

Rolling Mill Rolls

NIPPON STEEL ROLLS CORPORATION



Available Rolls

Rolls by Material

- Cast iron rolls
- Cast steel rolls
- YNT rolls (forged iron rolls)
- High-speed tool steel rolls (CPC process, centrifugally-casting process)

Type of Rolls

Mill	Rolls
Plate	Plate
Hot strip	Hot strip
Hot strip	Skin pass
Cold strip	Cold strip
Cold strip	Skin pass
Slab, bloom and billet	Slabbing, blooming and sizing
Section and bar	Billet
Section and bar	Rail, H-shape, sheet pile and shape for general use
Section and bar	Bar and wire rod

Available Roll Sizes and Maximum Weights

	Min. size	Max. size	Max. weight
Cast iron rolls	400φ × 1,400 mm ~ 1,500φ × 10,000 mm		65 tons/roll
Cast steel rolls	400φ × 700 mm ~ 2,560φ × 7,300 mm		60 tons/roll
YNT rolls	400φ × 2,300 mm ~ 1,600φ × 6,750 mm		60 tons/roll
CPC rolls	400φ × 2,000 mm ~ 850φ × 5,700 mm		15 tons/roll

Principal Roll Production Facilities

Melting Equipment

Electric Arc furnace	1
Induction melting furnace	Middle frequency × 2, High frequency × 2

Casting Equipment

Centrifugal-casting equipment	2 for rolls (max, 60 tons), 1 for sleeves (max, 15 tons)
CPC (continuous pouring process for cladding) equipment	1 for roll (15 tons)

Forging Equipment (operated by Japan Casting & Forging Corporation)

Forging press	3,000-ton 2-column pull-down type hydraulic, 8,000-ton 2-column type hydraulic
Turning roller	30 tons × 1
Manipulator	40 Mt × 1, 80 Mt × 1, 240 Mt × 1

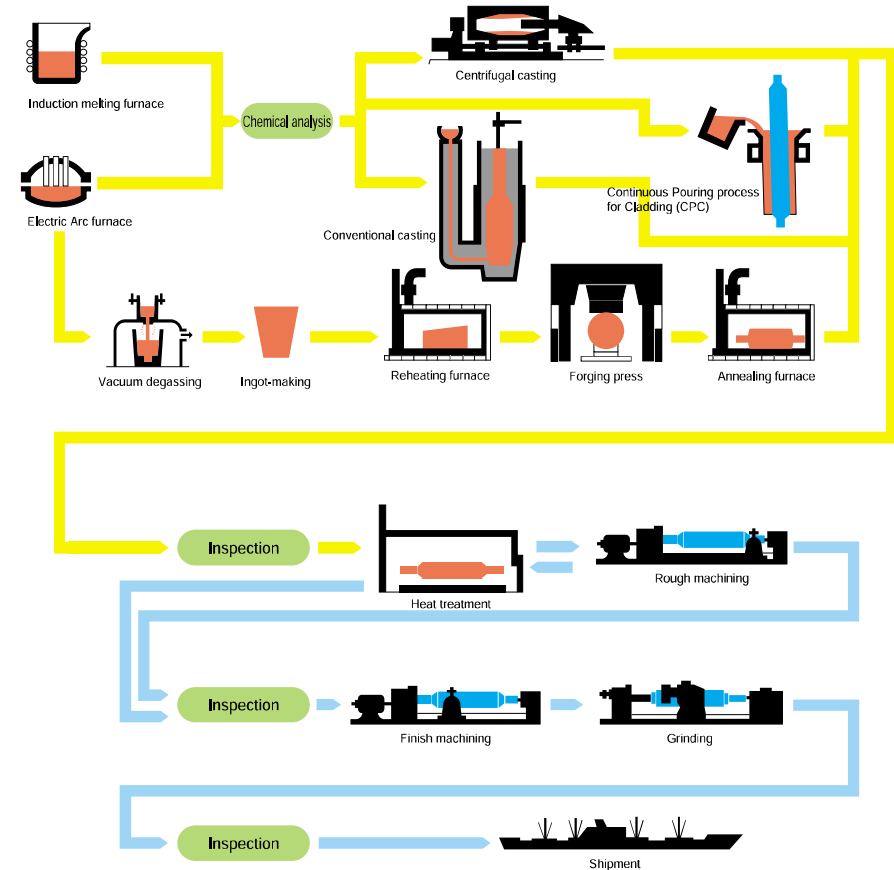
Heat-treatment Equipment

Electric heat-treatment furnace	10
Gas heat-treatment furnace	12
Sleeve shrink-fitting equipment	2
Induction quenching and tempering furnace	1

