BAOSTEEL

Abrasion Resistant Heavy Plate

耐磨钢厚板用户手册

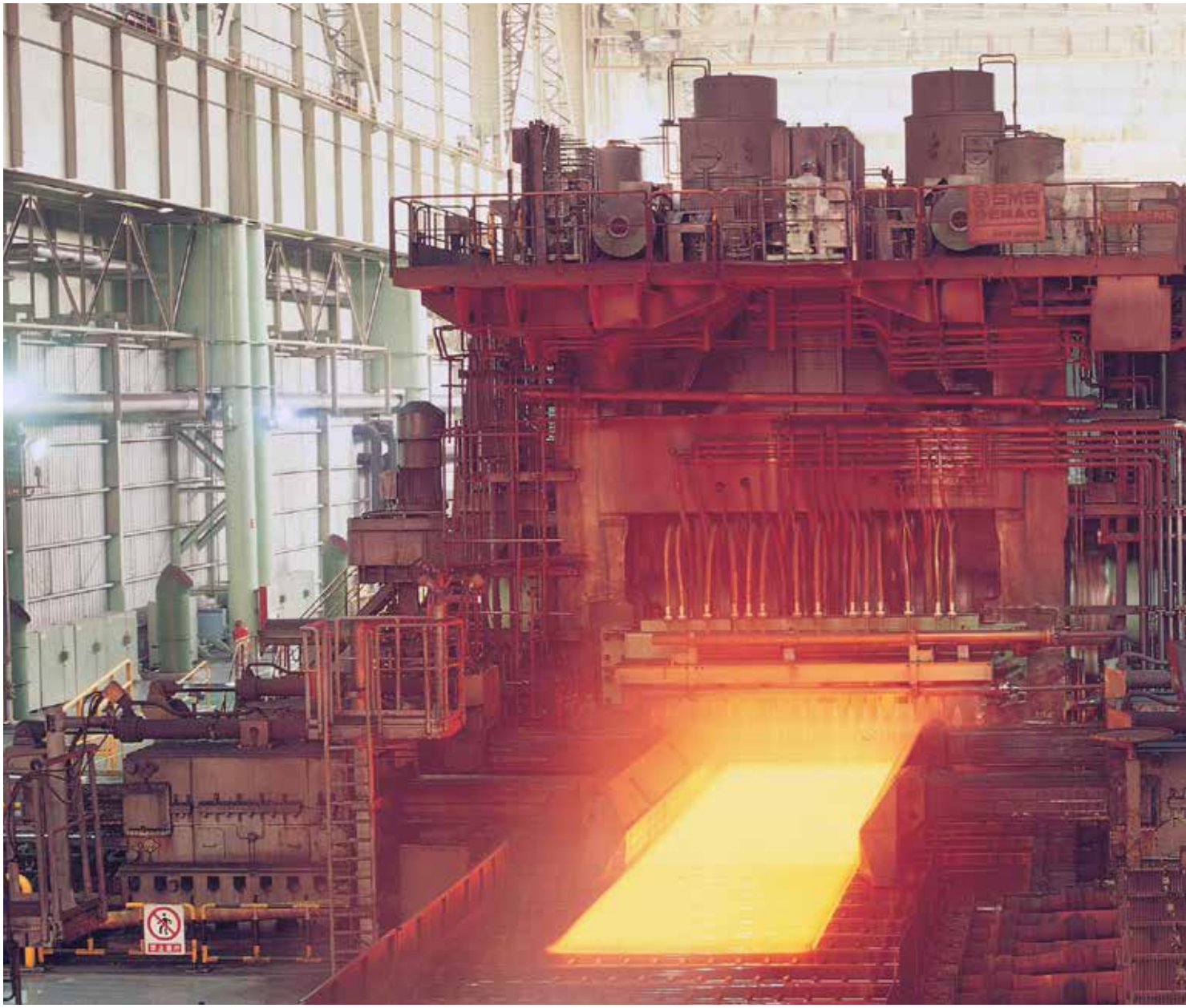
www.baosteel.com

宝山钢铁股份有限公司
BAOSHAN IRON & STEEL CO., LTD.

目 录
CONTENTS

5m 厚板产线简介

INTRODUCTION OF 5-METER HEAVY PLATE MILL



宝钢 5m 厚板产线于 2005 年投产，年生产能力为 180 万吨。厚板产线的主要装备由德国 SMS 和 SIE 提供，热处理炉由 LOI 提供。厚板产线包括万吨轧机、预矫直机、直接淬火装备、层流冷却装备、热矫直机、热处理炉、剪切机和在线探伤等装备。厚板产线具有先进的控制技术如轧制板形控制、高精度厚度公差控制、大冷速均匀冷却技术、高效矫直、无氧化均匀加热等先进技术，可以实现用户对表面质量、板形、力学性能均匀性等严苛要求。

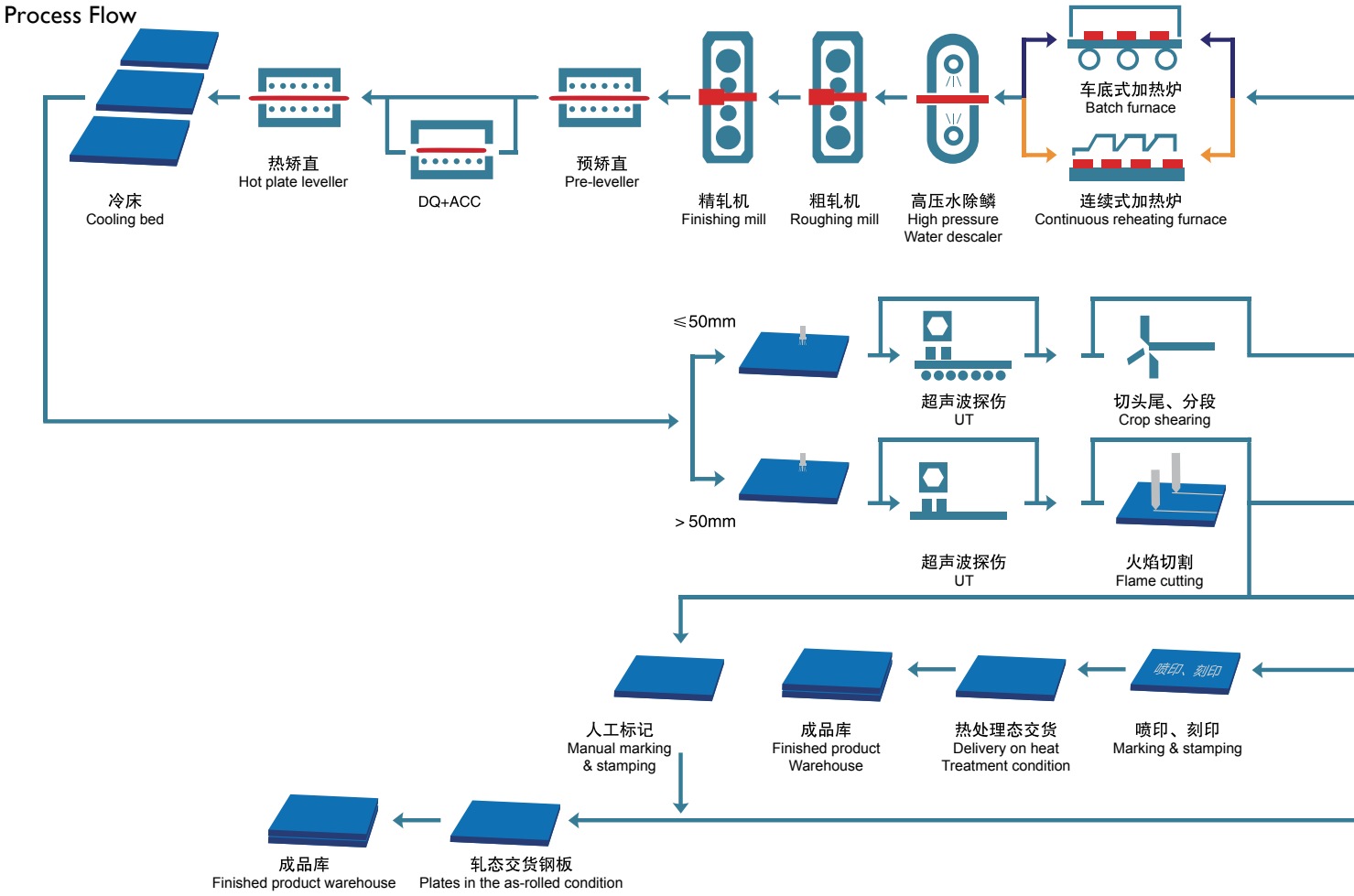
厚板产线生产的主要产品包括机械结构钢厚板、高等级船舶和海洋平台用钢、压力容器和核电用户用钢、管线钢等。厚板产品已广泛应用于国家先进装备制造业和重大工程。

Baosteel 5-meter heavy plate mill was established in March 2005, with the annual production capacity of 1.8 million tons.

