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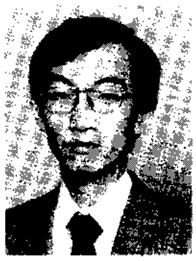
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1 Introduction

The number of rolls and rollers used in steelworks exceeds 8 000 in major processes, i.e., the continuous casting, hot rolling, cold rolling, and continuous annealing. Most of them are rolls used for transportation, feeding, supporting and levelling of flat-rolled products (hereinafter these rolls are called "process rolls").

Conditions of use and required functions of process rolls vary from process to process. In all cases, however, the rolls come into contact with products or semi-finished products; therefore, their surface properties constitute an important factor for assuring the surface quality of products, in the same way with the case of working rolls. Further, in some processes costs incurred in replacing and repairing the process rolls account for more than 20% of the total maintenance costs.

Chiba Works has been studying surface treatment techniques with the aim of achieving high reliability and long service life of these process rolls; for instance, 1967 saw the start toward an automatic roll-surface overlay welding technique, and in 1973, in meeting the growing trend of higher product quality, the development of surfacing welding materials and studies on thermal spraying techniques aimed at the application of ceramic coatings were commenced.

This report describes studies on the surface treatment techniques that will achieve the required functions of process rolls.

2 Functions Required of Process Rolls

Major steelworks processes for the continuous caster and downstream operations and the classification of process rolls viewed from the conditions of their use are shown in **Fig. 1**. Process rolls can be broadly divided into

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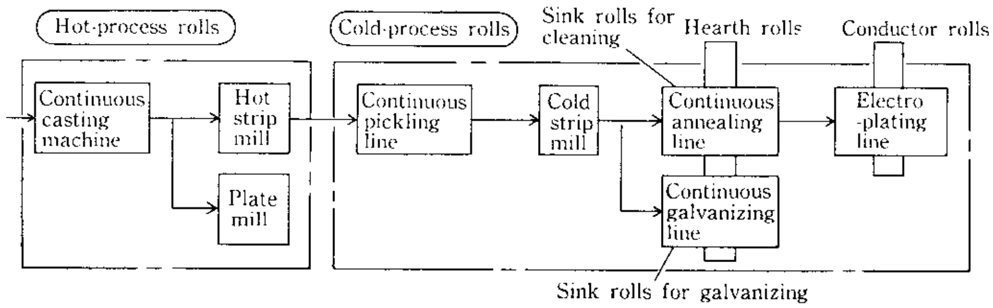


Fig. 1 Classification of process rolls

Table 1 Requirements for surface porperties of process rolls

Classification	Example	Requirements
Hot process roll	Pinch roll Guide roll Roller table Feed roller Wrapper roll Roller for leveler	Heat checks resistance Corrosion resistance Abrasive-wear rasistance Adhesion resistance
Cold process roll	Bridle roll Deflecter roll Wringer roll Tension roll Steering roll Roller for leveler	Slippage resistance (abrasive-wear resistance)
Furnace roll	Hearth roll	Slippage resistance (abrasive-wear resistance) at high temperature Build-up resistance
Electroplating roll	Conductor roll	Corrosion resistance Abrasive-wear resistance
Electrolytic-cleaning roll	Sink roll	Corrosion resistance Abrasive-wear resistance
Galvanizing roll	Sink roll	Corrosion resistance

those for hot-working and cold-working. Further in the cold-working process rolls, some are under special circumstances; such as hearth rolls for the continuous heat-treating furnace, conductor rolls for the electroplating line, and sink rolls for the electrolytic cleaning line and hot-dip galvanizing line.

Functions required of the surfaces of these process rolls are summarized in **Table 1**.

Hot-working process rolls are required to have heat-check resistance, because they are subjected to a repetition of heating and cooling, the former due to radiation and heat transfer from steel material, and the latter due to splashing of water for cooling the rolls or steel. These rolls are also required to have resistance to erosion and corrosion from the above-mentioned cooling water and also pressurized water for descaling. In addition, adhesion resistance is also required, because minor slippage between the roll and strip causes scratches due to adhesion.

In the cold-working process rolls which transport steel material at high speed and frequently cause acceleration and deceleration, slippage resistance to prevent scratches becomes particularly important. For this reason, it becomes an important factor to give proper surface roughness to the cold-working process rolls and to prevent the deterioration of this roughness.

Hearth rolls of the continuous annealing line, in which steel material passes at high speed, also cause slippage and mis-tracking owing to the deterioration of the roll surface roughness.[1] Therefore, high-temperature wear resistance is required which will maintain the roll surface roughness for a long term. In the case of hearth rolls of the hot-dip galvanizing line, scales from the steel strip or from its surface are sometimes deposited on the roll surface,[2] and a performance generally called the "build-up resistance" becomes necessary.