Machining Equipment

Roll lathe	8
Roll grinder	1
Roll wobler milling machine	2

Manufacturing Process

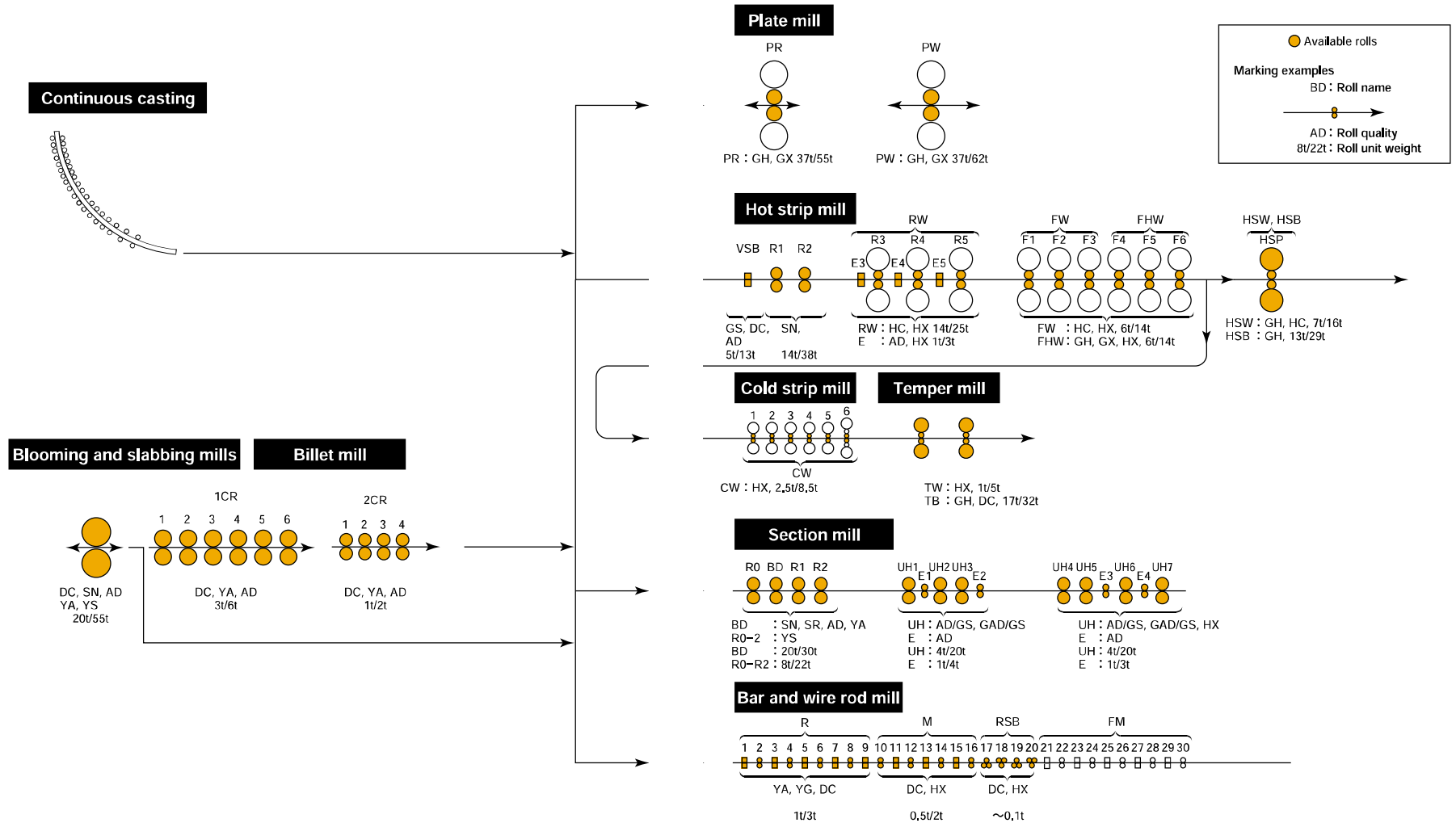


Quality Assurance

In 1995, NSR was the first company in the work roll manufacturing industry to acquire ISO 9002 certification (ISO 9001 in 1999). All NSR rolls are manufactured in compliance with this certification. We conducts intermediate inspections in every process in a manner appropriate to the type of rolls, the material quality of the rolls and the respective roll production process. Further, at the stage of shipping, we conducts the strictest possible inspections based on roll specifications.

