

# Hot-rolled High Strength Steel for Automobile

汽车用  
高强度热连轧结构钢

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## 开发历史

### The Development of Hot-rolled High Strength Steel for Automobile

随着对安全、减重节能和环保的要求，汽车对高强度汽车用钢的需求日益迫切。而热轧高强钢板广泛用于车轮、大梁、车厢、车桥、传动轴、底盘、悬挂等重要部件，具有很大的减重潜力。

宝钢于2004年开始热轧高强度汽车用钢的研制，相继开发出多种满足各种特定性能要求的高强钢种，如

- ① 屈服强度550~700MPa级的具有良好成形性能和焊接性能的低合金高强度钢，可用于汽车大梁、车厢、传动轴管和其它汽车结构件；
- ② 抗拉强度450~650MPa级车轮用钢；
- ③ 高强度桥壳用钢；
- ④ 先进高强度钢（440~780MPa级的高扩孔钢、580和780MPa级的双相钢、580和780MPa级的TRIP钢），具有良好成形性能和高的疲劳特性，可用于复杂形状零件的制造。

宝钢汽车用高强度钢采用了先进的冶炼技术，夹杂物含量低、钢质纯净，采用精确的控制轧制和控制冷却技术获得各钢种所需的组织结构满足使用要求。

宝钢汽车用高强度钢广泛应用于轿车和卡车的整车厂、汽车零部件厂和汽车改装厂产品的制造，用高强度钢替代传统低强度钢可明显减轻汽车自重，也可在一定程度上降低成本。



With the increasing awareness for safety, energy saving and environment protection, there is an urge for high strength steel for automotive. Hot-rolled high strength steel sheets, which are widely used in wheel, beam, carriage, axle, drive shaft, chassis, suspension and other important parts, can provide great potential for weight reduction.

Baosteel began to develop hot-rolled high strength steel for automobile in 2004 and successfully developed various types of high strength steel which can satisfy different performance requirements, such as:

- ① 550~700MPa low alloy high strength steels in yield strength with good formability and weldability, which can be used in beam, carriage, drive shaft and other structural parts of automobiles.
- ② 450~650MPa wheel steels in tensile strength.
- ③ 600MPa grade steel for axle housing in tensile strength.
- ④ Advanced high strength steel (440~780MPa high hole expansion steels, 580 and 780MPa dual-phase steels, 580 and 780MPa TRIP steels) with good formability and high anti-fatigue property, which is applicable to parts with complex shapes

Baosteel adopts advanced smelting technology to gain pure steel with low inclusion. Precisely controlled rolling and controlled cooling technologies are used to obtain expected microstructures to meet application requirements.

Baosteel hot-rolled high strength steels for automobiles are widely used in car and truck factories, auto parts factories and car tuning shops. High strength steel sheets make it possible to reduce auto body weight, which thereby contributes to improved manufacturing cost.

## 一、汽车大梁用高强钢系列

### I. High Strength Steel for Automobile Beam

#### 1、 产品牌号 Designation

强度级别 Yield Strength	代表牌号 Typical designation
550	B600L、 S550MC、 QSTE550TM
600	B650L、 S600MC、 QSTE600TM
650	B700L、 S650MC、 QSTE650TM
700	B750L、 S700MC 、 QSTE700TM、 ZQS700L、 ZQS700Z、 700L-Z

#### 2、 汽车大梁用高强钢化学成分（%） Chemical composition (%)

强度级别 Yield Strength	C	Si	Mn	P	S	Al	Nb	V	Ti	Mo
550	≤ 0.10	≤ 0.50	≤ 1.70	≤ 0.025	≤ 0.010	≥ 0.015	≤ 0.09	≤ 0.20	≤ 0.15	
600	≤ 0.10	≤ 0.50	≤ 1.80	≤ 0.025	≤ 0.010	≥ 0.015	≤ 0.09	≤ 0.20	≤ 0.15	
650	≤ 0.10	≤ 0.50	≤ 2.00	≤ 0.025	≤ 0.010	≥ 0.015	≤ 0.09	≤ 0.20	≤ 0.15	
700	≤ 0.10	≤ 0.50	≤ 2.10	≤ 0.025	≤ 0.010	≥ 0.015	≤ 0.09	≤ 0.20	≤ 0.15	≤ 0.50