Conductor rolls of the electroplating line come into contact with the plating solution which is highly acidic, and thus corrosion resistance becomes its important factor, and also they require resistance to wear due to sliding of rolls against strip.

Sink rolls of the electrolytic cleaning line and hop-dip galvanizing line also require corrosion resistance against a strong alkaline solution and molten zinc, respectively.

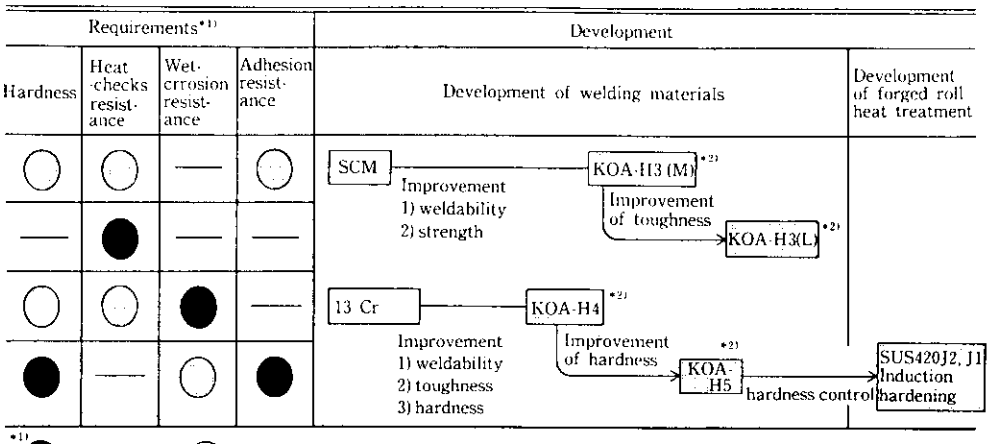
In order to achieve high reliability and long life of the process roll, it was a technical problem to develop and select surface coating materials suited to these required functions. In the following, studies on the hot-working process rolls, cold-working process rolls, hearth rolls, and conductor rolls are respectively described.

3 Studies on Hot-Working Process Rolls

3.1 Development of Surfacing Filler Metals

Functions required of surface coating and the devel-

Table 2 Requirements for rolls used in continuous casting and hot rolling processes and development of surface-welding materials



*1) ●: Primary ○: Secondary *2) See Table 3

Table 3 Typical chemical compositions and mechanical properties of weld metal

Brand name \ Item	Chemical composition (%)								Heat treatment	Mechanical properties		
	C	Si	Mn	Cr	Mo	Ni	Ti	V		TS (kgf/mm²)	$_{2V}E_{20}$ (kgm/cm²)	HV 1 kgf
KOA-H3 (M)	0.34	0.46	1.60	3.22	1.12	—	0.12	—	650°C SR	114.0	2.75	350
KOA-H3 (L)	0.04	0.09	1.19	3.04	1.40	—	0.04	—	700°C Temper	56.4	18.1	230
KOA-H4	0.04	0.30	0.92	13.97	0.05	4.62	—	—	625°C SR	94.4	6.0	300
KOA-H5	0.34	0.42	1.60	14.05	0.42	—	—	0.43	550°C Temper	98.0	0.4	550
K-420J2	0.32	0.45	0.52	13.32	—	0.20	—	—	950°CQ, 650°CT Induction hardening*	84.0	5.3	550
K-420J1	0.20	0.55	0.51	13.38	—	0.14	—	—	950°CQ, 680°CT Induction hardening*	74.0	6.9	420

* Middle frequency

opment process of surfacing filler metals are shown in **Table 2**. Their chemical compositions and mechanical properties are shown in **Table 3**. In the material development, first, functions required of hot-working process rolls are clarified, and then surfacing filler metals suited to these functions have been developed.

KOA-K3(M) is a medium C–Cr–Mo iron-based surfacing filler metal which has been developed with the aim of improving wear resistance, heat-check resistance, and adhesion resistance. This material is based on SCM steel[3] known as high hardening steel, containing 0.35% carbon to give wear resistance and adhesion resistance to the steel. Further, with the aim of improving heat-check resistance, chromium and molybdenum contents are increased to enhance tensile strength, and addition of titanium has improved its toughness.

