Development of On-line Roll Dressing Technology for Plate Rolling

by

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Synopsis

An on-line roll dressing system using an abrasive-jet was developed and applied to SMI Kashima plate finishing mill. In this system, 70 MPa high pressure water and iron sand were used as abrasive materials to dress the surface of mill work rolls. The merit of using the abrasive-jet was that it could keep dressing stable even under vibrations because it was a non-contact dressing. This enabled on-line roll dressing during rolling. Durability was also satisfied.

The purpose of on-line roll dressing was to improve plate quality and to reduce limitations in rolling schedules. By using this system, it became possible to maintain plate crown through out rolling and to decrease plate flatness defects. And, roll changing frequency was cut in half.

1. Introduction

With the recent trend fowards continuity in rolling processes, there is increased need to develop width-schedule free-rolling technology. Customers are requiring better flatness because the automation in their cutting and welding process is increasing. Even in this situation, maintaining high Hot Charge Rolling (HCR) ratio is important in order to minimize energy consumption in slab reheating and ensure the best quality. It is very difficult to do this especially in plate rolling because of its many size and grade variations and small production lot.

To realize width-schedule free-rolling, the rough surface on mill work rolls, which results from weare in on-line dressing, needs to be removed. As an on-line roll dresser, there already are stone grinders and belt grinder. However, it is difficult to use such grinders in plate mills because it is hard to keep dressing stable under vibration, and there is the need to rotate rolls in one direction during dressing which means dressing has to be stopped when the mill reverses. Much installion space is also needed.

To solve these problems, an abrasive-jet type on-line roll dresser has been developed[1),2)] and installed at the SMI Kashima plate finishing mill[3),4)]. The outline of this dresser and some test results are reported in this paper.

2. Dressing evaluation

2.1 Examination Device and Method

Figure 1 shows the examination device used for dressing evaluation. The abrasive-jet method is applied to this device which is composed of a high-pressure water pump, abrasive materials supply tank, jet nozzle, and test roll. The abrasive material is mixed with in high-pressure water at the nozzle, and is sprayed on the roll surface. The nozzle is traversed along the roll axis.

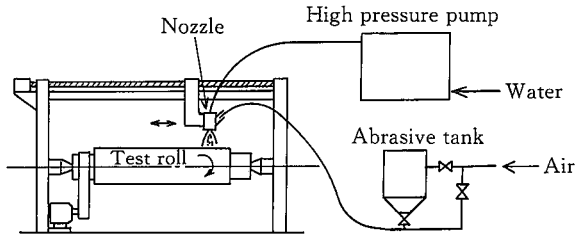


Fig. 1 Outline of examination device

Fig. 2 shows the nozzle structure. It is composed of a water jet nozzle that sprays water and an abrasive nozzle that sprays the mixture of water and abrasive material. The water velocity becomes about Mach 1 after it passes through the water jet nozzle.

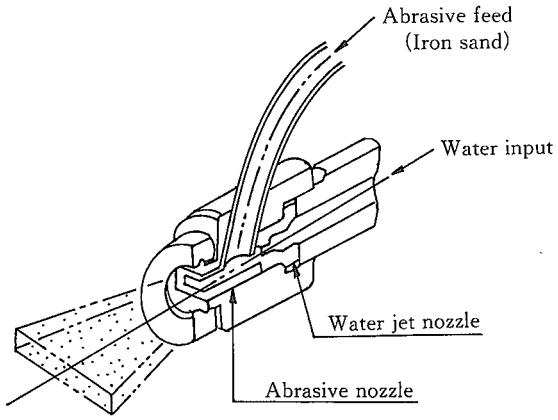


Fig. 2 Construction of nozzle

Experimental conditions are shown in **Table1**.

High-pressure water is generated by a three-ream plunger pump. It is capable of a pressure of 70 MPa and a flow rate of 42 l/min. The rolls are SKD11 for basic dressing evaluation, and Hi-Cr roll and Ni-Gr roll for real roll dressing evaluation. Abrasive materials such as iron and sand are used. They are raw materials for iron making, and are easy to find in steel works.

2.2 Examination Result of Basic Dressing Evaluation

SKD11 roll is used in basic dressing evaluation test.