注: Nb+ V+ Ti≤0.22%

Remarks: Nb+ V+ Ti≤0.22%



栏板半挂车 Bulk semi-trailer



仓栅半挂车 Stake semi-trailer

### 3、汽车大梁用高强钢机械性能 Mechanical properties

强度级别 Yield Strength	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 Elongation (%)		180 度冷弯, 弯心直径 180 degree cold bend, diameter
			厚度 <3mm $L_0=80\text{mm}$ $b=20\text{mm}$	厚度 $\geq 3\text{mm}$ $L_0=5.65 \sqrt{S_0}$	
550	$\geq 550$	600-760	$\geq 12$	$\geq 14$	1.5a
600	$\geq 600$	650-820	$\geq 11$	$\geq 13$	1.5a
650	$\geq 650$	700-880	$\geq 10$	$\geq 12$	2.0a
700	$\geq 700$	750-950	$\geq 10$	$\geq 12$	2.0a

注:

- 650MPa和700MPa级厚度大于8mm屈服强度可降低20MPa。
- 拉伸试样方向为纵向, 冷弯试样方向为横向。





Remarks:

- The yield strength of 650 and 700 with thickness > 8mm can be 20Mpa lower.
- Samples for the tensile test are taken in rolling direction. Samples for cold bend test are taken transversely.

### 4、汽车大梁用高强钢典型力学性能 Typical mechanical properties

强度级别 Yield Strength	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 Elongation (%)	冷弯 Cold bend
550	3.0	611	702	23	合格 OK
	11.6	590	713	22	合格 OK
	16.0	605	695	22	合格 OK
600	3.2	635	745	22	合格 OK
	8.0	635	735	22	合格 OK
650	3.0	682	748	21	合格 OK
	5.0	667	736	20	合格 OK
	8.0	680	758	22	合格 OK
	10.0	651	752	21	合格 OK
700	3.2	747	788	21	合格 OK
	4.0	741	819	20	合格 OK
	8.0	742	820	21	合格 OK
	9.0	724	805	22	合格 OK

5、冷弯性能  
Cold bend properties

650MPa级 650MPa Class		700MPa级 700MPa Class	
			
3mm钢板 3mm sheet	3mm和8mm钢板双弯试验 3mm and 8mm sheets double bend test	8mm钢板双弯试验 8mm sheet double bend test	4mm钢板单弯和双弯试验 4mm sheet single and double bend test

6、汽车大梁用高强钢可供规格  
Available product size range

强度级别 Yield Strength	规格 (mm) Size (mm)
550	2.0~16.0 X 900~1750
600	2.5~12.0 X 900~1600
650	2.5~12.0 X 900~1600
700	3.0~12.0 X 900~1600

如用户订货规格超过上表, 请联系确认。

Please contact the service team if required size is out of range.

## 7、 汽车大梁用高强钢的加工工艺 Processing technology



汽车大梁用高强钢具有高的强度、良好的加工弯曲性能,可进行适合加工梁类零件。大梁涉及的加工方式有剪切、冲孔、冲压、折弯、辊压等。随着强度的上升,汽车大梁用高强钢塑性及成形极限有所下降,零件设计时要有所考虑。又由于梁类零件成形时易回弹及扭曲,使用高强钢后,该趋势将更加严峻,模具设计甚至零件设计时要有所考虑。同时,高强钢剪切时,剪切间隙不合适将致使剪切边部成形性差,成形时易开裂,同时差的剪切断面后续也将成为疲劳开裂源;剪切时,模具或刀刃材料选择不合适时刃口将易磨损甚至崩刃。