KOA-H3(L) is a low C–Cr–Mo iron-based surfacing filler metal which has been developed to further improve its heat check resistance. For instance, severe heat cracks occur to the roller which is under a motionless hot rolled strip, propagating in a continuing manner, until the roller is broken in some cases. Under such condition, it is effective to improve toughness significantly to prevent the propagation of the crack. KOA-H3(L) has been made by decreasing carbon content of KOA-H3(M) and by adding a corresponding quantity of titanium, thereby greatly enhancing its toughness. KOA-H3(L) permits control of its mechanical strength and toughness by changing its heat-treating conditions. For instance, if it is tempered at 625°C, its tensile strength and impact value can be increased to 75 kgf/mm^2 and 15 kgf·m/cm^2, respectively. It can be used not only for surface coating of the roller but also as an underlaying material for various high hardness materials and a shape-reversion material[4] of tough and hard steel. When it is used as an underlaying material, it prevents the propagation of cracking at the underlaying portion, resulting in a far smaller crack depth than in the case where ordinary welding material is used.

KOA-H4 is a low C–13Cr–4Ni iron-based surfacing filler metal which combines corrosion resistance and heat-check resistance. This material is based on 13Cr stainless steel[5] which is known to have excellent corrosion and erosion resistance, and its corrosion resistance has been improved by nickel addition. Furthermore, by molybdenum addition it can maintain its high hardness and toughness in spite of its low carbon content. As a result, it possesses wear resistance without harming its heat-check resistance.

KOA-H5 is a medium C–13Cr–V iron-based surfacing filler metal which has been developed with the aim of enhancing wear resistance and heat-check resistance. In this material, carbon content is limited to 0.35% or below, with chromium content and vanadium addition, and further tempered at 550°C, carbides are precipitated. These carbides serve to enhance hardness and heat-check resistance. Further, a chromium content of 13% or more, it has contributed to increasing corrosion resistance.

Recently, in some cases, uneven wear due to slight differences in hardness between bead passes for surfacing welding was transcribed to the strip, causing mark. To prevent such discrepancy, retained austenite quantity of the roll is adjusted[6] by limiting the carbon contents of forged steels SUS420J1 and SUS420J2 to 0.20% and 0.35% maximum, respectively, and controlling conditions for intermediate-frequency induction hardening.

As a result of the above-mentioned development, various materials have now been provided which can satisfy the functions required of hot-working process rolls.

3.2 Results of Test Using Commercial Equipment

3.2.1 Commercial equipment test at continuous casting machine

Test results obtained by using rolls made of conventional and newly-developed materials at the commercial continuous casting machine are shown in **Fig. 2**. In KOA-H4 overlay rolls, wear rate was less than 1/10 of that with the conventional low-alloy rolls (DIN 13Cr–

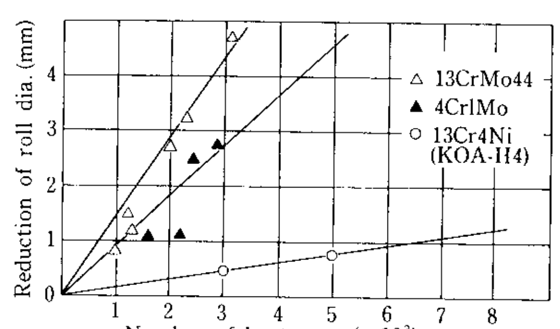


Fig. 2 Comparison of wear rate at slab casting machine[7]

Mo44). Since KOA-H3(L) is used as an underlaying material, cracks are dispersed, and their depth is small, so that roll breakage due to continuation of cracks has been completely eliminated. As a result, the life of the roll is extended to 15 to 36 months, about 10 times as long as the conventional rolls, and it has also become possible to attain a long-time holding of roll gaps which greatly affect product quality.

3.2.2 Commercial equipment test at hot strip mill

No.1 strip mill of Chiba Works is rolling ferritic stainless steel which is softer than carbon steel in the hot state and which is subjected to severe surface quality requirements. Consequently, in the table rollers both upstream and downstream of the rougher, a minute roller flaw due to butting of the leading tip of hot rolled slab may sometimes lead to the surface defect of strip. As a result, the roller surface requires high hardness. Since the reverse rolling of slab is performed at the rougher, a slight speed difference between the table roller and slab may sometimes cause adhesion. In addition, corrosion due to descaling water also occurs here. For these reasons, HOA-H5, which has high hardness and excellent resistance to adhesion and corrosion, has been used for this table roller.

The entry table of the crop shear is provided with a cover for slab heat insulation, and the hot-rolled slab sometimes stagnates here, being liable to cause heat checks to the roller, with rolled-in scale in the opening crack, leading to the undersurface defects of the strip. Hence, KOA-H3(L) having excellent heat-check resistance has been used to the roller of this part.

The other rollers from the scale breaker to the entry table of the rougher and also delivery table of the rougher require resistance to adhesion and heat-checking as well. The delivery table is provided with a cover for slab heat insulation as in the case of the entry table of the crop shear. At this portion, therefore, KOA-H3(M) has been used which has excellent resistance to adhesion and heat-checking.