(1) Relation between water pressure and dressing quantity

Figure 3 shows the relation between water pressure and dressing quantity. Dressing quantity increases as water pressure increases when the abrasive feeding rate is constant.

(2) Relation between abrasive feeding rate and dressing quantity.

Figure 3 also shows the relation between abrasive feeding rate and dressing quantity. Dressing quantity increases as abrasive feeding rate increases when water pressure is constant.

(3) Relation between water pressure and roll surface roughness.

Figure 4 shows the relation between water pressure and roll surface roughness. Even though roll surface roughness increases as water pressure increases, plate surface quality is not affected.

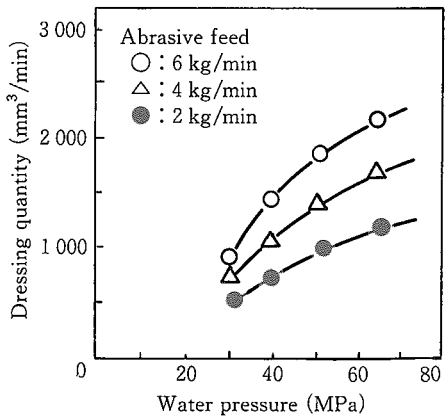


Fig. 3 Relation between water pressure and dressing quantity

Table 1 Experimental conditions

1.Test rolls	
(1)Material	SKD11 (Hs79) for basic evaluation test High Cr-cast iron (Hs70) ┐ for real roll Ni-grain cast iron (Hs75) ┘ evaluation test
(2)Diameter	75 mm (SKD11) 630 mm～1 100 mm (Hi-Cr, Ni-Gr)
2.High pressure water	
(1)Pressure	Max70 MPa
(2)Flow rate	42 l/min
3.Abrasive	
(1)Material	Iron sand
(2)Feed	Max 7 kg/min
(3)Tank volume	290 l
4.Nozzle traverse	
(1)Length	1 450 mm
(2)Rate	150～500 mm/min

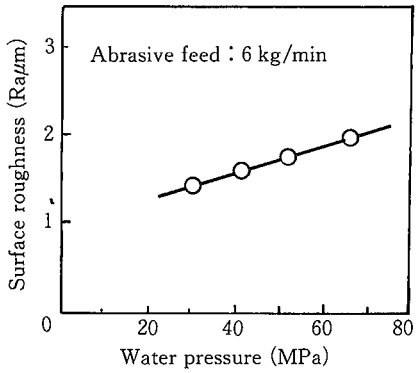


Fig. 4 Relation between water pressure and surface roughness

2.3 Examination Result of Real Roll Dressing Evaluation

Hi-Cr roll and Ni-Gr cast iron roll are used in the real roll dressing evaluation test to confirm if this method is sufficiently capable of real operation.

(1) Dressing quantity in different roll materials

Figure 5 shows the test results on dressing quantity in different roll materials. The target dressing quantity is more than the GOOD line. An adequate amount of dressing is obtained for practical use in both Hi-Cr roll and Ni-Gr cast iron roll.

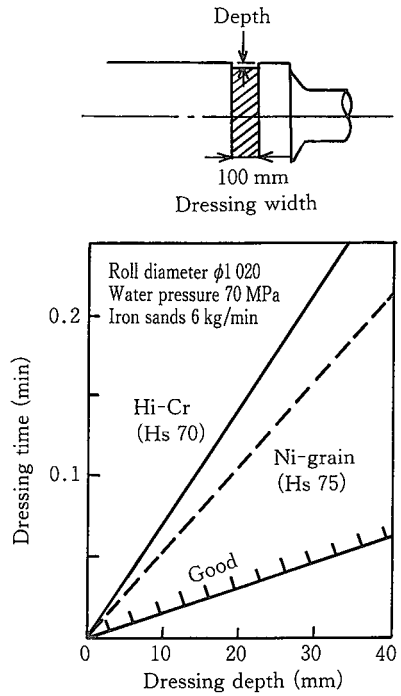


Fig. 5 Relation between dressing time and dressing quantity in different roll materials

(2) Relation between distance from nozzle head to roll and dressing quantity

Figure 6 shows the relation between distance from nozzle head to roll and dressing width and depth.