在辊压及折弯时,要考虑到弯曲圆角、弯曲角度的影响及边部剪切质量的影响。使用大梁高强钢,成形及冲裁力也将极大上升,须重新校核冲压成形设备能力是否满足要求。

High strength steels for automobile beams have high strength and good bending performance, which is suitable for beam parts. The processes include cutting, punching, stamping, bending, and rolling, etc. It should be taken into account during the design that the plasticity and formability of high strength steel for automobile decreases while strength increases. Also, the more springback and distortion should be taken into consideration during the design of die and parts when high strength steels are used. Besides, when high strength steels are sheared, improper shearing gap will cause a bad sheared edge and then cause the cracking during the formation. Poor shearing area will also be the source of fatigue cracking. Die or blade made up of inappropriate material will be easy to wear or even tipping.

In rolling and bending, the influences of bending radius, bending angle and shearing quality should be considered. The forming and blanking pressure of high strength steel for beam rises greatly. So it is recommended that the equipment be checked to make sure whether it can meet the requirements.

## 加工方式

### Processing methods

#### (1) 冲压与辊压成形

不同加工方式的比较:

冲压成形	<ul style="list-style-type: none"> <li>• 需冲压吨位大的冲床</li> <li>• 投资大</li> <li>• 可加工变截面大梁</li> <li>• 消除回弹, 需增加保压时间</li> <li>• 根据大梁的长短需要不同长度的钢板, 库存多</li> </ul>
辊压成形	<ul style="list-style-type: none"> <li>• 只能加工等截面大梁</li> <li>• 投资少</li> <li>• 不必储备不同长度的钢板, 库存少</li> </ul>

#### (2) 折弯

推荐折弯模具材料硬度为 56~58HRC。

抵消回弹的过弯角可参照355MPa级大梁钢板工艺参数, 按屈服强度每增加100MPa提高1°来计算。

折弯机凸模圆角半径R:

3~6mm 钢板	$R \geq 1.2t$
$\geq 6\text{mm}$ 钢板	$R \geq 1.6t$

(t为钢板厚度)

折弯机凹模圆角半径可根据板厚选取, 一般为  $3\sqrt{t} \sim 4\sqrt{t}$

#### (3) 剪切和冲孔

700MPa级高强度大梁钢板剪切和冲孔等的工具材料的硬度58~60HRC

700MPa级高强度大梁钢板剪切刀具间隙

板厚为5mm时约为板厚的8~10%

板厚为8mm时约为板厚的10.5~13%

#### (4) 热切割

推荐等离子切割或者激光切割



(1) **Punch and roll forming**

Comparison of different methods

Punch forming	<ul style="list-style-type: none"> <li>• Big capacity punching machine</li> <li>• Big investment</li> <li>• Variable cross section beams can be made</li> <li>• Holding time should be increased to eliminate the rebound</li> <li>• Different length sheets are needed for beams of different length, big inventory</li> </ul>
Roll forming	<ul style="list-style-type: none"> <li>• Only constant cross section beams can be made</li> <li>• Small investment</li> <li>• No need to store various length sheets, small inventory</li> </ul>

(3) **Bending**

Recommended hardness of bend mold materials is 56~58HRC.

The overbending angle for the offset of springback can refer to the processing parameter for 355MPa grade beam steels. Every 100MPa higher will need 1° more.

Radius R of corner of male mould of the bending machines:

3~6mm sheet	$R \geq 1.2t$
$\geq 6$ mm sheet	$R \geq 1.6t$

(t: thickness of the sheet)

Radius R of corner of female mould of bending machines are decided by the thickness of sheet, normally  $3\sqrt{t} \sim 4\sqrt{t}$ .

(4) **Shearing and punching**

Hardness of tool material for shearing and punching 700MPa class high strength beam steels: 58~60HRC

Shearing tool gap for 700MPa class high strength beam steels:

8~10% of the thickness (5mm thick)

10.5~13% of the thickness (8mm thick)

(5) **Hot cutting**

Plasma cutting or laser cutting is recommended.