- 1) Appearances, dimensions and shapes
- 2) Chemical analysis
- 3) Hardness measurement
- 4) Ultrasonic flaw detection
- 5) Mechanical test
- 6) Microstructure
- 7) Shell thickness
- 8) Residual stress

Mills and Rolls

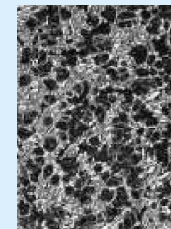


Characteristics of Roll Materials and Applications of Rolls

Classification		Designation		C (%)	Shore hardness (HsC)	Tensile strength (MPa)	Applications																		
							Plate			Hot strip					Cold strip			Billet	Section					Bar and wire rod	
							WR	Sizing	Edging	Strip casting	Strip casting	Strip casting	Strip casting	WR	BW	WR	Strip casting		Slabbing/blooming	2-high	Universal	Universal			
Cast iron rolls	Grain	GH	3.0~3.4	65~85	150~250	●							●	●	●	●									
		GX			●							●	●												
	Ductile	DC (Standard type)	3.0~3.4	55~65	300~450			●									●			●	●	●	●		
		DC (High strength/toughness type)	3.0~3.4	40~55	450~700		●	●									●	●							
		DC (Wear resistant type)	3.0~3.4	65~75	300~450											●								●	●
	High chromium	HC	1.0~3.0	70~90	600~900					●	●	●								●					
	High-speed tool steel	HX	CPC	1.0~3.0	80~95	700~900						●			●							●		●	●
			Centrifugal casting	1.0~3.0	70~90	700~900			●		●	●									●	●			
Cast Steel Rolls	Low-alloy cast steel	SN (Standard type)	0.4~1.0	35~60	750~1000		●		●								●		●	●					
		SN (High strength/toughness type)																							
	Cr-Mo cast steel	SR	0.5~1.1	35~45	650~1000		●										●	●	●	●					
	Graphitic cast steel	GS	1.1~1.7	35~45	500~800		●											●		●	●				
	Adamite	AD	1.3~2.3	40~55	400~600		●			●								●	●	●	●			●	
	High-alloy adamite	AD	1.3~2.4	45~70	500~700					●										●	●	●	●		
	Graphite adamite	GAD	1.5~2.4	55~70	500~700																●	●	●		
YNT Rolls	Alloy forged steel	YS	0.8~1.6	35~45	850~1100												●	●	●	●					
	Special forged adamite	YA	1.1~2.0	40~55	750~1000												●	●	●	●	●				
		YG	1.6~2.0	35~50	750~1000														●					●	
	Special forged high alloy cast iron	YF	2.0~2.5	45~60	550~800																			●	

WR: Work roll BW: Back-up roll

Typical Microstructures of Roll Materials



GH ×50



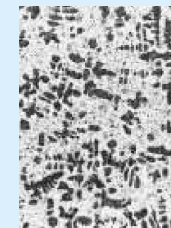
GX ×50



DC (Standard type) ×100



DC (High-strength/toughness type) ×100



HC ×50



HX (CPC process) ×400



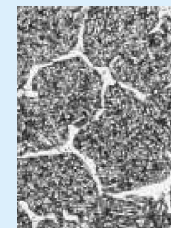
HX (Centrifugally-casting process) ×400



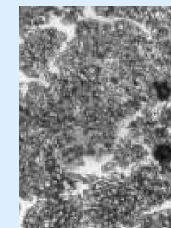
SN (High strength type) ×400



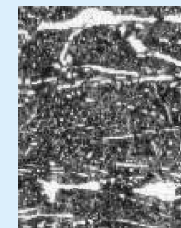
SR ×100



AD ×100



GAD ×100



YA ×100

Plate Mill Rolls



Plate mill

Work Rolls

Plate mill rolls are required to have improved toughness, wear resistance, surface roughening resistance and chill spalling resistance to accommodate automated rolling, controlled temperature rolling, improved plate crown rolling and stainless steel rolling.

Since 4-high roughing mills operate in longer runs than 4-high finishing mills, these roughing mills require rolls with high toughness and greater resistance to thermal cracking and wear. Excelled in these characteristics, GH and GX are highly evaluated.