Its main production equipments are provided by German SMS and SIE. The 5-meter heavy plate mill extensively adopts the state-of-the-art heavy plate technologies and facilities in the world, including high precision of rolling technique, TMCP/DQ technology, automatic control technique for strong leveling process, automatic cutting technique, automatic online ultrasonic detective technique, non-oxidation heat treatment technique, pre-leveler, comprehensive plate surface measuring apparatus and automatic marking, etc. In this way, requirements of high dimensional accuracy and mechanical property for high grade heavy steel plates from customers can be satisfied.

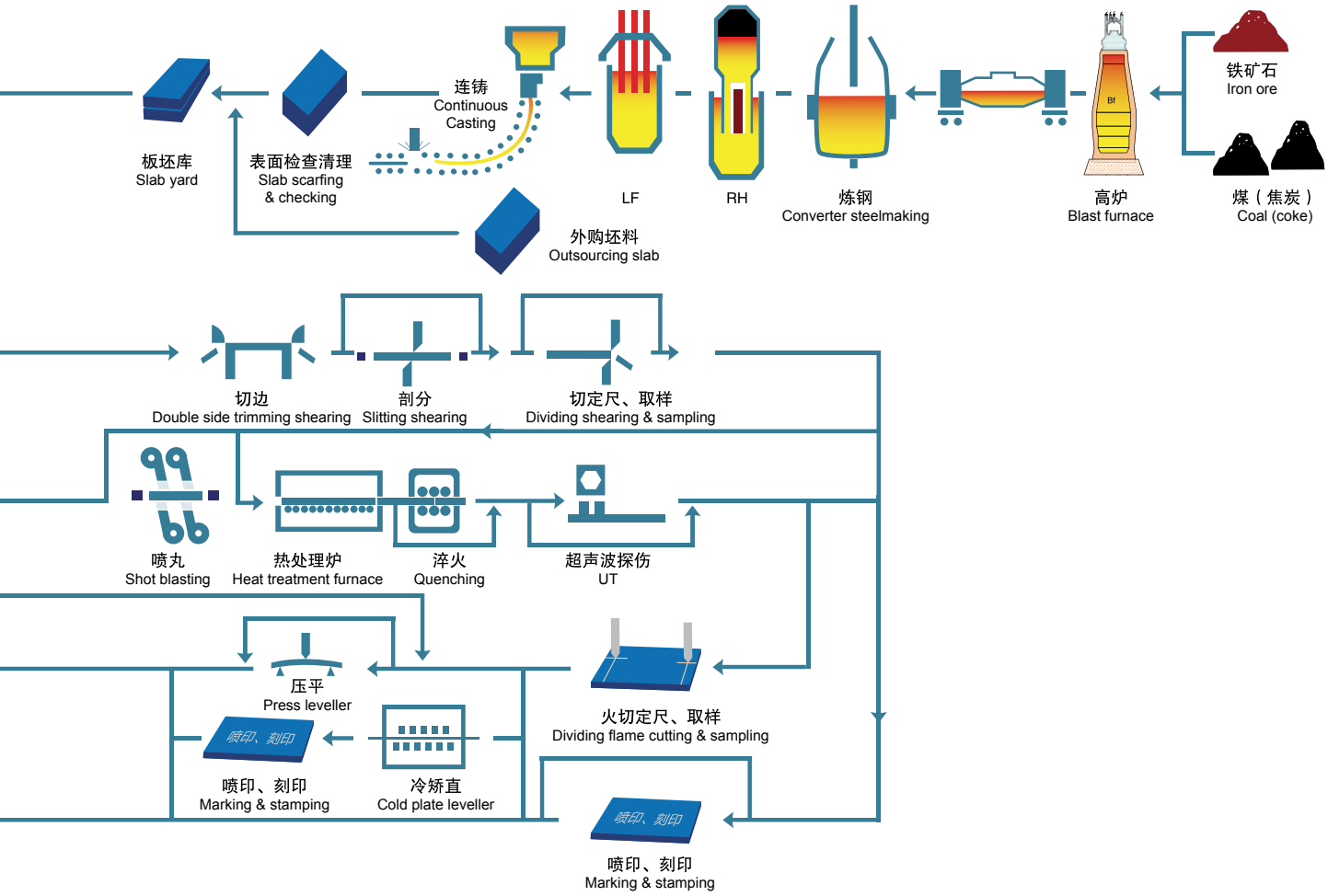
The heavy plate mill can produce high strength machinery structure steel, hull structural steel plates, offshore structural steel plates, oil and gas transportation pipeline steel plates, high strength construction structural steel plates and steel plates for boilers and pressure vessels. In the past decade Baosteel has exerted utmost effort to develop and supply high-quality heavy plates to meet customers' demands. We are continuously expanding our products types, improving our products quality.

制造工艺流程
Process Flow



产品和产线特征

产品交货状态及可供规格	机械结构钢厚板的交货状态包括：轧态、控制轧制、TMCP、直接淬火、直接淬火 + 回火、正火、离线淬火 + 回火等。 最大可供厚度：200mm，最大可供宽度 4800mm，最大可供长度 25m，最大单重 22.5 吨。 宝钢可供屈服强度 1300MPa 级超高强度钢板。
高纯净度钢水	宝钢采用 300 吨转炉、LF、RH 等装备以及 BRP 等技术，可以保证钢水的残余的 [P]≤50ppm、[S]≤10ppm、[O]≤20ppm 和 [H]≤1.5ppm，杂质元素含量低，钢水纯净度高。
板坯质量好	连铸坯采用电磁搅拌和轻压下技术，实现中心偏析、夹杂物和内部质量控制。
良好的表面质量	钢板表面缺陷深度 ≤0.2mm，深度在 0.05-0.2mm 之间的缺陷占表面积比例 ≤2%。表面粗糙度 ≤70μm。
板形控制技术	钢板采用 CVC 轧机和自动化系统控制轧态板形。通过不同冷却段的水量控制和矫直技术控制 DQ、TMCP 和热处理态板形。钢板的不平度可达到 3mm/m。
尺寸精度控制技术	精轧机装备有 AGC 系统以控制钢板厚度精度。长度方向的厚度变化量不超过 0.5mm。供货钢板的厚度进阶为 0.1mm，宽度进阶为 1mm。



PRODUCTS AND PROCESS FEATURES

Product delivery capability	Many delivery conditions can be available: as-rolled, control rolled, TMCP, direct quenched (DQ), direct quenched and tempered, normalized, quenched & tempered, etc. Max. thickness: 200mm; Max. width: 4800mm; Max. length: 25m; Max. unit weight: 22.5 tons And high-strength steel plate with yield stress of 1300MPa is also available in Baosteel.
High purity of steel	With advanced steel-making equipment and technology, high purity of the steel plates can be ensured by desulfurization of liquid iron, converter dephosphorization and ladle refining (RH-MFB, LF, RHOB, KIP/CAS).
Excellent metallurgical properties of the slab	Center segregation, inclusion, porosity and internal crack can be effectively controlled by electromagnetic stirring and soft reduction technique.
Excellent surface quality	Depth of scale on the surface of steel plate ≤0.2mm; Area with defect depth from 0.05mm to 0.2mm ≤2%; Surface roughness after shot-blasting ≤70um.
Plate shape control technology	CVC plate profile control technique. Multi-point setting and adaptation between passes can be implemented by high accuracy setting model.
Highly-accurate dimension control	The finishing mill stand is equipped with absolute AGC and closed-approached gauge meter type monitor AGC functions to improve thickness control accuracy. Thickness variation in length is less than 0.5mm. For ordering, the minimum thickness unit is 0.1mm, and the minimum length and width unit is 1mm.

产品介绍
INTRODUCTION OF MAIN PRODUCTS

耐磨钢产品系列

宝钢厚板耐磨钢目前主要分为 9 种产品：2 种基础型产品、4 种合金型产品和 3 种易焊接型产品，能够满足用户广泛要求。

基础型系列

本系列产品主要满足硬度要求，化学成分较为简单，合金含量较少。

合金型系列

本系列产品与基础型产品相比含有较多的合金元素，除了满足硬度要求外，还可满足低温冲击韧性要求。

易焊接型系列

本系列产品与基础型和合金型产品相比碳当量（CEV）更低，更易于焊接。

A Variety of Available Grades

A total of 9 grades are available: the basic series with 2 grades of hardness, and the alloy series with 4 grades, and the easy welding series with 3 grades, providing a complete product line that can meet a wide range of applications.