Functions required of each section of the hot strip mill[8] and the roller grinding ratio before and after applications of test materials are shown in **Table 4**. Here the term "roller grinding ratio" means the ratio of the number of rolls which have been found requiring surface grinding during a once per 4-week checking against the total number of rolls installed.

In the past, more than half the number of table rollers installed upstream and downstream of the rougher as well as delivery table rollers required roller grinding at one time of inspection, but after KOA-H5 was used for table rollers both upstream and downstream of the rougher, these table rollers ceased to develop defects such as adhesion, and thus the necessity of grinding was eliminated. In the case of other rollers, the application of

Table 4 Comparison of grinding ratio between carbon steel roll and surface welding roll at No.1 hot strip mill

		Roller table	Reversing mill	Roller table	Crop shear
Requirements and results of test	Equipment		Travel →		
Requirement*1	Corrosion resistance	—	○	—	—
	Hardness	○	●	○	—
	Heat-checks resistance	○	—	○	●
	Adhesive resistance	○	●	○	—
Comparison of grinding ratio*2	Original materials (G.R. 0 0.2 0.4 0.6 0.8 1.0)	S35C	S35C	S35C	S35C
	Test materials	KOA-H3 (M)	null KOA-H5	KOA-H3(M)	KOA-H3(L)

*1 ●: Primary ○: Secondary

*2 Grinding ratio (G.R.) = number of rolls grinded for preventing scratches / number of rolls

new overlay metals lowered the number of times of grinding to 1/2 to 1/6 compared with the case of convetional materials. It has become possible, therefore, to significantly improve the surface quality and productivity of products.

3.2.3 Commercial equipment test at plate hot leveler

This leveler had troubles of adhesion between the product and work roll, the transcription of roll wear and roll scratches on to the product, and the transcription of work roll flaws on to the back-up roll, presenting problems with conditioning of products and work rolls. To solve these problems, KOA-H5 and KOA-H4, were used for the work roll and back-up roll, respectively, with a hardness difference provided between them.

Test results at the hot leveler in the plate rolling line are given in **Fig. 3**. The term "wear rate" means roll wear depth per 10 000 t of steel plates during tracking of 500 000 t. The surfaced work roll and back-up roll showed wear rates of 1/10 and 1/6, respectively, of conventional material. The work roll made of forged steel, which had been given intermediate-frequency induction hardening, further reduced its wear rate by half due to the effect of homogeneous surface hardness.

As a result, it has been possible not only to decrease the conditioning frequency of the product and the roll, but also to extend the life of the roll drastically.

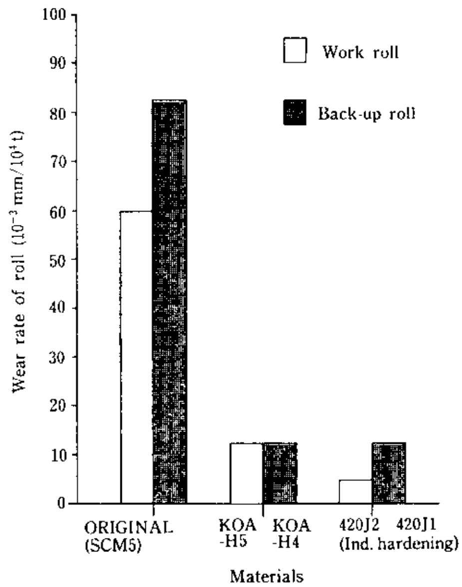


Fig. 3 Comparison of wear rate at hot leveler

4 Studies on Hearth Roll

4.1 Selection and Evaluation Method of Coating Materials

As a high-temperature wear resistant material, ceramics may be used, but ceramics are generally brittle and have low resistance for thermal shock.[9] Hearth roll requires thermal shock resistance because it is subjected

Table 5 Compositions of base metal and thermal spray coating material for hearth rolls (wt%)

Type	Major compositions
SCH22 (base metal)	23～27Cr, 19～22Ni, 0.35～0.45C (the balance; Fe)
Al_2O_3	Al_2O_3>99
Cr_2O_3	80 Cr_2O_3, 20 Al_2O_3
WC	85 WC, 15 Co
CrC	80 Cr_3C_2, 20 NiCr

to a repetition of heating and cooling during furnace heating and cooling as well as changes in cooling conditions in operation. Therefore, materials based on alumina (Al_2O_3), chromium oxide (Cr_2O_3), tungsten carbide (WC), and chromium carbide (CrC) have been selected which may be used as high-temperature wear resistant materials, and measurements of high-temperature hardness and a thermal shock test have been carried out.

