attached to the shutter to deal with the sputter were developed, and trouble-free operation has been realized (**Fig. 10**). Both the shutter and the scraper are designed in such a way as not to exert influence on the joining operation; the shutter is actuated only during the joining operation, and the scraper is actuated between join-

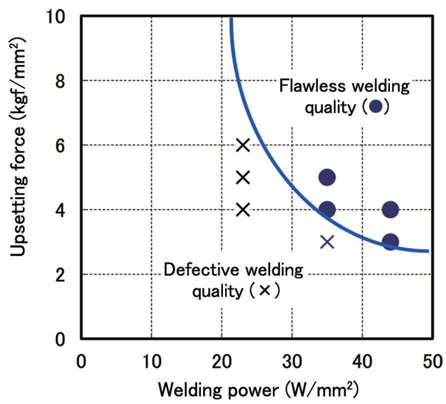


Fig. 11 Welding condition

ing operations. Furthermore, as burr is produced at the joining section, the development of a deburring machine was necessary. However, since the spacing between the welder and the roughing mill was limited, the development of a compact deburring machine was essential. To solve this problem, a compact deburring machine utilizing pushing force in rolling and a cutting tool was developed. Furthermore, the deburring operation timing was synchronized with the tracking of the joining section.

4.3.2 Application to high quality steel

Making the weld-joined section to saleable product is already currently practiced for commercial grade steel in other companies; however, as the application to steel tire cord is unprecedented, it was vitally important to ascertain the welding condition to guarantee that the quality of the weld-joined section is acceptable as required product quality. To this end, the welding power, welding time, and upsetting displacement were adjusted in the experiment conducted on the actual equipment in order for the nonmetallic inclusions to be discharged from the weld-joined section by being entrapped in the burr. Thus, a welding condition that realizes breaking-free wire drawing even for wire rods for steel tire cord has been established (**Fig. 11**). With the application of this technology, uniformity in quality along the entire length of a wire rod has been secured. By fully utilizing the technologies, production of 2.5 ton coils from 2 ton billets has

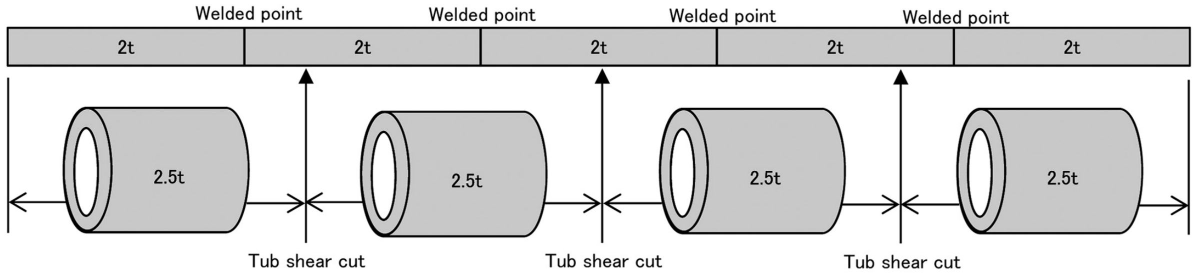


Fig. 12 Production process of coils of different weight

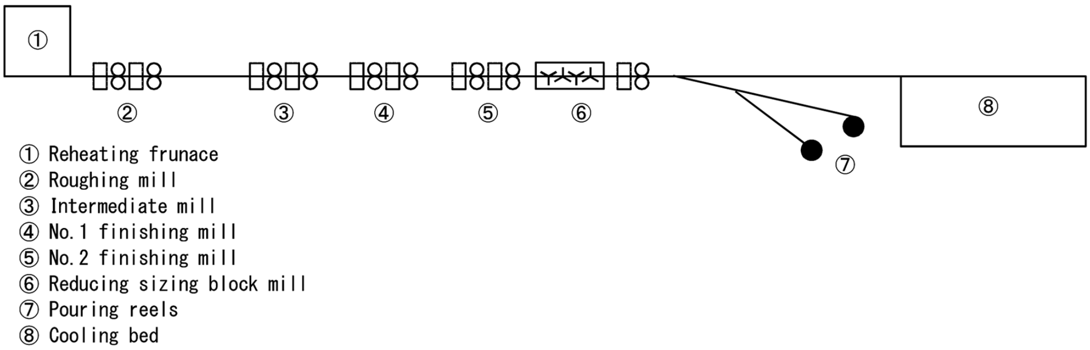


Fig. 13 Layout of Muroran Works bar mill

been realized (**Fig. 12**).

4.4 Summary

The application of endless rolling to a multi-strand mill for the first time in the world and the development of a technology that guarantees the same uniform quality in the weld-joined section and application thereof to actual use have greatly contributed to the improvements in yield, productivity, and freedom in choice of coil weight.