Basic Series

This series consists of grades produced with the main emphasis on their hardness levels, the chemical composition being basically simple while the addition of other alloying elements is restrained.

Alloy Series

This series contains alloying elements in greater quantities than the basic series. Both the prescribed hardness and low-temperature toughness are guaranteed.

Easy Welding Series

This series contains restrained contents of carbon and alloying elements. The value of CEV is lower than the standard series and the alloy series, which is good to welding.

牌号与规格

B-HARD 耐磨钢典型牌号与规格			
牌　号	规　格		
	厚度，mm	宽度，mm	长度，mm
B-HARD360A/B（基础型）	6-90	1300-4200	6000-25000
B-HARD360C/D/E（合金型）	6-80	1300-4200	6000-25000
B-HARD360CFA/B/C/D/E（易焊接型）	6-20	1300-4200	6000-25000
B-HARD400A/B（基础型）	6-90	1300-4200	6000-25000
B-HARD400C/D/E（合金型）	6-80	1300-4200	6000-25000
B-HARD400CFA/B/C/D/E（易焊接型）	6-20	1300-4200	6000-25000
B-HARD450A/B/C/D/E（合金型）	6-75	1300-4200	6000-25000
B-HARD450CFA/B/C/D/E（易焊接型）	6-20	1300-4200	6000-25000
B-HARD500A/B/C/D/E（合金型）	6-75	1300-4200	6000-25000

化学成分

B-HARD 耐磨钢典型化学成分												
牌　号	化学成分[a]（熔炼分析）%											CEV[b] ⩽
	C ⩽	Si ⩽	Mn ⩽	P ⩽	S ⩽	Cr ⩽	Mo ⩽	Ni ⩽	Ti ⩽	Alt ⩾	B ⩽	
B-HARD360（基础型）	0.20	0.60	1.60	0.025	0.015	0.80	0.30	0.20	0.050	0.015	0.005	0.55
B-HARD360（合金型）	0.20	0.60	1.60	0.025	0.015	0.80	0.50	0.80	0.050	0.015	0.005	0.58
B-HARD360CF（易焊接型）	0.18	0.60	1.80	0.025	0.015	0.60	0.30	0.50	0.050	0.015	0.005	0.52
B-HARD400（基础型）	0.20	0.60	1.60	0.025	0.015	0.80	0.30	0.20	0.050	0.015	0.005	0.56
B-HARD400（合金型）	0.20	0.60	1.60	0.025	0.015	0.80	0.50	0.80	0.050	0.015	0.005	0.60
B-HARD400CF（易焊接型）	0.18	0.60	1.80	0.025	0.015	0.60	0.30	0.50	0.050	0.015	0.005	0.53
B-HARD450（合金型）	0.25	0.70	1.60	0.020	0.010	1.00	0.80	0.80	0.050	0.015	0.005	0.65
B-HARD450CF（易焊接型）	0.22	0.70	1.60	0.020	0.010	0.60	0.50	0.50	0.050	0.015	0.005	0.63
B-HARD500（合金型）	0.30	0.70	1.60	0.020	0.010	1.50	1.00	1.00	0.050	0.015	0.005	0.70

a　根据需要可添加其它合金元素。当 Cu，As 作为残余元素时，则 Cu ⩽ 0.30%，As ⩽ 0.08%，如供方能保证可不做分析。

b　CEV= C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15；

交货状态

Q+T/Q

Grade and Specifications

Typical Grade and Specifications for B-HARD			
Grade	Specifications		
	Thickness, mm	Width, mm	Length, mm
B-HARD360A/B (Basic type)	6-90	1300-4200	6000-25000
B-HARD360C/D/E (Alloy type)	6-80	1300-4200	6000-25000
B-HARD360CFA/B/C/D/E (Easy welding)	6-20	1300-4200	6000-25000
B-HARD400A/B (Basic type)	6-90	1300-4200	6000-25000
B-HARD400C/D/E (Alloy type)	6-80	1300-4200	6000-25000
B-HARD400CFA/B/C/D/E (Easy welding)	6-20	1300-4200	6000-25000
B-HARD450A/B/C/D/E (Alloy type)	6-75	1300-4200	6000-25000
B-HARD450CFA/B/C/D/E (Easy welding)	6-20	1300-4200	6000-25000
B-HARD500A/B/C/D/E (Alloy type)	6-75	1300-4200	6000-25000

Chemical Composition

Typical Chemical Composition for B-HARD												
Grade	Chemical Composition wt.%											CEV[a] ≤
	C≤	Si≤	Mn≤	P≤	S≤	Cr≤	Mo≤	Ni≤	Ti≤	Alt≥	B≤	
B-HARD360 (Basic type)	0.20	0.60	1.60	0.025	0.015	0.80	0.30	0.20	0.050	0.015	0.005	0.55
B-HARD360 (Alloy type)	0.20	0.60	1.60	0.025	0.015	0.80	0.50	0.80	0.050	0.015	0.005	0.58
B-HARD360CF (Easy welding)	0.18	0.60	1.80	0.025	0.015	0.60	0.30	0.50	0.050	0.015	0.005	0.52
B-HARD400 (Basic type)	0.20	0.60	1.60	0.025	0.015	0.80	0.30	0.20	0.050	0.015	0.005	0.56
B-HARD400 (Alloy type)	0.20	0.60	1.60	0.025	0.015	0.80	0.50	0.80	0.050	0.015	0.005	0.60
B-HARD400CF (Easy welding)	0.18	0.60	1.80	0.025	0.015	0.60	0.30	0.50	0.050	0.015	0.005	0.53
B-HARD450 (Alloy type)	0.25	0.70	1.60	0.020	0.010	1.00	0.80	0.80	0.050	0.015	0.005	0.65
B-HARD450CF (Easy welding)	0.22	0.70	1.60	0.020	0.010	0.60	0.50	0.50	0.050	0.015	0.005	0.63
B-HARD500 (Alloy type)	0.30	0.70	1.60	0.020	0.010	1.50	1.00	1.00	0.050	0.015	0.005	0.70

a CEV= C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15;

Delivery Conditions

Q+T/Q

力学性能

B-HARD 耐磨钢典型力学性能							
牌　号	质量等级	冲击试验 [a]		布什硬度 [b] (HBW)	拉伸试验 [c]		
		温度 (℃)	冲击功 KV2 (J)		屈服强度 (MPa)	抗拉强度 (MPa)	延伸率 A_{50} (%)
B-HARD360 (基础型、易焊接型)	A	-	-	350-420	900	1050	9%
	B	+20	≥20				
B-HARD360 (合金型、易焊接型)	C	0					
	D	-20					
	E	-40					
B-HARD400 (基础型、易焊接型)	A	-	-	370-430	950	1150	9%
	B	+20	≥20				
B-HARD400 (合金型、易焊接型)	C	0					
	D	-20					
	E	-40					
B-HARD450 (合金型、易焊接型)	A	-	-	420-480	1100	1250	9%
	B	+20	≥20				
	C	0					
	D	-20					
	E	-40					
B-HARD500 (合金型)	A	-	-	470-530	1150	1400	9%
	B	+20	≥20				
	C	0					
	D	-20					
	E	-40					