Major compositions of test specimens are shown in **Table 5**. The heat resistant cast steel (SCH22) is a base material for the roll and a contrast material for high-temperature hardness test. For the coating method, thermal spray coating has been selected which can be easily applied to the 1 000-mm-diameter hearth roll of the continuous annealing line.

For the thermal shock test, a test specimen, which is made of a mild steel plate (25 mm × 25 mm × 10 mm) whose surface is given a 0.1-mm-thick thermal spray coating, is used and given a repetition of a heat cycle of water cooling after a 1 100°C heating (held for 10 min). High-temperature hardness has been measured at the cross section of the coating material using a commercial high-temperature hardness tester.

Build-up resistance performance is strongly affected by operating conditions such as the furnace atmosphere, steel plate temperature, material quality of the steel plate, and the condition of pretreatment. Consequently, it has been decided to evaluate using commercial equipment. The furnace atmospheric temperature and atmospheric dew point of the hot-dip galvanizing line are generally higher than those of the continuous annealing line. Therefore, for the test materials to be used in the hot-dip galvanizing line, alumina-zirconia (Al_2O_3-ZrO_2), zircon ($ZrSiO_4$) and a heat resistant alloy (CoCrAlY)[10] have been selected. Major compositions of the test specimens are shown in **Table 6**. For the evaluation method, "a non-conditioning period" of the roll has been used.

Table 6 Compositions of thermal spray coating material used for the test of build-up resistance of hearth roll (wt%)

Type	Major compositions
Al_2O_3-ZrO_2	75 Al_2O_3, 25 ZrO_2
$ZrSiO_2$	$ZrSiO_2$>99
CoCrAlY	90 CoCrAlYTa, 10 Al_2O_3 heat treated in air

4.2 Evaluation of High-Temperature Wear-Resistant Coating

4.2.1 High-temperature hardness and thermal shock test results

Results of the thermal shock test are given in **Fig. 4**. Oxide-based Al_2O_3 and Cr_2O_3 spray coatings peeled off

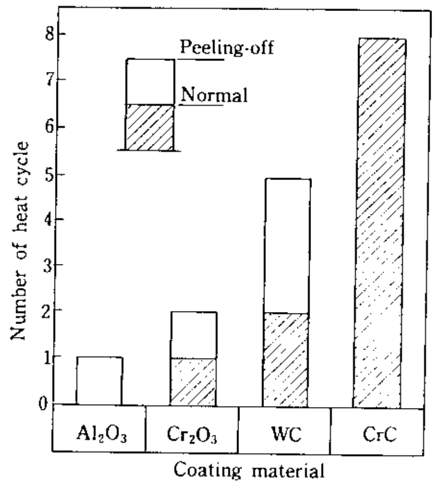


Fig. 4 Comparison of thermal shock resistance[1]

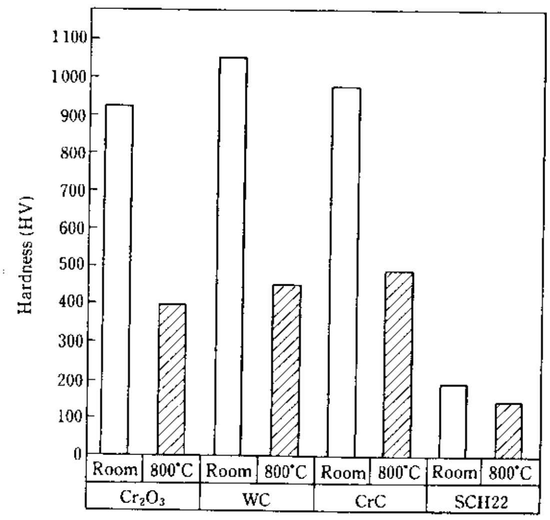


Fig. 5 Comparison of hardness between coatings and heat resisting steel[1]

by one or two repetitions of thermal shocks. Whereas the carbide-based cermet spray coating showed better thermal shock resistance than the oxide-based spraying material, and the CrC spray coating, in particular, developed no cracking or peeling-off even by an eight repetition of thermal shocks.

Results of high-temperature hardness measurements of various test specimens except the Al_2O_3 spray coating are shown in **Fig. 5**. All the test specimens show the lowering of hardness as the test temperature is raised, but compared with the conventional heat-resisting cast steel (SCH22), they show sufficiently high hardness at 800°C which is an ordinary operating temperature.