Figure 7 shows the relation between distance from nozzle head to roll and dressing quantity.

The dressing quantity increases with distance of about 100 mm, but it decreases when the distance is 150 mm or more. Thus, a distance of 100-150 mm between the roll and nozzle head offers the maximum dressing quantity.

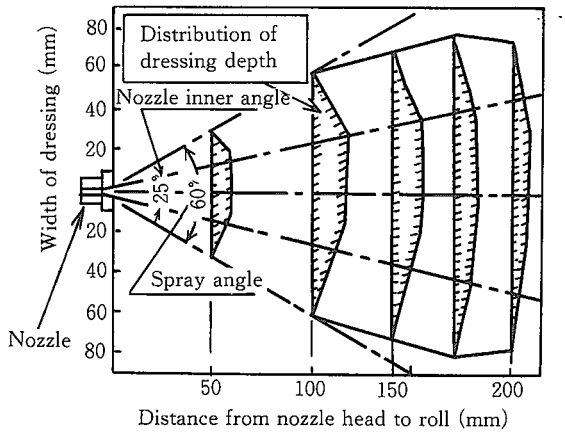


Fig. 6 Relation between distance from nozzle head to roll and dressing width and depth

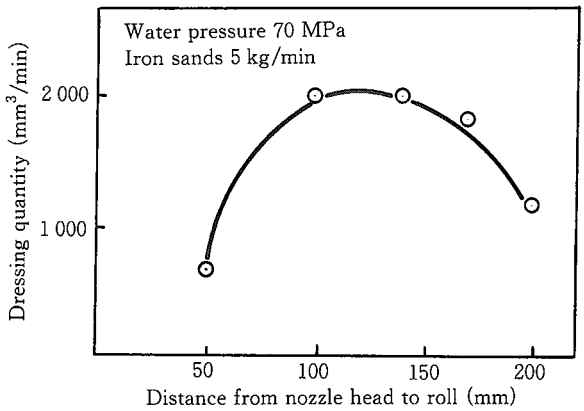


Fig. 7 Relation between distance from nozzle head to roll and dressing quantity

(3) Nozzle durability

When the nozzle is used for a long time, the dressing quantity may decrease, and the nozzle has to be changed. To keep the mill from shotting down, 150 hrs of nozzle life are required. **Figure 8** shows the comparison of dressing quantity between a new nozzle and a nozzle that has been used for 150 hrs. Though there is a little difference between the dressing quantity of both nozzles, durability is confirmed.

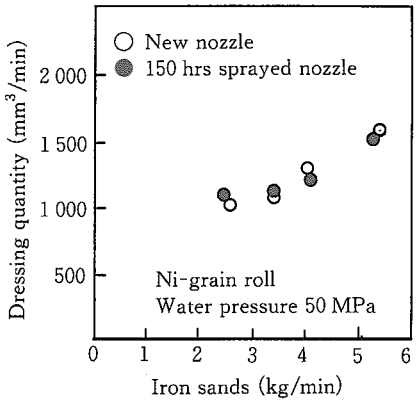


Fig. 8 Comparison of dressing quantity between new nozzle and a nozzle that has been used for 150 hrs

3. Installation in the Mill

3.1 Equipment Outline

The merit of using an abrasive-jet is that it is possible to keep dressing quantity stable even under vibrations because it is a non-contact dressing. And, it is possible to dress when the mill is reversing. Durability is also satisfied because the equipment in the mill is simple.

Figure 9 shows the outline of the equipment. It consists of a hopper to transport dried iron sand by compressed air, a water pump that supplies high-pressure water, four nozzles that spray a mixture of iron sand and high-pressure water, and the work roll to traverse the nozzles. The iron sand is temporarily saved in the 25 ton hopper, because the pipe becomes blocked while transporting the iron sand. When the iron sand is damp, it is dried with a dryer capable of drying 1.5 ton/hr. Dried iron sand is temporarily saved again in the following 15 ton hopper after being sifted and is supplied to the blaster and transported to the nozzle by compressed air. There are four nozzles in all, one each for the drive side (DS) and work side (WS) and one each for the top and bottom work roll.