5. Renewal of Pouring Reel and Master Control System of the Bar Mill of the Muroran Works

The bar mill of the Muroran Works started its operation in 1974 as a special steel bar mill and has been operated as a mill capable of producing two types of product (straight and coiled bars) since after the installation in 1988 of a coiled bar production line transferred from the old wire rod mill (**Fig. 13**). However, as for the bar-in-coil line, since forty five years had passed since the bringing into service of the pouring reel, and twenty eight years had passed since the bringing into service of the master control system, both sets of equipment were renewed in April, 2014 due to ageing. In the renewal, improvements in basic quality (coil outlooks and surface defects caused in banding), productivity and, working environment were aimed at. The content of the renewal is introduced below.

5.1 Outline of renewal of pouring reel and its feature

5.1.1 Problem of previous pouring reel

Figure 14 shows the schematic drawing of the previous pouring reel. A pin type was employed in which pins were arranged at an equal circumferential interval in a doughnut-like double-circular arrangement in a drum and, among such degradation of the entire equipment as distortion and deformation that had progressed over years, the deformation of the mechanism of the inner side pins was noticeable and was causing poor coil outlooks and surface defects due to contact of the pins with steel bars during its eccentric rotation in coiling. Furthermore, as the pins were not equipped with cooling apparatus and as the surface temperature became very high during coiling, a rough skin was developed on the surface of the pins by the seizure, and surface defects were also developed when the rough skin contacted the external side of a coil while it was being lifted after coiling. Therefore, the rolling operation had to be suspended periodically for an operator to go down into the inside of the reel to grind the rough skin on the surface of pins. This drop in productivity was a problem, and solution was also required as it was a work under a high temperature environment.

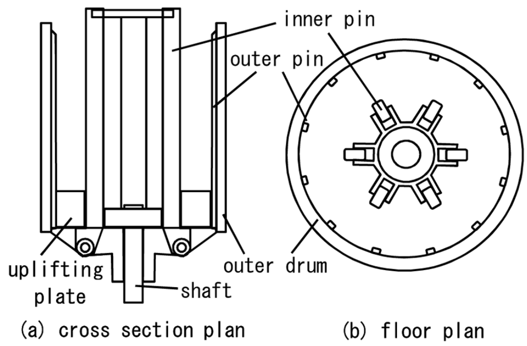


Fig. 14 Pouring reel before renewal

5.1.2 Feature of new pouring reel

The floor plan of the new pouring reel is shown in **Fig. 15**, and the main specifications of the pouring reel are shown in **Table 3**. There are two main points of modification from the previous one. First, a drum type (to increase contact of area with a coil) was employed, which was designed to prevent deterioration in coil outlooks due to the absence of containment of a coil between pins, a weak point of the previous reel, and for suppressing defects developed by

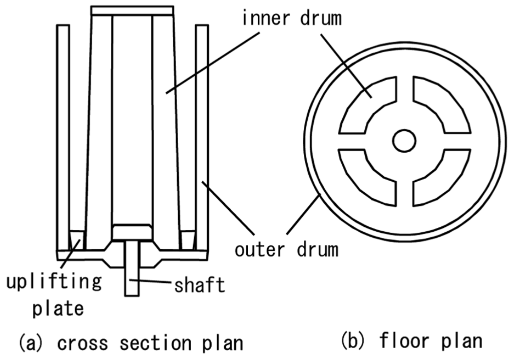


Fig. 15 Renewed pouring reel

Table 3 Main specifications of pouring reel

	Existing	New
Type	Pin	Pinless drum
Outside diameter	1400/1270 mm	1350 mm
Inside diameter	1010 mm	1000 mm
Height	1800 mm	2300 mm
Motor capacity	400 kW	600 kW
Manufacturer	Hitachi Zosen (Kobelco)	Danieli (Morgårdshammar AB)

the contact of a coil with pins. Second, a water cooling system is provided for suppressing seizure on the surface of the inside and outside drums. In addition, the motor capacity was increased to enable an increase in the maximum possible coiling speed from 16.5 m/s to 20.0 m/s.

5.2 Outline of renewal of master control system

Twenty eight years had passed since 1986 when the master control system that controls the operation of the equipment of the entire bar-in-coil line was brought into service. Spare parts have now ceased to be produced. In addition, because of the insufficient capacity of the control software, the actual state was that even the modification of a certain scale was impossible. In the renewal of the master control system, the previous system was replaced by one of the latest designs in the subject field, and an on-line-data collection system that enables the preservation and analysis of control data was introduced. With this system, the prevention of recurrent equipment troubles and/or quality deterioration was realized by the analysis of the operation data whenever equipment trouble and/or quality defects take place. Furthermore, along with the renewal of the pouring reel machine, the controlling software of the coiling system was remodeled, and improvements in coil outlooks and lowering of defects caused in banding were achieved.