a　冲击取纵向试样。

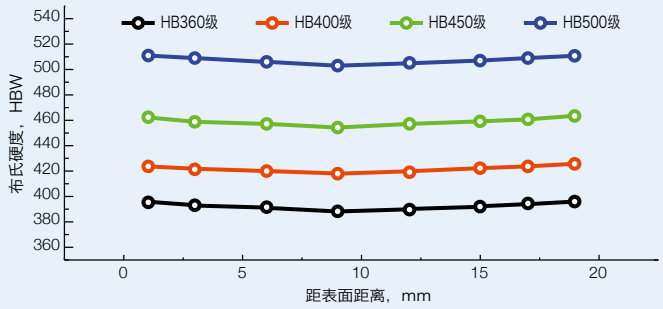
b　表面去掉 0.5-2mm 后检测性能，硬度值为一组三个试验结果的平均值。

c　拉伸横向取样，典型值。

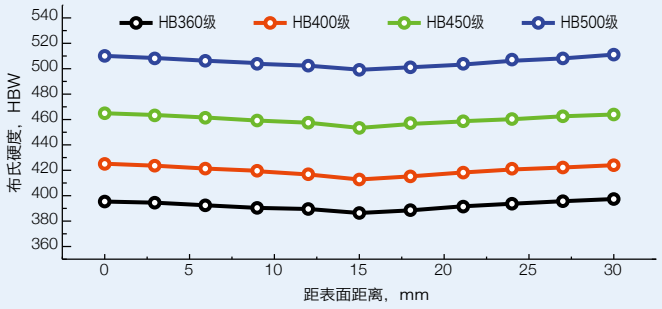
Mechanical Properties

Typically mechanical properties for B-HARD							
Grade		Impact properties		Hardness HBW	Tensile Properties		
		Test Temperature (°C)	Impact energy Charpy-V, longitudinal J		Yield strength ($R_{p0.2}$) MPa	Tensile strength (Rm) MPa	Elongation (A_{50}) %
B-HARD360 (Basic type, Easy welding)	A	-	-	350-420	900	1050	9%
	B	+20	≥20				
B-HARD360 (Alloy type, Easy welding)	C	0					
	D	-20					
	E	-40					
B-HARD400 (Basic type, Easy welding)	A	-	-	370-430	950	1150	9%
	B	+20	≥20				
B-HARD400 (Alloy type, Easy welding)	C	0					
	D	-20					
	E	-40					
B-HARD450 (Alloy type, Easy welding)	A	-	-	420-480	1100	1250	9%
	B	+20	≥20				
	C	0					
	D	-20					
	E	-40					
B-HARD500 (Alloy type)	A	-	-	470-530	1150	1400	9%
	B	+20	≥20				
	C	0					
	D	-20					
	E	-40					

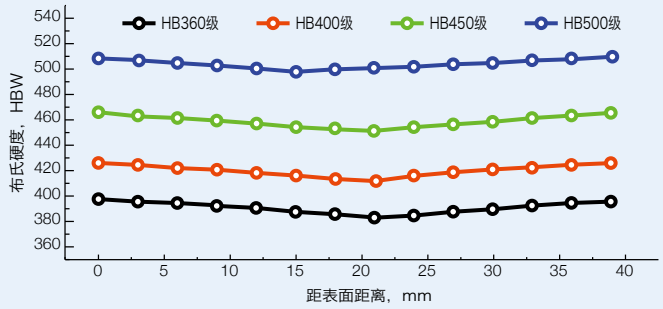
B-HARD 耐磨钢典型厚度截面硬度



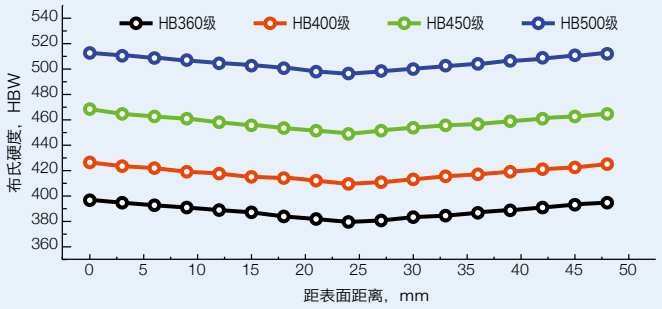
20mm 厚 B-HARD 耐磨钢典型厚度截面硬度



30mm 厚 B-HARD 耐磨钢典型厚度截面硬度

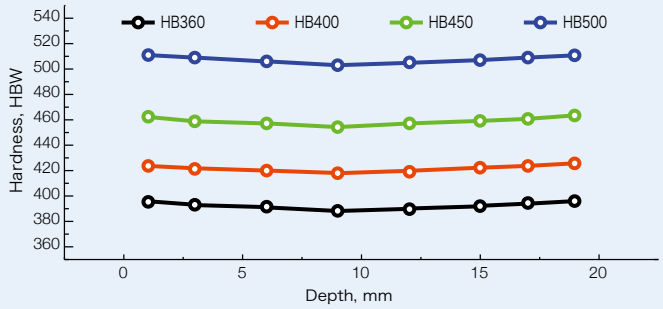


40mm 厚 B-HARD 耐磨钢典型厚度截面硬度

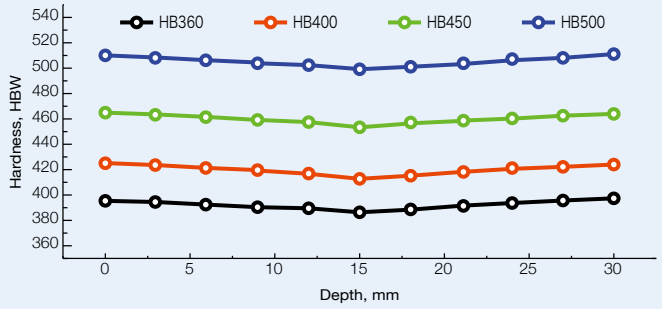


50mm 厚 B-HARD 耐磨钢典型厚度截面硬度

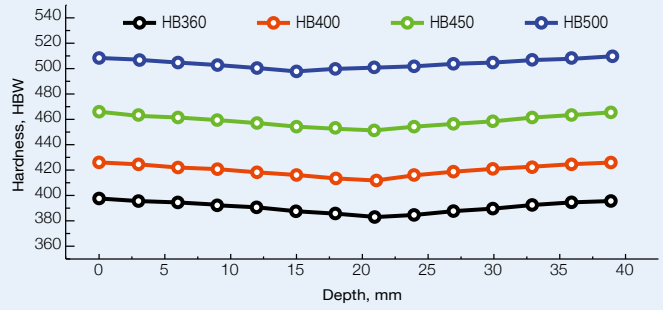
Typical hardness in thickness section of B-HARD



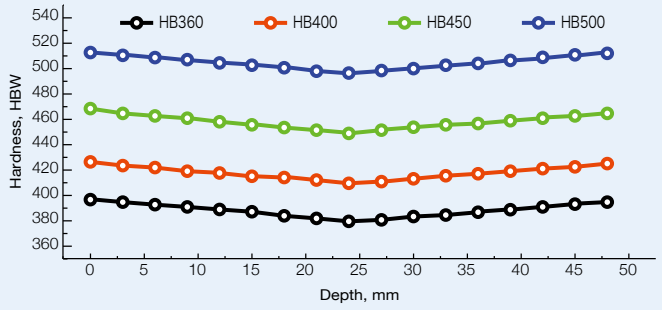
Typical values in thickness section for 20mm thickness plate