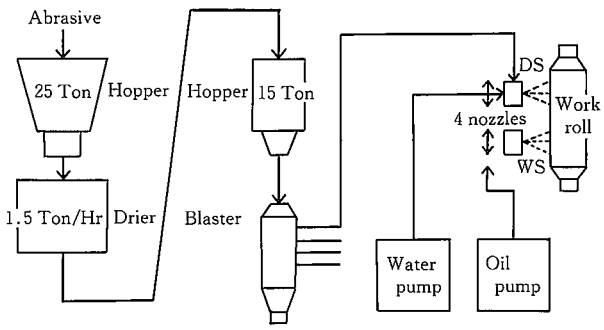


Fig. 9 Outline of on-line roll dresser

Figure 10 shows a schematic view of the equipment in the mill. The nozzle and the traverse device for the top work roll are mounted on a top header guide, and while the bottom ones are installed on the mill housing. Both are set on the mill's front side.

Table 2 gives the main specification. The water pressure is 70 MPa, water flow rate is 45 l/min/nozzle, and iron sand feeding rate is 5 kg/min/nozzle.

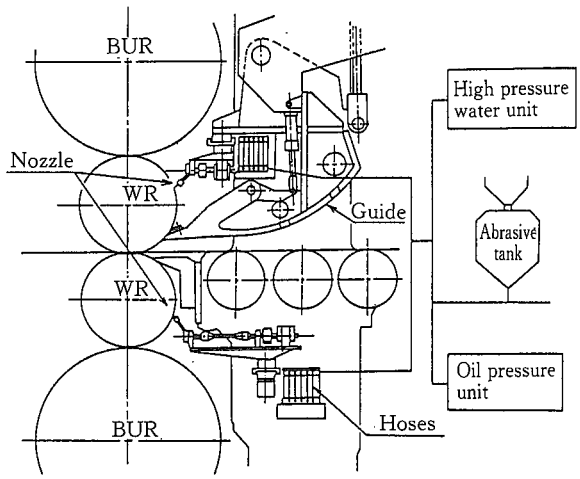


Fig. 10 Schematic view of on-line roll dresser in plate mill

Table 2 Main specifications

Type	Abrasive water jet
Water pressure	70 MPa
Water flow rate	45 l/min/nozzle
Abrasive material	Iron sand
Abrasive feeding rate	5 kg/min/nozzle

3.2 Example of Improving Roll Profile

Figure 11 shows an example of roll profile

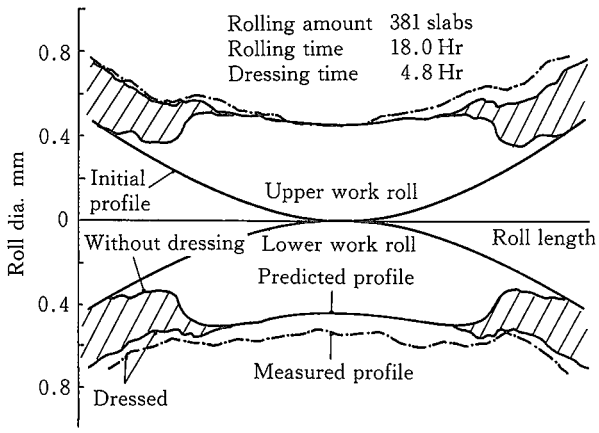


Fig. 11 An example of dressing test result

improvement made by the application of this dresser. The dressing is done based on the estimated profile from the actual result of each rolling pass, and it is done to remove wear difference. This shows that there is enough dressing quantity.

3.3 Extension Test of Rolling Chance

3.3.1 Examination Method

Rolling chance extension is tested with this equipment. **Figure 12** shows the outline of the test pattern. Usually, the width change pattern in a rolling chance is of the Coffin type. The size at a rolling chance is about 500 slabs. Test pattern A is when the chance has been extended to twice as usual keeping Coffin pattern. Test pattern B is when the usual Coffin pattern is repeated twice. 910 slabs are rolled in test pattern A, and 1 120 slabs are rolled in B. The usual rolling tonnage is 4 600 tons but the rolling tonnage is 8 500 tons in test pattern A, and 10 500 tons in B.