车架 Frame



连接板 Junction panel

## 二、汽车车轮用高强钢系列 II. High Strength Steel for Wheel

汽车车轮是汽车的非常重要零部件之一，它在制造中变形较为复杂，既要满足产品的技术要求，又要适应大批量流水生产工艺要求。为此，对于车轮所用的钢材也相应提出了严格要求。车轮用钢必须具有高的强度、良好的抗疲劳性能、可塑性和良好的焊接性能。车轮用钢高强度是汽车用钢的发展趋势，通过减轻汽车重量、减少废品产生等措施来实现对环境的保护。从车轮用钢的服役状况来看，高的强度、高的疲劳性能、高的表面质量以及卓越的焊接性能是其所必备的综合性能。

Wheels are one of the most important parts of automobiles. Because of their complicated formation during manufacturing, the strict technical requirements of products and adaptation of mass production are necessary. Therefore, wheel steels must have high strength, good fatigue resistance, good plasticity and weldability. The application of high strength wheel steels has become a tendency to reduce weight and gas emission for environment protection. High strength, good fatigue resistance, good surface quality and weldability are necessary for wheel steel.



### 1、汽车车轮用高强钢的化学成分 (%) Chemical composition (%)

牌号 Designation	C	Si	Mn	Nb + Ti	P	S
B450CL	≤ 0.10	≤ 0.50	≤ 1.5	≤ 0.10	≤ 0.025	≤ 0.010
B500CL	≤ 0.10	≤ 0.50	≤ 1.5	≤ 0.10	≤ 0.025	≤ 0.010
B550CL	≤ 0.10	≤ 0.50	≤ 1.8	≤ 0.10	≤ 0.025	≤ 0.010
B600CL	≤ 0.10	≤ 0.50	≤ 2.0	≤ 0.20	≤ 0.025	≤ 0.010
B650CL	≤ 0.10	≤ 0.50	≤ 2.0	≤ 0.20	≤ 0.025	≤ 0.010

2、 汽车车轮用高强度钢机械性能  
Mechanical properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A50) Elongation (A50) (%)
B450CL	1.6~12.0	≥ 320	450~600	≥ 28
B500CL	1.6~12.0	≥ 400	500~650	≥ 26
B550CL	1.8~12.0	≥ 450	550~700	≥ 24
B600CL	1.8~12.0	≥ 500	600~750	≥ 22
B650CL	1.8~12.0	≥ 550	650~800	≥ 20

3、 汽车车轮用高强度钢典型力学性能  
Typical mechanical properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A50) Elongation (A50) (%)
B500CL	2.3	451	540	30
	3.5	445	526	33
	5.0	439	515	34
	10.8	452	539	37
B550CL	2.0	500	575	27
	4.0	505	572	33
	8.0	489	568	33

#### 4、 汽车车轮用高强钢加工工艺 Processing technology

钢制车轮主要可分为轮辋、轮辐两部分。轮辋的加工方式主要为滚形加工，轮辐的加工方式有冲压、旋压，其中乘用车轮辐主要为冲压成形，商用车轮辐有冲压（有内胎）和主要为旋压（无内胎）成形。

使用车轮高强钢后，随着强度的提高，材料塑性有所下降，需要分析零件的可成形性，校核轮辋、轮辐各工序成形量的分配是否合理。同时，高强后，零件回弹会有所增加。使用车轮高强钢后，还应注意剪切质量，剪切质量太差，轮辋在扩口、扩张时边部易裂，轮辐中心孔冲裁断面差翻边时易裂。且这些剪切冲裁断面差都易成为后续疲劳开裂源。成形设备吨位及冲孔设备吨位在使用车轮高强钢后也须重新校核是否满足要求。

Wheel is made up of the rim and the disk. The main processing technique for rim is roll forming. Punch forming and spin forming are usually applied for disc. Punch forming is mainly used for disc of passenger cars, while disc of commercial cars are usually punch-formed (with inner tire) or spin-formed (without inner tire).