Four-high finishing mills require cast iron rolls that possess high toughness, excellent wear resistance and a fine surface finish. They must also be highly resistant to breakage caused by chill spalling. GH and GX, with finer microstructures and greater hardness than the rolls for roughing mills use, are highly reputed.

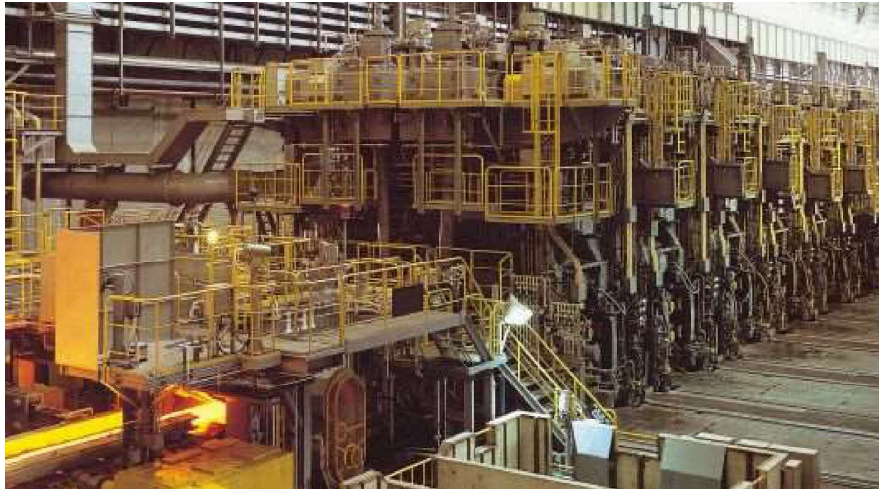


Plate mill finishing work roll

Materials of Rolls

Mill	Stand	Designation of material	Hardness Hs
4-high	Roughing mill work roll	GH, GX	65~75
	Finishing mill work roll	GH, GX	68~79

Hot Strip Mill Rolls



Hot strip mill

Roughing Mill Rolls

Resistance to slippage, thermal cracking and wear are imperative for the rolls of 2-high roughing mills. Solid type and Sleeve built-up type SN rolls, with improvements on material and heat treatment based on the accumulated experience in abundance, have shown greater performance.

The rolls of 4-high roughing mill trains require not only favorable resistance to thermal cracking but must also demonstrate resistance to both surface roughening and wear as required for front stand rolls of the finishing mill train. The uses of HX sleeve type rolls are expanding their uses for this purpose. The application of roughing edger rolls is rapidly expanding.

Materials of Rolls

Mill		Designation of material	Hardness Hs
Roughing	2-high roughing	SN Solid SN Sleeve	50~60
	4-high roughing	HC, HX Solid HX Sleeve	77~83

Mill	Designation of material	Hardness Hs
Scale breaker	AD, GS DC	45~50 45~50
Vertical Edger	AD HX	45~55 77~83



4-high roughing Work Rolls (sleeve built-up type)

Finishing Mill Rolls

Front Stands

Finishing mill work rolls of front stands, which are subjected to higher rolling temperatures and heavier loads compared to those of latter stands, are liable to develop banding-like surface roughening.

NSR makes constant efforts to grasp rolling conditions and roll wear, study optimum roll materials and manufacture rolls best suited for specific applications.

In 1992, NSR spearheaded the development of CPC rolls over world's roll makers.

Rear Stands

The work rolls of the rear stands, in particular, must possess high resistance to wear and chill spalling and must provide good surface texture to rolled coils. Centrifugally-cast GH rolls have won high reputations. Since GX rolls show remarkably improved wear resistance, applications for them are growing.

In hot strip mills aiming at high productivity, CPC and centrifugally-cast rolls of high-speed tool steel are expanding their use as in the front stands.



Finishing mill work roll

Materials for Rolls

Mill	Stand	Designation of material	Hardness Hs
4-high tandem	Finishing	HC	70~78
	#1-3	HX	80~90
4-high tandem	Finishing	GH, GX	78~82
6-high tandem	#4-7	HX	80~90
2-high single	Hot skin-pass	HC	86~90
4-high single	(Work roll)	GH	75~85
4-high single	Hot skin-pass (Back-up roll)	GH	65~75