Table 3 Test condition

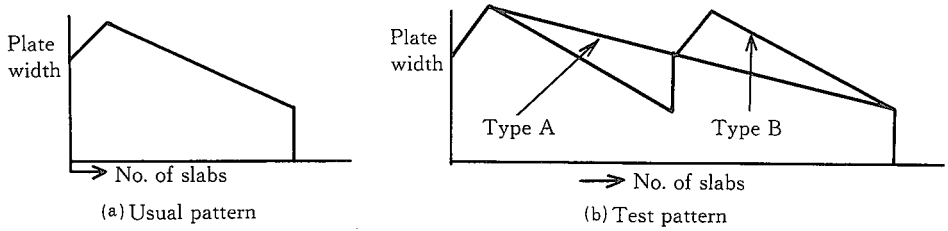
	No. of slabs	Rolling tonnage
Usual	490	4 600
Type A	910	8 500
Type B	1 120	10 500

3.3.2 Test Result

Figure 13 shows the width change in a rolling chance and the roll dressing timing in each test pattern. An important characteristic of the abrasive -jet method is the point at which dressing can be performed during rolling . In test pattern A, the roll is dressed for about 5 hrs after the maximum width and is dressed for another 5 hrs at intervals of several hours. In test pattern B, the roll is dressed for about 5 hrs after the maximum width and is dressed for another 10 hrs at intervals of several hours. In the latter half of test pattern B, the roll is dressed about 5 hrs more after the maximum width. That is, a roll is dressed about 10 hrs in a 40 hr rolling in test pattern A, and in about 20 hrs in 48 hrs rolling in test pattern B.

Figure 14 (a) shows the roll profile after rolling in test pattern A. The estimated roll profile undressed, the initial roll profile, and the measured roll profile after rolling are shown. The difference between estimated wear profile in an undressed roll and the measured roll profile after rolling is the part where the roll is dressed. The amount of wear is about 0.8-0.9 mm in the center part of the roll. And, the amount of dressing becomes about 0.6 mm at the edge. The roll profile after rolling in test pattern B is shown in **Fig. 14 (b)**. The amount of the wear is about 1.0-1.2 mm in the center part of the roll, And the amount of dressing becomes about 0.7 mm at the edge.

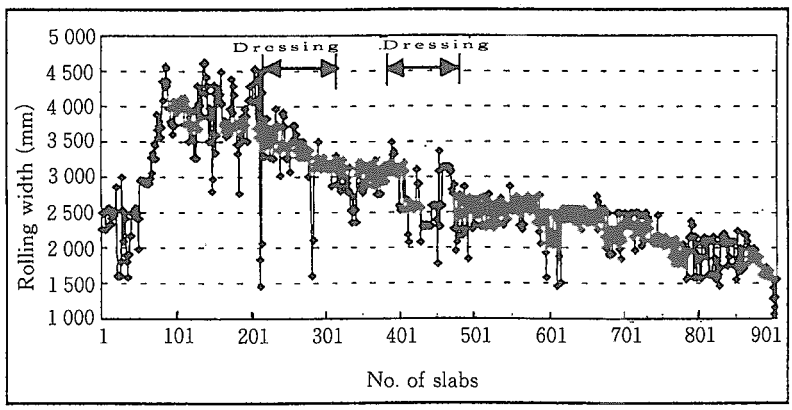
Figure 15 shows the plate quality in the test patterns. **Figure 15 (a)** shows the average value of the plate crown of a 10-20 mm thickness and 2 000 -3 000 mm width. The plate crown decreases in test pattern A though the rolling chance is extended. On the other hand, the crown increases a little in the latter half of test pattern B. **Figure 15 (b)** shows the bad flatness occurring, it is shown with a relative value when a usual rate is assumed 100%. It decreases in test pattern A and in the latter half of B. Though it increases in the first half of test pattern B, it is at the same level as usual across the whole pattern.