The plasticity of high strength steel for wheel will decrease with the increase of strength. So the analysis of the formability of rims and discs has become necessary to check the reasonability of formation distribution of them in every process. The application of high strength steel will lead to more springback. Meanwhile, attention should be paid on shearing quality. If the shearing quality is poor, the rim edge tends to crack during flanging and expanding. The poor cross section may be easy to cause crack during hole expansion. The capability of the punching equipment and molding equipment should be checked to make sure it can meet the requirements.

### 三、汽车传动轴管及车桥用高强度钢系列 III. High Strength Steel for Shaft Tube and Axle

牌号 Designation	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 Elongation (%)	180度冷弯, 弯心直径 180 degree cold bend, diameter
B600QZR	≥ 550	600-760	≥ 14	1.5a
B700QZR	≥ 600	700-850	≥ 13	1.5a
B750QZR	≥ 700	750-900	≥ 13	1.5a
B600QK	≥ 550	≥ 600	≥ 15	3a

注: 拉伸试样方向为纵向, 冷弯试样方向为横向。

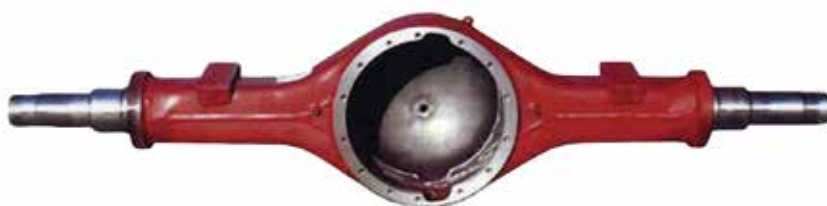
Remark: Test piece for tensile test taken to the rolling direction. Test piece for cold bend test taken transverse to the rolling direction.

#### 典型力学性能 Typical mechanical properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 Elongation (%)	冷弯 Cold bend
B600QZR	3.5	630	720	20	合格 OK
	5.5	640	710	24	合格 OK
B700QZR	4.0	710	760	20	合格 OK
B750QZR	4.0	735	795	22	合格 OK
B600QK	13.0	580	690	21	合格 OK



传动轴 Drive shaft



桥壳 Axle housing

## 四、先进高强钢(AHSS)系列 IV. Advanced High Strength Steel

### 1、高扩孔钢系列 High hole expansion steel

高扩孔钢是先进高强钢(AHSS)的一个重要钢种,它具有较高的强度、延伸率、优良的成形性和翻边性能,能满足成形性能要求很高的复杂形状的汽车零部件的要求,如汽车底盘后桥悬架摆臂等。也可用于其它需要凸缘翻边的零部件上。其翻边能力以扩孔率表示。扩孔性能作为钢材的一项成形性能指标,反映的是在扩孔过程中材料抵抗因孔缘局部伸长变形过大而在垂直于孔缘方向上抵抗局部开裂的能力。

High hole expansion steel is an important kind of AHSS. It has high strength, good elongation, good formability and flangeability, which can meet the forming requirement of auto parts with complex shapes, such as lower arm, etc. It can also be applied to other parts that need flanging. The flangeability is expressed by the hole expansion ratio. Hole expansion ratio is one of criteria to the formability of steels. It reflects the material's resistance to local cracking because of large local stretch in the direction perpendicular to the hole during hole expansion.

高扩孔钢各钢级的基本化学成分 (%)  
Chemical composition (%)

牌号 Designation	C	Si	Mn	Nb + Ti
BR290/440HE	<0.10	<1.50	0.5~2.0	0~0.10
BR340/490HE	<0.10	<1.50	0.5~2.0	0~0.10
BR390/540HE	<0.10	<1.50	0.5~2.0	0~0.10
BR440/590HE	<0.10	<1.50	1.0~2.5	0.02~0.20
BR540/690HE	<0.10	<1.50	1.0~2.5	0.02~0.20
BR600/780HE	<0.10	<1.50	1.0~2.5	0.02~0.20