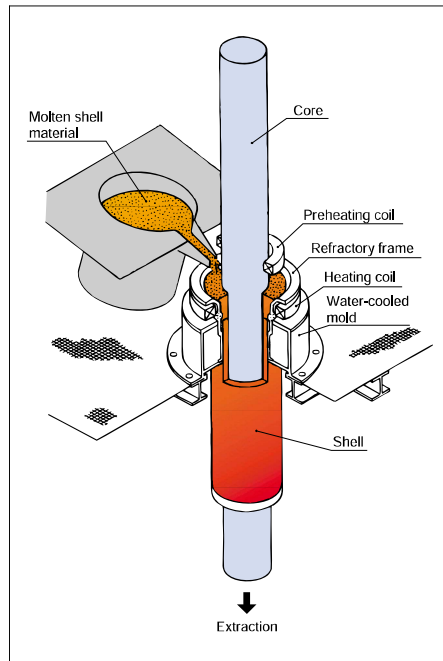
CPC High-speed Tool Steel Rolls

NSR leads the world's roll makers in the successful development and practical application of CPC (Continuous Pouring process for Cladding) rolls with excellent resistance to wear and surface roughening. These innovative rolls are widely accepted for the hot strip mills at the steelworks of Nippon Steel and other steelmakers and are rapidly growing its use.

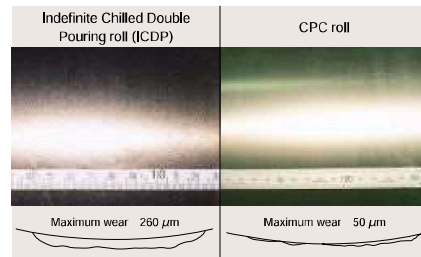
Being of composite structure, CPC high-speed tool steel rolls are manufactured by continuously pouring molten shell material for cladding on the roll cores and by making metallurgically bonded interface with cores, as shown in the figure below. Consisting of a shell clad with very hard and highly wear-resistant high-speed tool steel over a core of tough forged steel, CPC rolls of high-speed tool steel have a number of advantages over conventional rolls of Indefinite Chilled Double Pouring (ICDP):

- (1) Resistance to wear is more than five times greater,
- (2) Resistance to surface roughening is more than four times greater,
- (3) Toughness is twice as great.

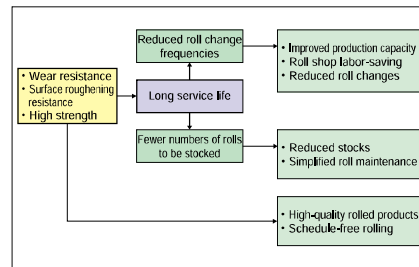
In addition, the adoption of CPC high-speed tool steel rolls brings about other advantages: remarkable reductions in unit wear, improvements in the quality of rolled products and higher productivity.



Schematic Image of Production Process for High-speed Tool Steel Rolls



Roll Surface and Wear Conditions of Hot Strip Finishing Mill Rolls

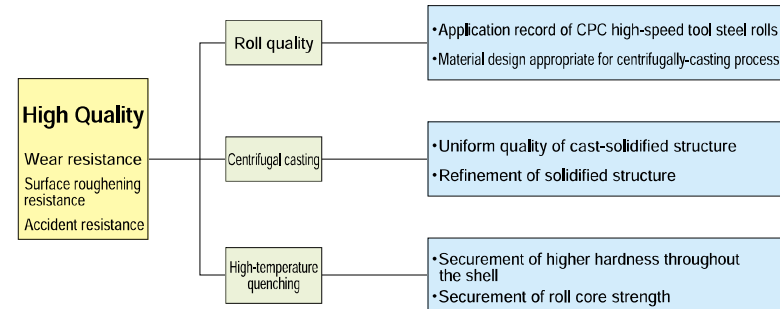


Application Advantage of CPC High-speed Tool Steel Rolls

CPC roll (NCPC_®): Continuous Pouring process for Cladding

Centrifugally-cast High-speed Tool Steel Rolls

In order to meet the diversifying needs inherent in steel rolling, high-quality, centrifugally-cast rolls of high-speed tool steel have been put into practical use. These rolls have been developed by NSR and are based on our rich record of successful applications of CPC high-speed tool steel rolls: a record that relies on advanced technologies and equipment such as the latest material design technology, material designs appropriate for the centrifugal casting process, centrifugal casting equipment and heat-treatment equipment for the production of high-performance rolls.



Horizontal centrifugal casting equipment



High-temperature quenching furnace

Cold Strip Mill Rolls



Tandem mill work rolls

Work Rolls

The rolls used in cold strip mills require smoother surface roughness retention ability to secure remarkably high wear resistance and stability in rolling. CPC high-speed tool steel rolls for cold strip mills have recently been developed by enhancing the casting technology used for producing the CPC high-speed tool steel rolls with high wear resistance used in hot strip mills.