4.2.2 Results of test using commercial equipment

Since it was found that the CrC-base spray coating showed excellent thermal shock resistance and gave a hardness of about HV500 even at a high temperature of 800°C, a commercial equipment test of a roll with a coating thickness of 0.1 mm was carried out at No.2 continuous annealing line at Chiba Works. Results of two-year investigation of the surface roughness of the roll are shown in **Fig. 6**. Conventional roll made of heat-resisting cast steel showed 70% deterioration in surface roughness after one-year use, but the CrC-base spray-coated roll showed a surface-roughness deterioration of only about 20% after two-year use. This trend remained unchanged at the test of the heating zone, soaking zone, and cooling zone.

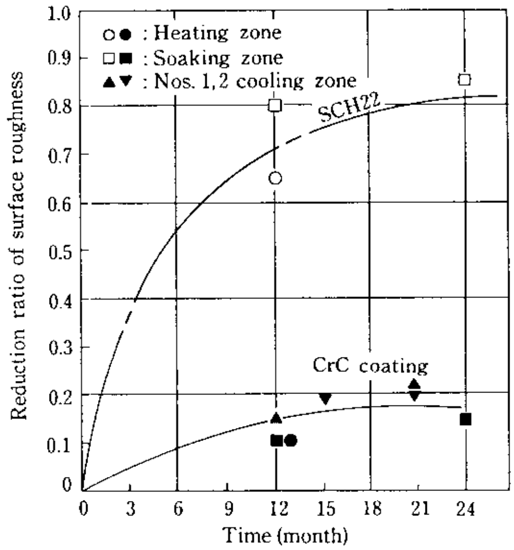


Fig. 6 Change in surface roughness of rolls

4.3 Evaluation of Build-up Resistant Coating (Results of Commercial Equipment Test)

Evaluation of build-up resistant coating was made at the hot dip galvanizing line of Chiba Works. The results are shown in **Fig. 7**. Conventional heat-resisting cast steel rolls had to be surface-ground once in every two months, whereas, for Al_2O_3-ZrO_2 spray-coated rolls, this non-conditioning period was extended to seven months. Further, CoCrAlY spray-coated rolls, heat treated in the air after thermal spraying, developed no build-up even after two-year use. This was considered attributable to the effect of a thin surface oxide film layer which was confirmed by the hot adhesion test[11] conducted by the authors.

The $ZrSiO_4$ spray-coated roll developed no build-up, but wear which was considered due to the slip-off of the coating particles progressed, limiting the life of the roll to only one year.

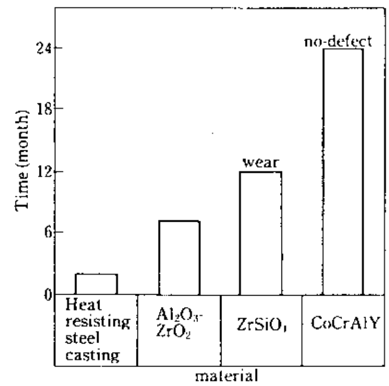


Fig. 7 Comparison of operating time without build-up

5 Studies on Conductor Roll

5.1 Selection and Evaluation Method of Coating Materials

The conductor roll is required to have corrosion resistance and wear resistance in addition to electric conductivity. Self-fluxing alloys of the nickel group and of the cobalt group in thermal spray materials have electric conductivity and generally have corrosion resistance and wear resistance.[12] In addition, the self-fluxing alloy has a lower melting point than carbon steel which is an ordinary roll-making material, and consequently it is possible to easily form a coating film free from air pores, by giving it heat treatment after coating. As a result, corrosion on the base metal boundary due to air pores can be prevented. Since the plating solution of the electro-

Table 7 Chemical composition and hardness of coating materials for conductor rolls

Type	Chemical composition (wt %)											Hardness (HV)
	Ni	Cr	B	Si	C	Fe	Co	Mo	Cu	W	WC	
MSF-Ni4	Bal	16.0	4.0	4.0	0.5	2.5		3.0	3.0			500~700
MSF-Co2	13.0	19.0	3.0	3.0	1.0	4.0	Bal			13.0		500~800
MSF-WC2	Bal	11.0	2.5	2.5	0.5	2.5					35	500~700 (WC: 1500)
Cr plating		>99.8										700~1 000

plating line is a strong-acid solution containing a mixture of hydrochloric acid and fluoric acid, it has been considered necessary to investigate the corrosion of the self-fluxing alloy.