Typical values in thickness section for 30mm thickness plate

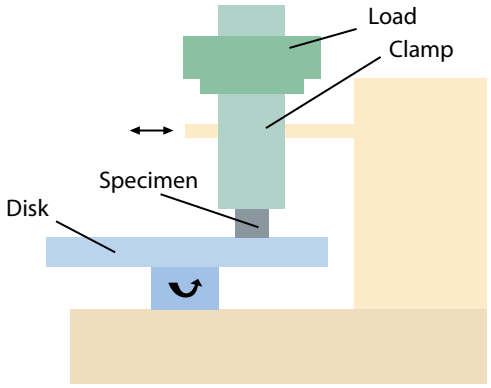


Typical values in thickness section for 40mm thickness plate

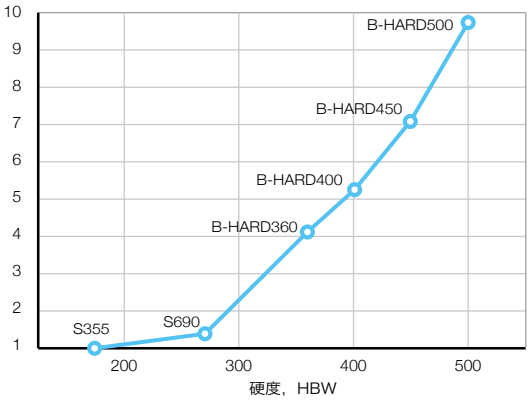


Typical values in thickness section for 50mm thickness plate

耐磨性能

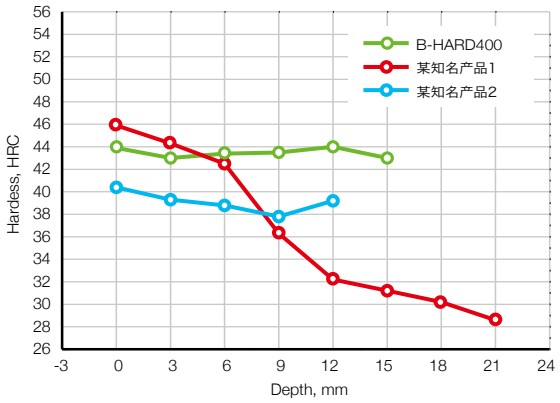


ML-100 磨粒磨损试验机工作原理图

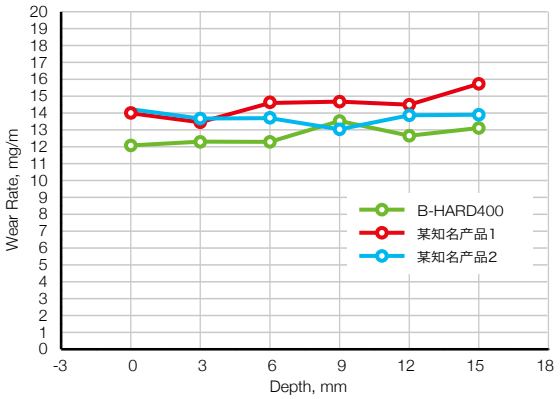


B-HARD 耐磨钢与典型高强钢使用寿命对比

第三方对 B-HARD 耐磨钢和国外先进耐磨钢对比试验结果

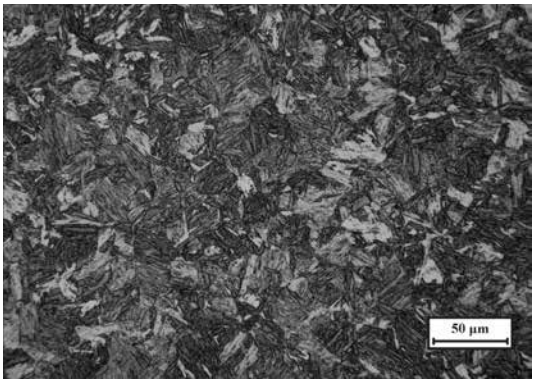


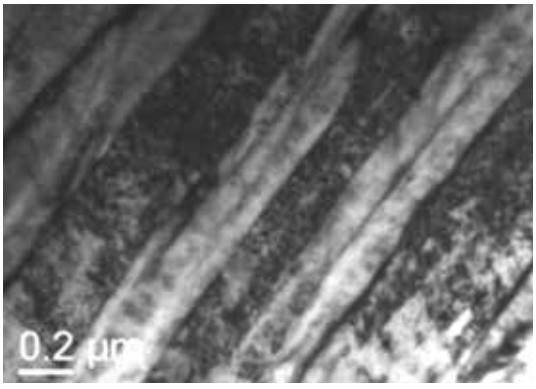
HB400 级别耐磨钢厚度截面硬度对比



HB400 级耐磨钢厚度截面磨损对比

显微组织





B-HARD 耐磨钢典型板条马氏体组织

Wear-Resisting Property

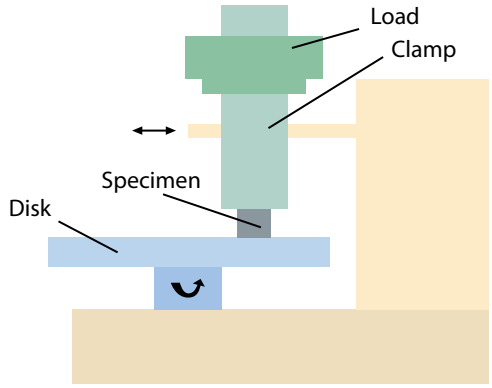
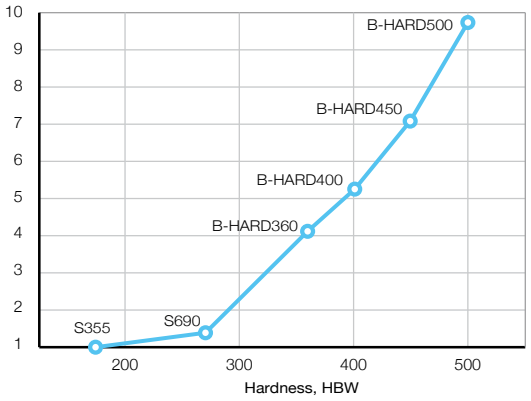
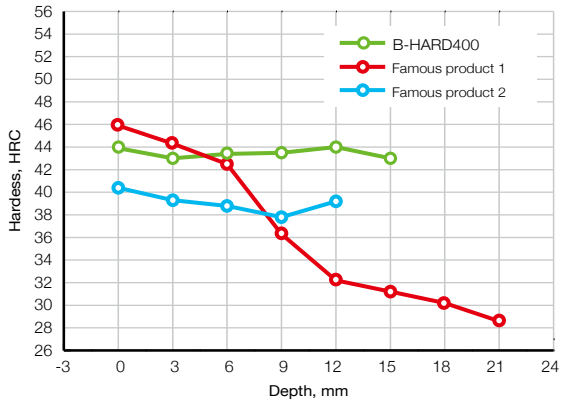


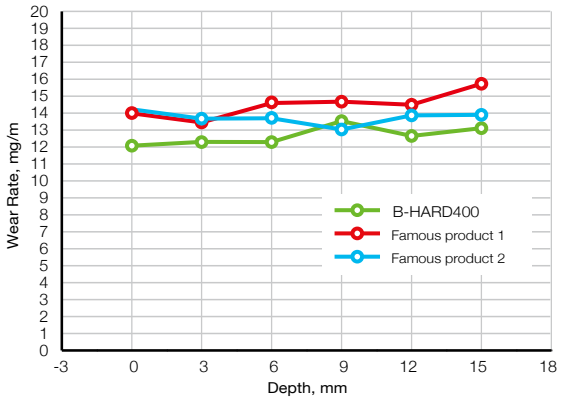
Diagram of operational principle for MI-100



Comparison of relatively used time for B-HARD and high strength steel

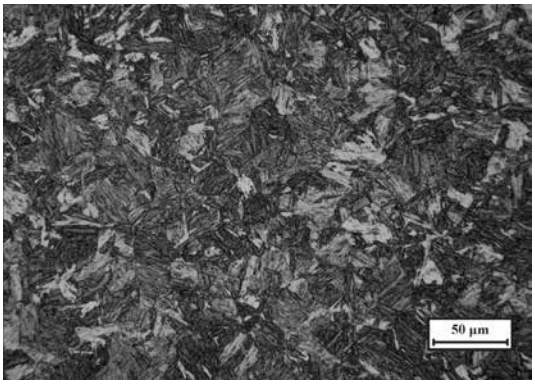


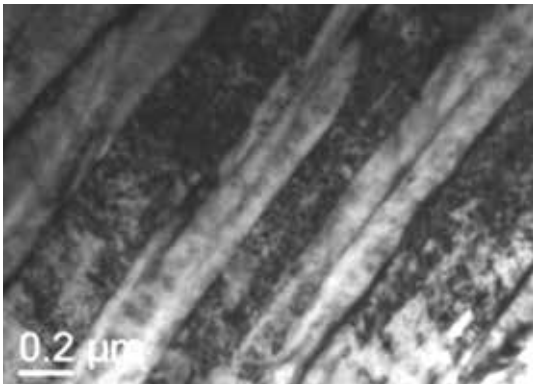
Hard comparison in thickness section for B-HARD and Famous product



Comparison of wear-resisting property in thickness section for B-HARD and famous product

Microstructure





Typical microstructure for B-HARD

使用技术
PROCESSABILITY

切割

切割方法

冷切割和热切割方法都适用于 B-HARD 耐磨钢板的切割。冷切割包括水射流切割、剪切、锯切或磨料切割，热切割包括氧气燃料火焰切 割、等离子切割和激光切割。

不同切割方法的一般特性				
切割方法	切割速度	切口	热影响区	尺寸公差
水射流切割	8-150 mm / min	1-3 mm	0 mm	± 0.2 mm
激光切割	600-2200 mm / min	< 1 mm	0.4-3 mm	± 0.2 mm
等离子切割	1200-6000 mm / min	2-4 mm	2-5 mm	± 1.0 mm
气割	150-700 mm / min	2-5 mm	4-10 mm	± 2.0 mm

剪切机剪切

我们提供的剪切参数只是在一般情况下使用的，在实际操作中，要根据机器的稳定性和刀刃的条件进行选择。

刀　刃　刀刃应该坚硬、锋利，并且稍带一点圆边。

间　隙　这是取得满意效果最重要的参数。移动刀刃和固定刀刃的间隙应随着钢板的拉伸强度增加而增加。不正确的间隙将造成剪切面不平，在随后的焊接或弯曲中可能引起钢板的开裂。

刀面角　刀面角越大，钢板侧移的可能性越大或所切的钢板发生扭曲变形的可能性越大，但剪切力越低。通常，刀面角应随所切钢板强度的增加而增加。

剪切力　在给定刀面角条件下，剪切力与钢板强度成正比增加的关系。

B-HARD 耐磨钢典型剪切参数		
牌　号	剪刃间隙 △= %t	剪刃倾斜角 °
B-HARD360（基础型）	13-16	2-5
B-HARD360（合金型）	13-16	2-5
B-HARD360CF（易焊接型）	13-16	2-5
B-HARD400（基础型）	13-16	2-5
B-HARD400（合金型）	13-16	2-5
B-HARD400CF（易焊接型）	13-16	2-5
B-HARD450（合金型）	13-16	2-5
B-HARD450（易焊接型）	13-16	2-5
B-HARD500（合金型）	13-16	2-5

Cutting

Cutting methods

B-HARD can very well be cut using both cold and thermal cutting methods. The cold methods are abrasive water jet cutting, shearing, sawing or abrasive grinding, while thermal methods are oxy-fuel, plasma and laser cutting.