A Shore hardness of 90 or more (equivalent to Vickers hardness of 800) has been realized for cast high-speed tool steel rolls through the application of low-frequency induction heating.

These rolls demonstrate excellent wear resistance and have seen extensive use as work rolls (wet) in tandem mills and as the work rolls (wet, dry) of temper-rolling and skin-pass mills.

Features of CPC High-speed Tool Steel CW Rolls

- 1) Fine microstructures and excellent wear resistance produced by the use of CPC technology
- 2) Excellent accident resistance due to improved heat-treatment technology
- 3) Regular grinding by ceramic grindstones; dull workability similar to that of conventional cast steel rolls and no restrictions on use

Materials of Rolls

Mill	Designation of material	Hardness Hs
Tandem mill	HX	90~95
Temper mill	HX	90~95
Skin-pass mill		



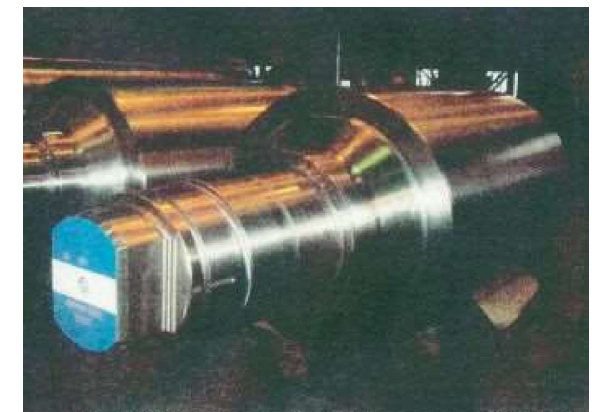
Skin-pass mill

Back-up Rolls

Cast iron back-up rolls are used for 4-high skin-pass mills and temper-rolling mills. A definite requirement of back-up rolls used in long runs and continuous rolling is the prevention of chill spalling due to rolling fatigue. To prevent chill spalling, NSR has improved the cast structures of cast iron back-up rolls, resulting in the wide acceptance of both the solid-type and sleeve built-up type rolls.

Materials of Rolls

Mill	Roll type	Designation of material	Hardness Hs
Temper mill	Solid	GH	66~76
Skin-pass mill	Sleeve	DC	70~76



Back-up roll for skin-pass mill

Slabbing/Blooming/Billet Mill Rolls



Slabbing mill roll

Slabbing and Blooming Mill Rolls

In the field of specialty steel products, semi-finished products are still produced by means of blooming. Rolling procedures by which produce various semi-products from one continuous casting slab have been applied. NSR supplies rolls appropriate for these diverse rolling operations.

For blooming mill rolls having roll calibers, YA rolls with favorable biting and wear resistance on the caliber side-wall is widely used.

For horizontal slabbing mill rolls with no calibers, SN rolls with improved toughness and wear resistance by special heat treatment are used; high-alloy, wear-resistant AD rolls are used for vertical slabbing mill rolls with calibers.

Materials of Rolls

Mill	Rolling	Rolled product	Required performance	Designation of materials	Hardness Hs
Blooming	2-high caliber	Ordinary steel Spring steel 13 Cr steel, etc.	Breakage resistance	SN	34~40
			Wear resistance	AD	39~45
			Breakage resistance	YS	37~43
			Wear resistance	YA	39~45
Slabbing	Universal horizontal	Ordinary steel	Breakage resistance	DC (high strength, high toughness)	45~50
			Wear resistance	SN (high-strength type)	50~55
	Universal vertical	Ordinary steel	Wear resistance	High-alloy AD	50~55



Billet mill

Billet Mill Rolls

Numerous large-section calibers are provided with billet mill rolls having comparatively small roll diameters. Further rolling materials cover mostly specialty steel and thus the applied loads are apt to grow larger. The roll materials have to be selected according to application conditions. In addition, demand for rolled products with finely finished surfaces is increasing.

NSR supplies continuous billet mill rolls consisting of materials appropriate for 6-stand continuous billet mills with reciprocally arranged vertical and horizontal rolling stands. For the uses of No.1 and No.2 stand, AD and GS are widely applied since favorable biting is emphasized. For the uses of intermediate and rear stands, DC and GAD are widely applied since anti surface roughness is emphasized. And for the stands where anti breakage is emphasized, YA and YG reinforced by forging have been applied.