Out of self-fluxing alloys stipulated in JIS H 8303, therefore, the self-fluxing nickel-based alloy (MSF–Ni4), self-fluxing nickel-based alloy containing tangsten carbide (MSF–WC2) and self-fluxing cobalt-based alloy (MSF-Co2) were selected as test specimens and compared with hard chromium plating which was the conventional coating material. Chemical compositions and hardness of the test specimens are shown in **Table 7**. Since self-fluxing alloy coating has a hardness of more than HV500, and the WC grain contained in MSF-WC2 has a hardness of HV1500, wear resistance can be expected of the self-fluxing alloy. For the composition of the solution to be used in the corrosion test, that of tin-plating solution[13] was used, and the solution temperature was set at a slightly higher value, i.e., 95°C, than the actually-used value, to accelerate reaction. Portions other than the coated portion were masked by carbon resin, and the specimens were immersed in the stationary solution for 48 h, and corrosion resistance was evaluated by weight loss.

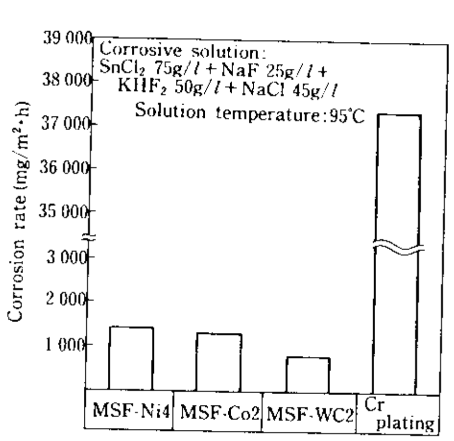


Fig. 8 Comparison of corrosion rate between self-fluxing alloy coatings and Cr plating

Results of the corrosion test are shown in **Fig. 8**. All self-fluxing alloy spray coating had better corrosion resistance than the conventional chromium-plating film. It was found that the corrosion loss of MSF-WC2, in particular, was only about 1/50 of the film thickness. Namely, under such corrosion environment of the plating solution, it would be difficult for the Cr-plated film to maintain a passive state.

5.2 Results of Test Using Commercial Equipment

It was found that the spray coating of MSF-WC2 had excellent corrosion resistance and sufficient hardness as well. Therefore, conductor rolls with a coating thickness of 1.0 mm were made and subjected to a commercial-equipment endurance test at No.2 electrolytic tinning line of Chiba Works. The results are shown in **Table 8**.

Conventional chromium-plated rolls have a life of only four weeks as a result of exposure of base metal, whereas MSF-WS2 spray-coated rolls show a decrease in coating thickness of only 0.33 mm even after the use for 10 months. From this fact, it can be expected that the MSF-WS2 spray-coated roll can extend its life to more than two years by re-grinding.

Table 8 Test results of self-fluxing alloy coated roll and Cr plated roll at electro-plating line

Material	Operating time	Results
MSF-WC2	10 months	Decrease of coating thickness of 0.33 mm
Cr plating	4 weeks	Base metal is exposed by corrosion

6 Studies on Rolls for Cold-Working Process

6.1 Selection and Evaluation Method of Coating Materials

When surface roughness of rolls for the cold-working process is lowered, slippage occurs; conversely when the surface roughness is enhanced, steel strip develops a dent. To achieve the long life of the roll for the cold-working process, it is necessary to maintain a prescribed surface roughness for a long time, and to this end, coating by ultra-hard material has been examined. As ultra-hard spray-coating materials, WC-based cermet is generally known.[14] In particular, 87%WC–13%Co spray-

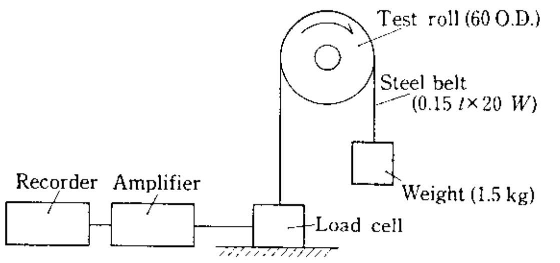


Fig. 9 Outline of testing machine for frictional coefficient

coating film has a hardness of as high as HV 1 200. Therefore, first the relation between surface roughness and the frictional coefficient was clarified using the testing machine for the frictional coefficient of the roll, and then changes in roughness of WC-based spray-coating film were investigated using a commercial line.

The outline of the testing machine for the frictional coefficient is shown in **Fig. 9**. A weight was fitted to one end of a steel plate, and tension was measured which was generated at the other end of the steel belt when the roll was rotated. The frictional coefficient was obtained by calculating the equation shown below. Oil was sprayed between the roll and the steel plate, and relative sliding speed is set at 1.8 m/min.

$$T/W = \exp(\mu\theta)$$

where T: Tension to be measured (kg)
W: Mass of the weight (kg)
μ: Frictional coefficient
θ: Contact angle (rad.)

For test rolls, the following were prepared: After two rolls were spray-coated with WC-based material, their center-line average roughness was adjusted by blasting to 1.2 μmRa and 3.2 μmRa, respectively. Another roll was chromium-plated after blasting to adjust its roughness to 3.2 μmRa.