General features for different cutting methods				
Cutting method	Cutting speed	Kerf	HAZ	Dim. tolerance
Abrasive water-jet cutting	8-150 mm / min	1-3 mm	0 mm	± 0.2 mm
Laser cutting	600-2200 mm / min	< 1 mm	0.4-3 mm	± 0.2 mm
Plasma cutting	1200-6000 mm / min	2-4 mm	2-5 mm	± 1.0 mm
Gas cutting	150-700 mm / min	2-5 mm	4-10 mm	± 2.0 mm

Shearing

Note that our setting suggestions are only general recommendations. In practice, the choice is dictated by the machine stability and the condition of the blades.

Blades The blades should be hard and sharp, with slightly rounded edges.

Clearance This is the most important parameter for achieving good results. The clearance between the moving and stationary blades should be increased with increasing tensile strength. Incorrect clearance will result in poor sheared surfaces and may give rise to cracking when the plate is subsequently welded or bent.

Rake angle The larger the rake angle, the lower the shearing force, although the risk will be greater of the plate sliding sideways or the piece of plate that has been sheared off deforming (twisting). As a general rule, the rake angle should be increased when shearing high strength plate.

Shearing force For a given rake angle, the shearing force increases linearly with increasing strength of the plate.

Clearance and rake angle settings for different plate grades		
Grade	Clearance, Δ in % of t	Rake angle, λ [°]
B-HARD360 (Basic type)	13-16	2-5
B-HARD360 (Alloy type)	13-16	2-5
B-HARD360CF (Easy welding)	13-16	2-5
B-HARD400 (Basic type)	13-16	2-5
B-HARD400 (Alloy type)	13-16	2-5
B-HARD400CF (Easy welding)	13-16	2-5
B-HARD450 (Alloy type)	13-16	2-5
B-HARD450 (Easy welding)	13-16	2-5
B-HARD500 (Alloy type)	13-16	2-5

火切

预热

消除切边裂纹的最佳方法是在切割之前进行预热。在进行火焰切割前，通常都要预热。预热温度取决于钢板的等级和厚度。

在火焰切割之前对 B-HARD 耐磨钢进行预热		
等级	钢板厚度 mm	预热温度 ℃
B-HARD360	40 - 60	100
	60 - 80	150
	> 80	175
B-HARD400	40 -60	100
	60 - 80	150
	> 80	175
B-HARD450	35 -50	100
	50 -70	150
	70 - 75	175
B-HARD500	30 -50	100
	50 -60	150
	60 - 75	175

B-HARD 耐磨钢典型火切参数					
割嘴号	板厚 (mm)	切割速度 (mm/min)	割缝宽度 (mm)	预热氧 / 切割氧压力 (Mpa)	LPG 压力 (Mpa)
0	6-10	800-900	0.8-1.0	0.7	0.03
1	10-20	700-800	1.0-1.8	0.7	0.03
2	20-40	450-600	1.8-3.0	0.7	0.03
3	40-60	400-450	3.0-4.0	0.7	0.03
4	60-80	340-400	4.0-5.0	0.7	0.035
5	80-100	280-320	5.0-6.0	0.7	0.035

Oxy-fuel cutting

Preheating

Preheating prior to cutting is the best way of eliminating the risk of cut edge cracking. Preheating is most commonly applied prior to oxy-fuel cutting. The preheating temperature depends on the steel grade and the plate thickness.

Preheating of B-HARD prior to oxy-fuel cutting.		
Grade	Plate thickness, mm	Preheating temp. ºC
B-HARD360	40 - 60	100
	60 - 80	150
	> 80	175
B-HARD400	40 -60	100
	60 - 80	150
	> 80	175
B-HARD450	35 -50	100
	50 -70	150
	70 - 75	175
B-HARD500	30 -50	100
	50 -60	150
	60 - 75	175

Oxy-fuel cutting Parameter of B-HARD					
Cutting torch	Thickness (mm)	Cutting speed (mm/min)	Kerf (mm)	Preheat oxygen / Cutting oxygen pressure (Mpa)	LPG pressure (Mpa)
0	5-10	800-900	0.8~1.0	0.7	0.03
1	(10)-20	700-800	1.0~1.8	0.7	0.03
2	(20)-40	450-600	1.8~3.0	0.7	0.03
3	(40)-60	400-450	3.0~4.0	0.7	0.03
4	(60)-80	340-400	4.0~5.0	0.7	0.035
5	(80)-100	280-320	5.0~6.0	0.7	0.035

等离子切割

B-HARD 耐磨钢典型等离子切割参数									
厚度	电流	喷嘴型号	涡流环	保护帽	PG2（压力 :bar）	WG（压力 :bar）		电压 (V)	切割速度 (mm/min)
					切割气体 (O_2)	压缩空气	氮气		
8	300A	T2127	V4345	T3045	7.4		2.5	128	5000
10	300A	T2127	V4345	T3045	7.4		2.5	125	4100
12	300A	T2127	V4345	T3060	7.2	1.5		128	3800
15	300A	T2127	V4345	T3060	7.2	1.5		132	3200
20	300A	T2127	V4345	T3045	7.2	2.5		140	2000
25	300A	T2127	V4345	T3045	7.4	2.5		143	1500
30	300A	T2127	V4345	T3045	6.8	2.5		145	1200
40	300A	T2127	V4345	T3045	7.2	1.5		153	700
50	300A	T2127	V4345	T3045	5.7	2.2		157	450
60	300A	T2127	V4345	T3045	5.7	2.2		166	270
75	300A	T2127	V4345	T3045	5.7	2.2		187	130

Plasma cutting

Plasma cutting parameter of B-HARD							
Thickness	Current	Vortex ring	PG2 (pressure: bar)	WG (pressure: bar)		Voltage (V)	Cutting speed (mm/min)
			Cutting gas (O_2)	Compressed air	nitrogen		
8	300A	V4345	7.4		2.5	128	5000
10	300A	V4345	7.4		2.5	125	4100
12	300A	V4345	7.2	1.5		128	3800
15	300A	V4345	7.2	1.5		132	3200
20	300A	V4345	7.2	2.5		140	2000
25	300A	V4345	7.4	2.5		143	1500
30	300A	V4345	6.8	2.5		145	1200
40	300A	V4345	7.2	1.5		153	700
50	300A	V4345	5.7	2.2		157	450
60	300A	V4345	5.7	2.2		166	270
75	300A	V4345	5.7	2.2		187	

铣、刨、钻

B-HARD 耐磨钢铣、刨、钻等工序典型参数				
工序	典型工艺参数			
铣	典型设备	铣削速度	铣削深度	刀头材质
	立式升降台铣床	30-50 转 /min	1-3mm/ 刀	硬质合金
刨	典型设备	切削速度	切削深度	刀头材质
	牛头刨床	7-8m/min	0.1-0.3mm/ 刀	硬质合金
钻	典型设备	钻削速度	钻削深度	钻头材质
	立轴式钻机	50-200 转 /min	01-0.5mm/ 转	硬质合金

Mill, Plane and Drill

Mill, plane and drill parameter of B-HARD				
Process	Parameter			
Mill	Equipment	Speed	Depth	Cutter
	Milling machine	30-50Rotation /min	1-3Mm/pass	Carbide
Plane	Equipment	Speed	Cutting depth	Cutter
	Facing machine	7-8M/min	0.1-0.3Mm/pass	Carbide
Drill	Equipment	Speed	Depth	Boring crown
	Drilling machine	50-200Rotation/min	01-0.5Mm/rotation	Carbide