Materials of Rolls

Mill	Stand	Required performance	Designation of materials	Hardness Hs
V—H continuous	Nos.1 and 2	Slippage resistance	AD,GS	42~48
		Breakage resistance	YA, YG	42~48
	Nos.3 and 4	Wear and breakage resistance	AD,GAD	44~50
		Breakage resistance	YA, YG	44~50
	Nos.5 and 6	Surface roughening resistance	GAD	50~56
		Wear resistance	DC	54~60



Billet mill rolls

Section Rolling Mill Rolls



Universal structural mill

Breakdown Mill Rolls

Long rolls with multiple calibers are used in breakdown mills where materials extracted from reheating furnaces are first rolled. The optimal materials used in these rolls are selected by analyzing the conditions under which they will be applied, such as the kind of rolling materials, rolling loads, caliber type and the forces loaded on the rolls.

YS rolls enhanced their strength by forging are used for rolls that require toughness, and YA rolls are used for rolls requiring both toughness and surface roughness resistance.

2-high Roughing and Finishing Mill Rolls

Rolls that are used to shape sheet piles, rails and angles require two features. One is the strength to withstand the pressing force on the caliber side wall while rolling. The other is to minimize wear and chance of burning caused by a friction between the roll and products to be rolled.

While AD have been used as a conventional material, YA with higher strength and wear resistance by caliber forging and GAD with improved anti heat crack by graphite in the microstructure are used recently.

In addition, sleeve built-up type AD rolls are being used, depending on the shape of the rolling materials.

Universal Mill Rolls

When Nippon Steel began operating a universal structural mill at its Sakai Works in 1962, sleeve built-up type AD rolls were developed and put into use for the roughing and finish rolling of wide-flange beams. Since then, high-alloy AD rolls with improved wear resistance and GAD rolls with improved anti sticking have been used for universal mill rolls. High-alloy AD and sleeve built-up type GAD rolls are used for the vertical rolls. Further, HX rolls with remarkably improved wear resistance are used to roll certain types of steel products.

Materials of Rolls

Mill	Roll type	Rolled products	Required performance	Designation of material	Hardness Hs
Breakdown	Solid	Angle, channel, sheet pile	Wear resistance	SN, SR, AD	35~50
		Wide-flange beam (open-caliber type)	Breakage resistance	YS	37~43
		Wide-flange beam (closed-caliber type)	Wear resistance	YA	40~46
2-high Roughing and finishing	Solid	Wide-flange beam	Surface roughness resistance	AD	40~55
		Sheet pile	Breakage resistance	YA	40~55
		Rail, angle, channel	Wear resistance	GAD	50~60
	Sleeve	Sheet pile	Wear resistance	High-alloy AD	45~55
Universal	Horizontal: Sleeve	Angle, channel	Surface roughness resistance	GAD	50~60
		Wide-flange beam	Breakage resistance	High-alloy AD	55~65
		Channel	Burning resistance	GAD	60~70
	Vertical: Sleeve	Rail	Wear resistance	HX	75~85
		Wide-flange beam	Wear resistance	High-alloy AD	55~65
		Channel	Surface roughness resistance	GAD	60~70



Structural mill breakdown roll



Universal vertical roll



Universal horizontal roll (after building-up)



Universal horizontal sleeve

Bar and Wire Rod Rolling Mill Rolls



Bar mill

Roughing Mill Rolls: Favorable biting and heat crack resistance are required for rolls used in roughing mills where billets or blooms just extracted from reheating furnaces are rolled at extremely low speeds. Rolling mills that simultaneously pass numerous rolling materials require tough rolls that withstand the high stresses generated. Attaining such high toughness and wear resistance, YA and YG rolls are highly evaluated among customers.

Intermediate Mill Rolls: DC rolls with excellent resistance to wear and surface roughening are used for intermediate mills. In recent applications, HX rolls have demonstrated extremely high wear resistance compared to DC rolls.

Block Mill Rolls: Recently, block mills that have shifted from the conventional 2-roll system to a 3-roll system to improve dimensional accuracy in finish rolling are increasing. Both DC and HX rolls have gained high user evaluations.

Materials of Rolls

Mill	Type	Designation of materials	Hardness Hs
Roughing	2-high	YA, YG	40~50
Intermediate+Finishing	2-high	DC	60~65
		HX	80~85
Finishing	Block mill	DC	65~70
		HX	80~85



Roughing mill roll at wire rod mill

YNT Rolls

Incompatible performance characteristics, such as wear resistance and toughness, are simultaneously required of rolling mill rolls. By utilizing both high-purity forging materials and special forging approaches, YNT rolls offer a combination of high toughness, thermal cracking resistance and wear resistance—all of which are important properties of hot rolling mill rolls.