5.3 Improvement in fundamental quality of bar-in-coil

5.3.1 Improvement in coil outlooks

Coil outlooks can be evaluated by the filling rate of a bar within a coil, and it is generally considered that the higher the filling rate is, the better the coil outlooks become. The filling rate is defined as the coil height per ton of a coil obtained by dividing the height of a coil after banding by the weight of the coil. As an example, coil height data before and after the renewal of S10C 19 mm diameter bars are shown in **Figs. 16** and **17**. After the renewal, the coil height was on average lowered by 9%, and the improvement in coil outlooks was achieved. Similar results have been obtained in differently sized

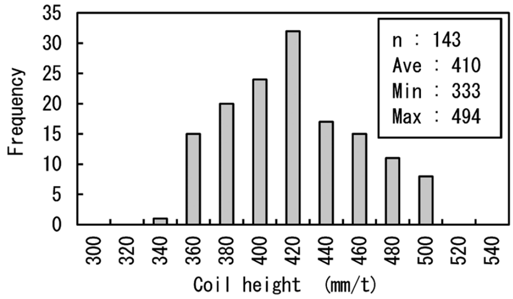


Fig. 16 Coil height before renewal (19 mm dia. S10C)

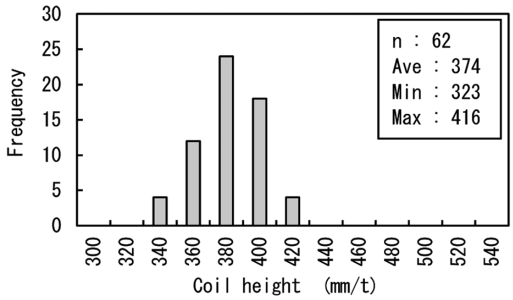


Fig. 17 Coil height after renewal (19 mm dia. S10C)

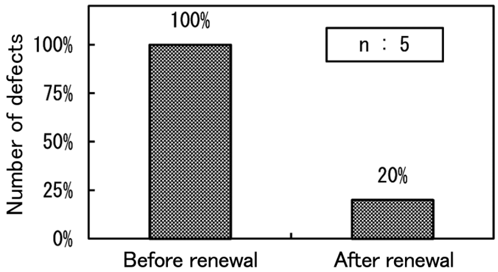


Fig. 18 Numbers of defects caused in banding before and after renewal (19 mm dia. S10C)

products.

5.3.2 Effect in reducing defects caused in banding

As a reduction in defects caused in coil banding is expected by improving the coil outlooks, an S10C 19 mm diameter bar rolled before and after the renewal was inspected for defects (offline inspection for the entire length), and the result is shown in **Fig. 18**. The number of the banding-caused defect has been reduced by 80% with respect to the figure before renewal, and the effect in reducing the banding-caused defect has been confirmed.

5.4 Other effects

Besides effects in improving coil outlooks and a reduction in banding-caused defects after the renewal of the pouring reel, as a result of the introduction of a drum water cooling system, the drum surface temperature during the coiling of a bar was controlled to below 200°C, and, therefore, roughened surface caused by seizure did not occur, the grinding work for the surface of pins that had been left unsolved could be eliminated, and improvements in productivity and working environment were realized.

5.5 Summary

By the renewal of the pouring reel and the master control system, improvements in fundamental coil quality (coil outlooks and banding-caused defects), productivity, and working environment have been realized in its commercial operation since May, 2014.

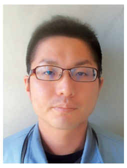
6. Conclusion

Examples of equipment renewal in the bar and wire rod mills in Nippon Steel & Sumitomo Metal have been reported. As stated in the article, to meet the continuously growing, stringent, and diversified demands of customers, we have to respond incessantly to develop world-leading technologies. The authors are determined to promote further research and development to supply bar and wire rod products produced with world-leading fully integrated capabilities and always remain one step ahead of customers' expectations.


Shohhei SAKIYAMA
Bar & Wire Rod Rolling Technical Dept.
Bar & Wire Rod Rolling Div.
Muroran Works
12 Nakamachi, Muroran City, Hokkaido 050-8550


Keisuke SAITOH
Manager
Technical Dept.
Production Div.
Kamaishi Works


Takeshi NAKAJIMA
Senior Manager
Plant Planning & Coordination Dept.
Production & Technical Control Div.
Kimitsu Works


Masahiro ISHIMARU
Manager
Bar & Wire Rod Rolling & Processing Technical Dept.
Bar & Wire Rod Div.
Yawata Works (Kokura Area)


Atsushi AOYAMA
Senior Manager
Bar & Wire Rod Technology Dept.
Bar & Wire Rod Technology Div.