Results of frictional coefficient measurements are shown in **Fig. 10**. Through a comparison between the two WC-based spray-coated test rolls having surface roughness of 1.2 and 3.2 μmRa, respectively, it is found that, as roughness is lowered, the frictional coefficient is drastically decreased. Through a comparison between the WC spray-coated test roll and Cr-plated test roll having the same surface roughness, it is found that the former has a higher frictional coefficient than the latter.

6.2 Results of Test Using Commercial Equipment

As a result of the frictional coefficient measurements, it was found that the frictional coefficient decreased as roughness deteriorated. It was also suggested that the WC-based spray-coating was ultra-hard and considered to be effective in preventing the lowering of roughness. Therefore, the deflector roll at the delivery-side of No.6 stand of No.2 cold tandem rolling mill at Chiba Works was given a 0.1 mm-thickness spray-coating and a comparative test with the conventional chromium-plated roll was carried out. The results are shown in **Fig. 11**.

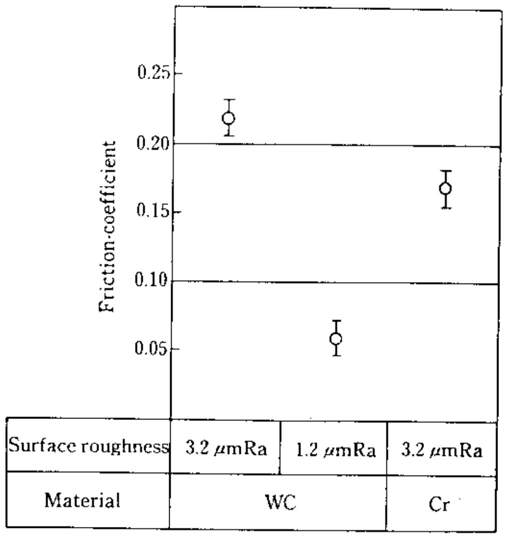


Fig. 10 Comparison of friction-coefficient between WC coating and Cr plating

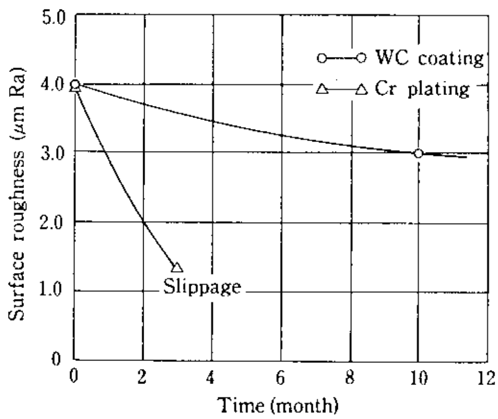


Fig. 11 Changes in surface roughness of rolls

In the case of the conventional chromium-plated roll, roughness was reduced from 4.0 μmRa to 1.2 μmRa after three-month use, thereby causing the slippage of the roll. Whereas for the WC-based spray-coated roll, roughness was reduced from 4.0 μmRa to 3.0 μmRa after 10-month use, thus it was found that this roll can withstand a long-time use.

7 Conclusions

Rolls used in steelworks processed have been roughly classified by their conditions of use, and the results of studies on their respective functional requirements and surface treating techniques suited to the requirements are summarized as follows:

(1) For rolls to be used in the hot-working process, commercial manufacture of the following have been achieved: Low C-Cr-Mo iron-based surfacing filler metal, KOA-H3(L), which was developed with importance placed on heat-check resistance, low C-13Cr-4Ni iron-based surfacing filler metal, KOA-H4, developed aiming at corrosion and erosion resistance, and medium C-13Cr-V iron-based surfacing filler metal, KOA-H5, developed for assuring adhesion resistance.

(2) For the hearth roll, application techniques of CrC-based cermet spray-coating material, which combines both high-temperature hardness and thermal shock resistance, have been developed. Also CoCrAlY-based spray-coating material having excellent build-up resistance has been found.

(3) For the conductor roll, application techniques of WC-containing Ni-based self-fluxing alloy having corrosion resistance and sufficient hardness, have been developed.

(4) For rolls to be used in the cold-working process, the relation between surface roughness and the frictional coefficient has been clarified, and application of high-hardness WC-based cermet spray-coating material has permitted a long-time holding of slippage resistance.

By expanding the application of these techniques, it was possible to prolong the life of process rolls and improve product quality. However, in view of the recent growing trend toward stricter demand for product quality and more rigorous conditions of use for process rolls, the authors will endeavor to develop new coating materials and study new surface treatment techniques in the future.

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