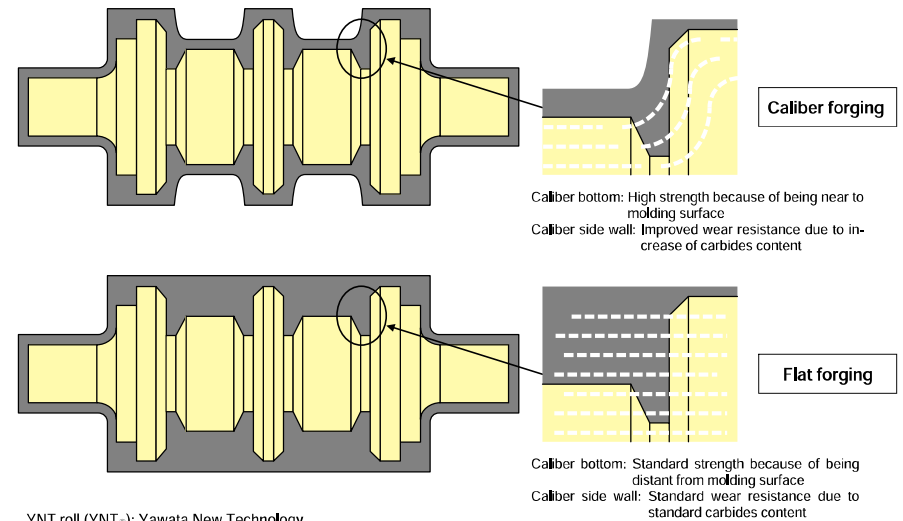
In particular, section rolling mill rolls with calibers have incorporated compatible performances of extremely high breakage resistance and wear resistance through near-net-shape (caliber) forging.



8,000-ton press (Photo: Japan Casting & Forging Corp.)



YNT roll material



YNT roll (YNT[®]): Yawata New Technology

ISO Certification



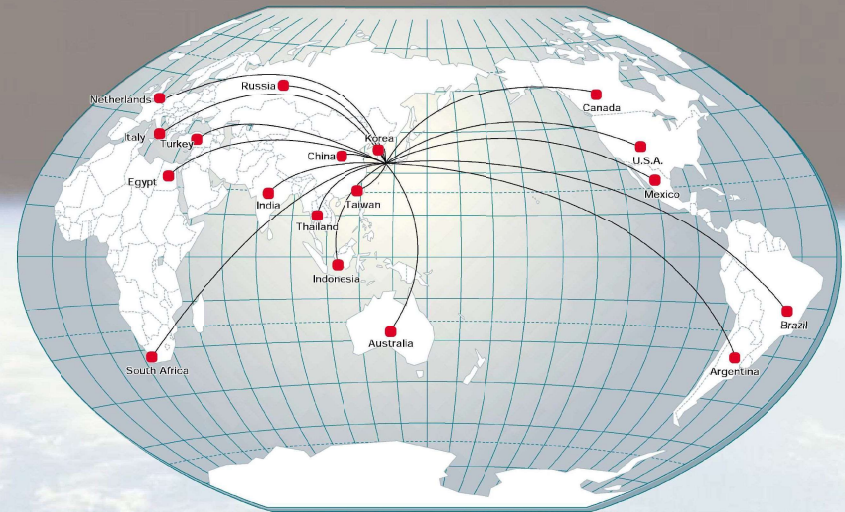
Okochi memorial production prize

NSR was awarded the Okochi memorial production prize in 1998 for the "Development of High-speed Tool Steel Hot-strip Mill Rolls by Continuous Pouring Process for Cladding (CPC Process)."



Overseas Users

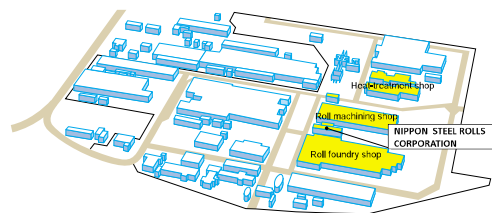
Many of the rolling mill rolls produced by NSR are highly rated by overseas users.



NIPPON STEEL ROLLS CORPORATION



Full view of the Tobata Area of Nippon Steel Yawata works



Rolling Mill Rolls

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