四、先进高强钢(AHSS)系列  
IV. Advanced High Strength Steel



高扩孔钢各钢级交货性能指标

Delivery performance

牌号 Designation	厚度 Thickness (mm)	抗拉强度 Tensile strength (MPa)	屈服强度 Yield strength (MPa)	延伸率 (A50) Elongation (A50) (%)	扩孔率 Hole expansion rate (%)
BR290/440HE	1.6~6.0	≥ 440	≥ 290	≥ 28	≥ 100
BR340/490HE	1.6~6.0	≥ 490	≥ 340	≥ 24	≥ 80
BR390/540HE	1.6~6.0	≥ 540	≥ 390	≥ 20	≥ 80
BR440/590HE	1.6~6.0	≥ 590	≥ 440	≥ 18	≥ 75
BR540/690HE	1.6~6.0	≥ 690	≥ 540	≥ 14	≥ 70
BR600/780HE	1.6~6.0	≥ 780	≥ 600	≥ 10	≥ 60

高扩孔钢典型力学性能

Typical mechanical properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A50) Elongation (A50) (%)	扩孔率 Hole expansion rate (%)
BR440/590HE	2.2	571	635	30	95
	2.9	501	622	26	100
	3.5	533	599	28	99
BR390/540HE	3.2	439	564	29	101
BR290/440HE	3.5	325	460	33	115

## 2、 双相钢系列 Dual phase steel

双相钢具有优越的成形性能，强度高、屈强比低，初始加工硬化率高，强度和延性匹配合理等优点。双相钢的出现基本解决了高强度低合金钢不易冲压成形的矛盾。双相钢适用于复杂形状零件的制造，如轿车车轮轮辐等部件。

Dual phase steel has many advantages such as good formability, high strength, low yield ratio, high initial work hardening rate, good balance of strength and ductility, etc. It is a solution to the problem that the high-strength low-alloy steel is not easy to punch. Dual-phase steel is suitable for manufacturing parts of complex shapes, such as car wheel discs and other components.



### 双相钢各钢级的基本化学成分 (%) Chemical composition (%)

牌号 Designation	C	Si	Mn	Nb + Ti
BR380/580DP	<0.23	<2.0	<3.3	0~0.10
BR450/780DP	<0.23	<2.0	<3.3	0~0.10

### 双相钢各钢级交货性能指标 Delivery performance

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A80) Elongation (A80) (%)
BR330/580DP	1.6~6.0	330~470	≥ 580	≥ 19
BR450/780DP	1.6~6.0	450~610	≥ 780	≥ 14

### 双相钢典型力学性能实绩 Typical mechanical properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A80) Elongation (A80) (%)
BR330/580DP	3.5	400	650	24
BR450/780DP	2.5	460	835	21



### 3、 TRIP钢简介 TRIP Steel

TRIP钢是相变导致塑性 (Transformation Induced Plastics) 钢的缩写, 作为先进高强钢 (AHSS) 中的一个钢种, TRIP的组织为铁素体+残余奥氏体+贝氏体, 它较好地解决了强度和塑性矛盾, 实现了强度和塑性较好的统一, 使材料在获得高强度的同时, 获得很高的塑性, 能满足对拉伸变形性能要求很高的复杂形状的汽车零部件的要求。

TRIP steel is the abbreviation of Transformation Induced Plastics steel. As one of AHSS, the microstructure of TRIP steel is made up of ferrite, bainite and retained austenite. It has solved the contradiction between strength and ductility. It has high strength while it has good plasticity, too. This specific property can meet the formation requirements of automobile parts with complex shape which the good ducticity is needed.