弯曲

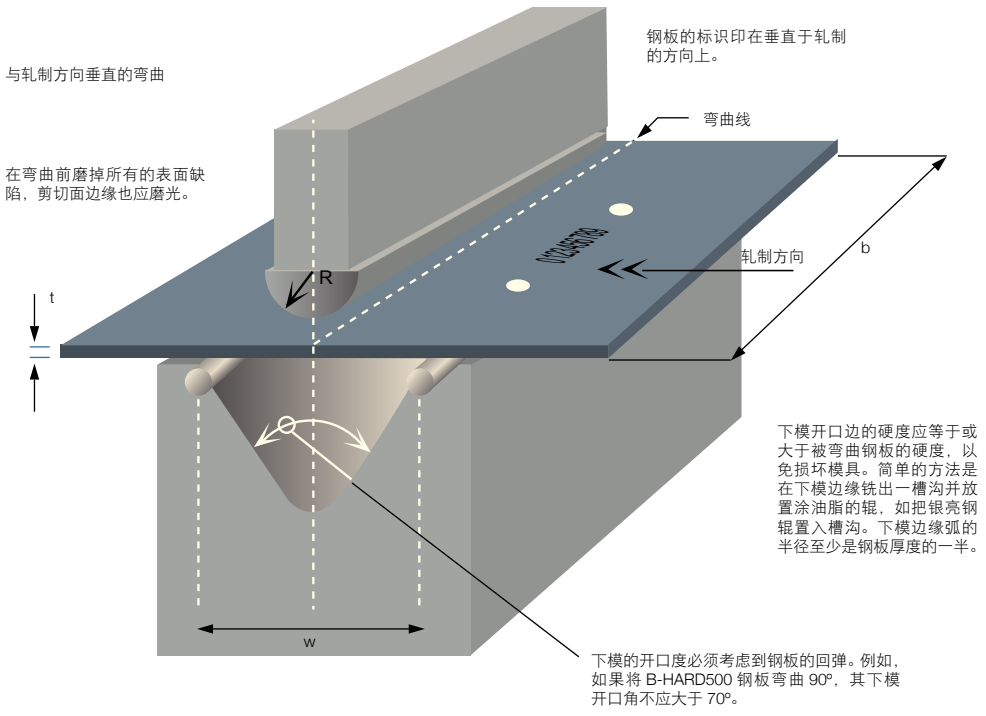
折弯主要与钢板、工具和工艺流程等三方面因素有关。对于耐磨钢而言由于其强硬度极高，故在折弯过程中的工具和工艺等方面控制要求更为严格。对于宝钢 B-HARD 耐磨钢厚板可参考以下方式弯曲。

对于钢板弯曲 90° 时，推荐的上模半径（R）和下模开口度（W）			
牌　号	钢板厚度 tmm	垂直轧制方向	垂直轧制方向
B-HARD360	t < 8	R≥2.5t	W≥8.5t
	t=8- < 20	R≥3t	W≥10t
	t≥20	R≥4.5t	W≥12t
B-HARD400	t < 8	R≥2.5t	W≥8.5t
	t=8- < 20	R≥3t	W≥10t
	t≥20	R≥4.5t	W≥12t
B-HARD450	t < 8	R≥3.5t	W≥10t
	t=8- < 20	R≥4t	W≥10t
	t≥20	R≥5t	W≥12t
B-HARD500	t < 8	R≥4t	W≥10t
	t=8- < 20	R≥5t	W≥12t
	t≥20	R≥7t	W≥16t

钢板弯曲时应去除因剪切或火焰切割造成的应变区和热影响区。为避免钢板边部因加工硬化造成的应力集中，可对边部倒圆，倒圆半径不超过试样厚度的 1/10。

折弯力可以用下式计算　$p=\frac{1.6xbxt^2xR_m}{10000xW}$

p—折弯力（t）；b —钢板宽度（mm）；t—钢板厚度（mm）；R_m—钢板抗拉强度（MPa）；W—下模开口距离（mm）



Bending

The bending results are dependent on a number of factors which we have grouped here under three headings: the plate, the tools and the procedure.

Minimum recommended punch radius (R) and die opening width (W) for plate thickness(t) when the plate is being bent to 90° at right angles to the direction of rolling			
Grade	**Thickness, mm**	**At right angles**	**At right angles**
B-HARD360	t<8	R≥2.5t	W≥8.5t
	t=8-<20	R≥3t	W≥10t
	t≥20	R≥4.5t	W≥12t
B-HARD400	t<8	R≥2.5t	W≥8.5t
	t=8-<20	R≥3t	W≥10t
	t≥20	R≥4.5t	W≥12t
B-HARD450	t<8	R≥3.5t	W≥10t
	t=8-<20	R≥4t	W≥10t
	t≥20	R≥5t	W≥12t
B-HARD500	t<8	R≥4t	W≥10t
	t=8-<20	R≥5t	W≥12t
	t≥20	R≥7t	W≥16t

焊接

B-HARD 耐磨钢典型焊接方法和焊材					
牌　号	碳当量 (%)	推荐的焊接工艺方法	预热温度		配套焊材
B-HARD360 (基础型、合金型、易焊接型)	0.45-0.58	GMAW	6-30mm >30-50mm >50-90mm 6-20mm	100℃ 150℃ 200℃ 易焊接型可不预热	70-100kg 级焊丝
B-HARD400 (基础型、合金型、易焊接型)	0.48-0.60	GMAW	6-30mm >30-50mm >50-90mm 6-20mm	100℃ 150℃ 200℃ 易焊接型可不预热	70-100kg 级焊丝
B-HARD450 (合金型、易焊接型)	0.55-0.65	GMAW	6-30mm >30-75mm 6-20mm	150℃ 200℃ 易焊接型 100℃	70-100kg 级焊丝
B-HARD500 (合金型)	0.60-0.70	GMAW	6-30mm >30-60mm	180℃ 200℃	70-100kg 级焊丝

注：

(1) 符号说明 GMAW-Gas metal arc welding (气体保护焊)。

(2) 表中按照实心焊丝混合气体保护焊工艺估算，预热温度比国内其它钢厂的同类钢的预热温度偏低；预热温度的确定不仅仅取决于母材的 Ceq、还与钢板的厚度、所使用焊接材料的扩散氢水平及焊接热输入量密切相关。同种钢材随着板厚、结构拘束度、焊接材料的含氢量的增加，预热温度要相应提高。

B-HARD 耐磨钢典型焊接工艺									
牌　号	厚度 (mm)	焊丝直径 (mm)	焊接电流 (A)	电弧电压 (V)	焊接速度 (mm/s)	层间温度 (℃)	干伸长 (mm)	保护气体	线能量 (kJ/mm)
B-HARD360 (基础型、合金型、易焊接型)	6-90	Φ1.2/1.6	150-350	20-35	5-10	≤200	16-20	80%Ar+20%CO_2	≤1.5
B-HARD400 (基础型、合金型、易焊接型)	6-90	Φ1.2/1.6	160-320	20-35	5-10	≤200	16-20	80%Ar+20%CO_2	≤1.5
B-HARD450 (合金型、易焊接型)	6-75	Φ1.2/1.6	160-320	20-35	5-10	≤200	16-20	80%Ar+20%CO_2	≤1.5
B-HARD500 (合金型)	6-75	Φ1.2/1.6	160-360	20-35	5-10	≤200	16-20	80%Ar+20%CO_2	≤1.5

注：

(1) 表中参数仅指气体保护焊；气体保护焊的具体参数焊接要根据板厚、焊接位置、接头型式及保护气体种类来定，以平位置中厚板对接接头焊接为例：打底焊：200~240A，22~26V；填充焊、盖面：260~300A，28~31V；定位焊：260~280A，30V。

(2) 从保证接头性能出发，气体保护焊推荐采用多道多层焊接，禁止纵向和横向摆动，焊接热输入量应控制在要求范围内。

(3) 需根据结构件受力情况评定焊丝和焊接工艺。

B-HARD 耐磨钢焊后热处理工艺要求				
牌　号	后热 150-250℃	消氢 150-250℃	消除应力 450-500℃	其它热处理 （正火或调质）
B-HARD360（基础型、合金型、易焊接型）	推荐	推荐	禁用	禁用
B-HARD400（基础型、合金型、易焊接型）	推荐	推荐	禁用	禁用
B-HARD450（合金型、易焊接型）	推荐	推荐	禁用	禁用
B-HARD500（合金型）	推荐	推荐	禁用	禁用