(a) Usual pattern (b) Test pattern

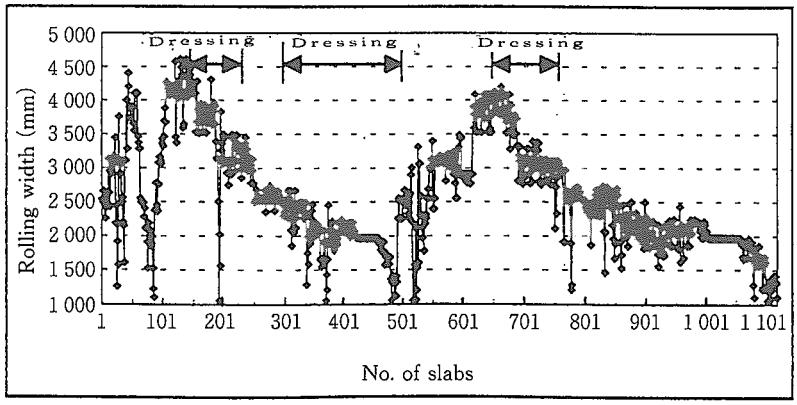
Fig. 12 Outline of test pattern

Total No. of slabs	910
Width average	2 719 mm
Total rolling time	39.5 Hr
Total dressing time	10.5 Hr



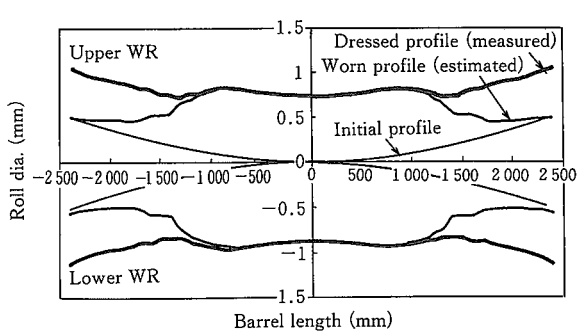
(a) Test pattern (Type A)

Total No. of slabs	1 120
Width average	2 593 mm
Total rolling time	47.6 Hr
Total dressing time	19.5 Hr

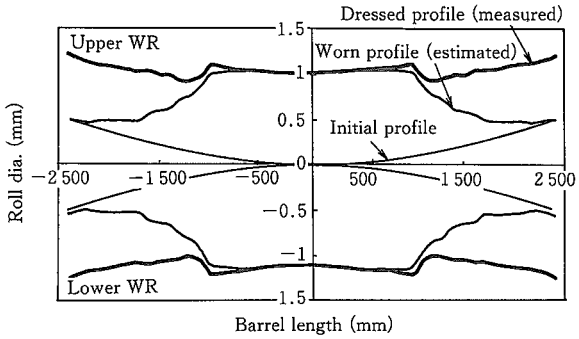


(b) Test pattern (Type B)

Fig. 13 Rolling pattern and dressing timing

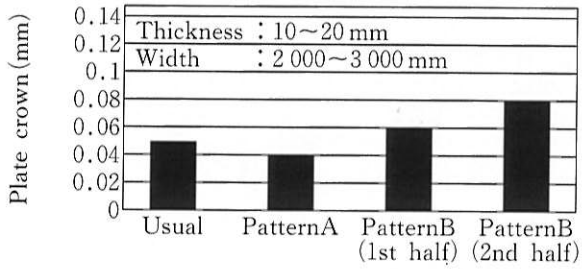


(a) Pattern A

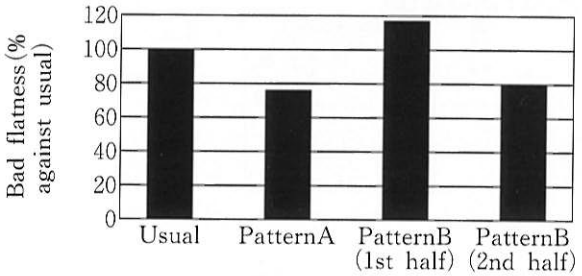


(b) Pattern B

Fig. 14 Roll profile



(a) Plate crown



(b) Bad flatness

Fig. 15 Test results

4. Summary

(1) On-line roll dressing system using abrasive-jet was developed.

(2) This system makes it possible to control work roll profile during rolling.

(3) It becomes possible to extend rolling chance without causing problems to plate quality, and roll changing frequency is decreased by 50 %.

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