#### TRIP钢各钢级的基本化学成分 (%)

##### Chemical composition (%)

牌号 Designation	C	Si	Mn	Nb + Ti
BR400/590TR	<0.3	<2.2	<2.5	0~0.10
BR450/780TR	<0.3	<2.2	<2.5	0~0.10

#### TRIP钢各钢级交货性能指标

##### Delivery performance

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A80) Elongation (A80) (%)
BR400/590TR	1.6~6.0	≥ 400	≥ 590	≥ 24
BR450/780TR	1.6~6.0	≥ 450	≥ 780	≥ 20

#### 4、 复相钢系列 Complex phase steel

“轻量化”使得高强钢的应用范围越来越广泛。但随着强度的提高,钢板的成形性能降低。与常规的高强钢相比,复相(Complex Phase)钢具有以下特点:

- (1). CP钢属于超高强钢系列,其显微组织主要为铁素体/贝氏体,包含少量的马氏体,残余奥氏体和珠光体;
- (2). 由于添加了如Ti、Nb等合金元素,其组织非常细小;
- (3). 含有较多的硬质相如贝氏体和马氏体,同时含有细小的沉淀弥散强化基体;
- (4). 与DP和TRIP的成分体系相同;
- (5). 与DP和TRIP钢相比屈强比较高,相同抗拉强度下屈服强度较高,延伸率较低;
- (6). 更好的弯曲和拉伸翻边性能。复相钢可用于制造具有复杂形状的工作件。

"Lightweight" of vehicles has lead to wide application of high strength steels. But the formability of the steel will degrade with the increase of the strength. Compared with normal high strength steel, complex phase steel has the following features:

- (1). CP steel is one kind of ultra high strength steel. Its microstructure is mainly made of ferrite and bainite with a small amount of martensite, residual austenite and pearlite.
- (2). The grain size is fine due to the microalloying additions such as Ti, Nb, etc.
- (3). Apart from hard phases such as martensite and bainite, matrix is also strengthened by small dispersed precipitates.
- (4). The chemical composition system is the same as DP and TRIP steels.
- (5). Its yield ratio is relatively high and its elongation is relatively low compared to those of DP steels and TRIP steels in same tensile strength level.
- (6). With good bendability and stretch flangeability, CP steel can be used to manufacture parts with complex shapes.

四、先进高强钢(AHSS)系列  
IV. Advanced High Strength Steel

复相钢化学成分 (%)

Chemical composition (%)

牌号 Designation	C	Si	Mn	P	S	Al	Cr+Mo	Nb+Ti
CP800	≤ 0.18	≤ 0.80	≤ 2.2	≤ 0.08	≤ 0.015	≤ 2.0	≤ 1.0	≤ 0.15

复相钢交货性能指标

Delivery performance

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A80) Elongation (A80) (%)
CP800	2.0-10.0	680-830	≥ 780	≥ 10

复相钢典型力学性能实绩

Typical mechanical properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A80) Elongation (A80) (%)
CP800	3.5	730	820	18



保险杠 Bumper

## 5、 热成型用钢系列 Hot stamping steel

为满足日益苛刻的车体减重和抗碰撞安全性能的要求, 要求进一步提高车体部件强度。但随着强度的提高, 钢板的成形性能降低, 要提高冲压设备能力, 冲压时易出现开裂、回弹大、形状稳定差等缺陷。板材热成型工艺就是利用金属在高温状态下延展性会迅速增加、屈服强度迅速下降的特点, 利用模具使零件成形的工艺。将钢板加热到奥氏体温度区间进行热冲压, 同时在冲模内对冲压件快速冷却, 可制造抗拉强度达到1400MPa以上的部件。

To meet the increasing demands for reducing auto body weight and improving crashworthiness, it is necessary to further enhance the strength of auto body parts. But the formability of the steel will degrade with the increase of the strength. The application of high strength steels will result in the increase of capability of punching equipments, increase of cracking and springback, and poor shape stability, etc. Hot stamping is the process by deforming the heated steel in a mould to make parts, which take the advantage of a specific feature of metals that the ductility of metals increases and the yield strength decreases rapidly under a high temperature. The steel sheet is heated to the austenite temperature for hot stamping, and then rapidly cooled in the mould. By such a process, parts with tensile strength above 1400MPa can be manufactured.