注：从防止冷裂纹及保证焊接接头力学性能考虑，焊接接头焊后建议采用后热或消氢处理（两者选一）；焊后采用过高温度的消除应力热处理可能损害焊接接头的力学性能，使用前需进行必要的评定；焊后采用正火或调质处理将使焊缝金属的组织和力学性能受到严重影响。

Welding

Typical welding method and welding consumables for B-HARD					
Grade	CEV (%)	Welding method	Preheating temp.		Welding consumables
B-HARD360 (Basic type, Alloy type, Easy welding)	0.45-0.58	GMAW	6-30mm >30-50mm >50-90mm	100°C 150°C 200°C	70-100kg
B-HARD400 (Basic type, Alloy type, Easy welding)	0.48-0.60	GMAW	6-30mm >30-50mm >50-90mm	100°C 150°C 200°C	70-100kg
B-HARD450 (Alloy type, Easy welding)	0.55-0.65	GMAW	6-30mm >30-75mm	150°C 200°C	70-100kg
B-HARD500 (Alloy type)	0.60-0.70	GMAW	6-30mm >30-60mm	180°C 200°C	70-100kg

Remarks: (1) CEV= C+Mn/6+(Cr+Mo+V)/5+(Ni+Cu)/15; (2) GMAW-Gas metal arc welding

Typical welding procedure for B-HARD								
Grade	Thickness (mm)	Diameter of welding stick (mm)	Current (A)	Voltage (V)	Welding speed (mm/s)	Interpass temperature (°C)	Shielding gas	Heat input (kJ/mm)
B-HARD360 (Basic type, Alloy type, Easy welding)	6-90	Φ1.2/1.6	150-350	20-35	5-10	≤200	80%Ar+20%CO_2	≤1.5
B-HARD400 (Basic type, Alloy type, Easy welding)	6-90	Φ1.2/1.6	160-320	20-35	5-10	≤200	80%Ar+20%CO_2	≤1.5
B-HARD450 (Alloy type, Easy welding)	6-75	Φ1.2/1.6	160-320	20-35	5-10	≤200	80%Ar+20%CO_2	≤1.5
B-HARD500 (Alloy type)	6-75	Φ1.2/1.6	160-360	20-35	5-10	≤200	80%Ar+20%CO_2	≤1.5

Post weld heat treatment				
Grade	Post heating 150-250°C	Hydrogen elimination 150-250°C	Stress relieving 450-500°C	Other (normalizing or tempering)
B-HARD360 (Basic type, Alloy type, Easy welding)	Yes	Yes	No	No
B-HARD400 (Basic type, Alloy type, Easy welding)	Yes	Yes	No	No
B-HARD450 (Alloy type, Easy welding)	Yes	Yes	No	No
B-HARD500 (Alloy type)	Yes	Yes	No	No

热处理

B-HARD 耐磨钢无需进一步热处理。但如钢板使用后或预热温度超过 250℃，则其性能无法保证与交货条件所规定的性能一致。

Heat Treatment

B-HARD has obtained its mechanical properties by quenching and when necessary by means of and Fabrication subsequent tempering. The properties of the delivery condition can not be retained after exposure to service or preheating temperatures in excess of 250ºC (480ºF).

钢板的尺寸、外形、重量及允许偏差

宝钢的高精度轧制技术，可有效控制钢板的厚度公差和同板差。钢板的尺寸、外形、重量及允许偏差满足《GB/T709-2006 热轧钢板和钢带的尺寸、外形、重量及允许偏差》，并可满足用户高精度厚度偏差需求，在技术协议中注明。钢板切割后具有良好的板形，满足用户高精度加工需求。

DIMENSION, SHAPE, WEIGHT, AND TOLERANCES

Dimension, shape, weight, and tolerances should be according to Chinese standard *GB/T709-2006 Dimension, shape, weight, and tolerances for hot-rolled plates and sheets*.

加工配送

宝钢具有钢板加工和配送能力，可根据用户要求将钢板深加工（如将钢板加工成用户要求的尺寸、形状）后供货。

PROCESSING AND CARRIAGE

Plates can be processed and carried according to the different requirement.

技术咨询电话

姚连登	021-26647182	15021195961
李红斌	021-26641017	15802128251

技术服务咨询电话

张向葵	021-26642550	13671660696
刘劲松	021-26642543	13564306946

Technical support

Liandeng Yao	021-26647182	15021195961
Hongbin Li	021-26641017	15802128251

Technical service support

Xiangkui Zhang	021-26642550	13671660696
Jingsong Liu	021-26642543	13564306946

宝山钢铁股份有限公司
http://www.baosteel.com

BAOSHAN IRON & STEEL CO., LTD.
http://www.baosteel.com

厚板与工程材料销售部
Heavy Plate & Engineering Materials Sales Department
地址：上海市宝山区漠河路 151 号
邮编：201999
电话：021-26649630
传真：021-26645289

客户与产品服务部
Customer and Product Service Department
地址：上海市宝山区漠河路 151 号
邮编：201999
电话：021-26648888
传真：021-26645295

宝钢服务热线
Baosteel Service Hot-line
400-820-8590

宝钢在线
http://www.baosteel.net.cn

国内贸易公司

上海宝钢钢材贸易有限公司
电话：021-50509696
传真：021-68404618

广州宝钢南方贸易有限公司
电话：020-32219999
传真：020-32219555

北京宝钢北方贸易有限公司
电话：010-56512000
传真：010-56512199

成都宝钢西部贸易有限公司
电话：028-85335388
传真：028-85335680

武汉宝钢华中贸易有限公司
电话：027-84298800
传真：027-84298224

沈阳宝钢东北贸易有限公司
电话：024-31391158
传真：024-31391160

上海宝钢商贸有限公司
电话：021-26640781
传真：021-26640700

上海宝钢浦东国际贸易有限公司
电话：021-26640606
传真：021-26640666

上海宝钢宝山钢材贸易有限公司
电话：021-26640526　26640530
传真：021-26640529

东北亚及澳洲大区　Northeast Asia and Oceania Region

宝和通商株式会社
HOWA TRADING CO., LTD.
TEL: 0081-3-3237-9121
FAX: 0081-3-3237-9123

宝和首尔事务所
SEOUL OFFICE
TEL: 0082-2-5080893
FAX: 0082-2-5080891

宝钢澳大利亚贸易有限公司
BAO AUSTRALIA PTY LTD
TEL: 0061-8-94810535
FAX: 0061-8-94810536

东南亚及南亚大区　Southeast Asia and South Asia Region

宝钢新加坡贸易有限公司
BAOSTEEL SINGAPORE PET LTD.
TEL: 0065-63336818
FAX: 0065-63336819

宝钢印度公司
BAOSTEEL INDIA COMPANY PRIVATE LTD.
TEL: 0091-22-30071700
FAX: 0091-22-30071777

越南代表处
VIETNAM OFFICE
TEL: 0084-8-39100126
FAX: 0084-8-39100124

泰国代表处
THAILAND OFFICE
TEL: 0066-2-6543008
FAX: 0066-2-6543010

欧非及中东大区　Europe, Africa and Middle East Region

宝钢欧洲有限公司
BAOSTEEL EUROPE GMBH
TEL: 0049-40-41994101
FAX: 0049-40-41994120

宝钢中东代表处
BAOSTEEL MIDDLE EAST REPRESENTATIVE OFFICE
TEL: 00971-4-8840458
FAX: 00971-4-8840485

宝钢西班牙有限公司
BAOSTEEL ESPAÑA, S.L.
TEL: 0034-93-4119325
FAX: 0034-93-4119330

宝钢意大利钢材集散中心有限公司
BAOSTEEL ITALIA DISTRIBUTION CENTER SPA
TEL: 0039-010-5308872
FAX: 0039-010-5308895

宝钢东欧代表处
BAOSTEEL CENTRAL AND EASTERN EUROPE OFFICE
TEL: 0048-32-7315012
FAX: 0048-32-7315011

美洲大区　America Region

宝钢美洲贸易有限公司
BAOSTEEL AMERICA INC.
TEL: 001-201-3073355
FAX: 001-201-3073358

底特律代表处
DETROIT OFFICE
TEL: 001-248-2089918
FAX: 001-248-2080999

休斯顿代表处
HOUSTON OFFICE
TEL: 001-281-4847333
FAX: 001-281-4842655

洛杉矶代表处
LOS ANGELES OFFICE
TEL: 001-949-7526789
FAX: 001-949-7521234

宝钢巴西贸易有限公司（宝美巴西代表处）
BAOSTEEL DO BRAZIL PTE LTDA.
TEL: 0055-21-25311363
FAX: 0055-21-25310298

2014 年 11 月印刷于中国上海

NMH1411C0101