保险杠 Bumper



车门加强件 Door reinforcement



B柱 B pillar

四、先进高强度钢(AHSS)系列  
IV. Advanced High Strength Steel

热成型用钢各钢级的化学成分 (%)

Chemical composition (%)

牌号 Designation	C	Si	Mn	P	B
BR1500HS	0.20~0.25	≤ 0.40	1.0~1.5	≤ 0.015	≤ 0.0035
BR1200HS	0.16~0.20	≤ 0.40	1.0~1.5	≤ 0.015	≤ 0.0030

可以添加Cr、Ti、Nb等微合金元素

Remark: Cr, Ti, Nb can be added on a demand

热成型用钢各钢级交货性能指标

Delivery properties

牌号 Designation	厚度 Thickness (mm)	屈服强度 Yield strength (MPa)	抗拉强度 Tensile strength (MPa)	延伸率 (A50) Elongation (A50) (%)
BR1500HS	1.75~4.0	≥ 320	≤ 800	≥ 13
1500 级别 (热处理后) 1500 grade (Heat-treated)		950~1250	1500~1800	≥ 6
BR1200HS		≥ 280	≤ 700	≥ 18
1200 级别 (热处理后) 1200 grade (Heat-treated)		900~1200	≥ 1200	≥ 8

\* 热冲压后的性能跟工艺有紧密的关系, 此处仅供参考。

\* Remark: The properties after hot stamping has a close relationship with process. Here only for reference.

## 五、焊接工艺 V. Welding

### 焊 接 Welding

宝钢汽车用热轧高强钢通过低碳低合金设计降低钢的碳当量和焊接裂纹敏感系数，并采用先进的冶炼、轧制技术结合微合金强化技术，获得良好的可焊接性。

Using advanced smelting, rolling technology combined with microalloy strengthening technology, Baosteel hot-rolled high strength steel gets good weldability by reducing carbon equivalent and welding crack sensitive factor through low carbon low alloy design.

代表牌号 Typical designation	碳含量实绩 C, %	碳当量实绩 Carbon equivalent (CE)
B750L	≤ 0.08	0.40
B700L	≤ 0.08	0.34
B650L	≤ 0.08	0.29
B600L	≤ 0.08	0.23
HR60	≤ 0.08	0.16
BR330/580DP	≤ 0.08	0.15

$$CE = C + \frac{Mn}{6} + \frac{Cu+Ni}{15} + \frac{Cr+Mo+V}{5}$$

## 冷 裂

### Cold crack

由于宝钢汽车用热轧高强钢碳当量较低，与其他高强钢相比，有较低的淬硬倾向、出色的抗冷裂纹能力。因此当环境温度大于0°C时，宝钢热轧高强钢板不需预热就可直接进行焊接，不易产生焊接裂纹。

Compared with other high strength steel, Baosteel hot-rolled high strength steel for automobile has low hardenability, excellent resistance to cold crack due to low carbon equivalent. So when the ambient temperature is higher than 0°C, Baosteel's hot-rolled high strength steel can be welded without preheating and welding cracks tend not to occur.

## 焊前准备工作

### Preparation before welding

在焊接前，应清除焊接处的异物，保持其清洁和干燥。

The mess on the welding area should be cleared to keep it clean and dry.

## 焊接方法

### Welding method

宝钢汽车用热轧高强钢可使用气体保护焊（MAG）和手工电弧焊（SMAW）、埋弧焊（SAW）进行焊接，推荐使用气体保护焊（MAG）。

MAG, SMAW, SAW can be used for Baosteel hot-rolled high strength steel for automobile. It is recommended to use MAG.



### 焊接热输入 Welding heat input

焊接时使用推荐的热输入，可使热影响区具有良好的机械性能。并且热输入范围越宽说明该钢种的焊接性能越好。

Use the recommended welding heat input may give heat-affected zone good mechanical properties. And the wider range of heat input, the better the weldability of the steel.

焊接热输入由下列公式计算：

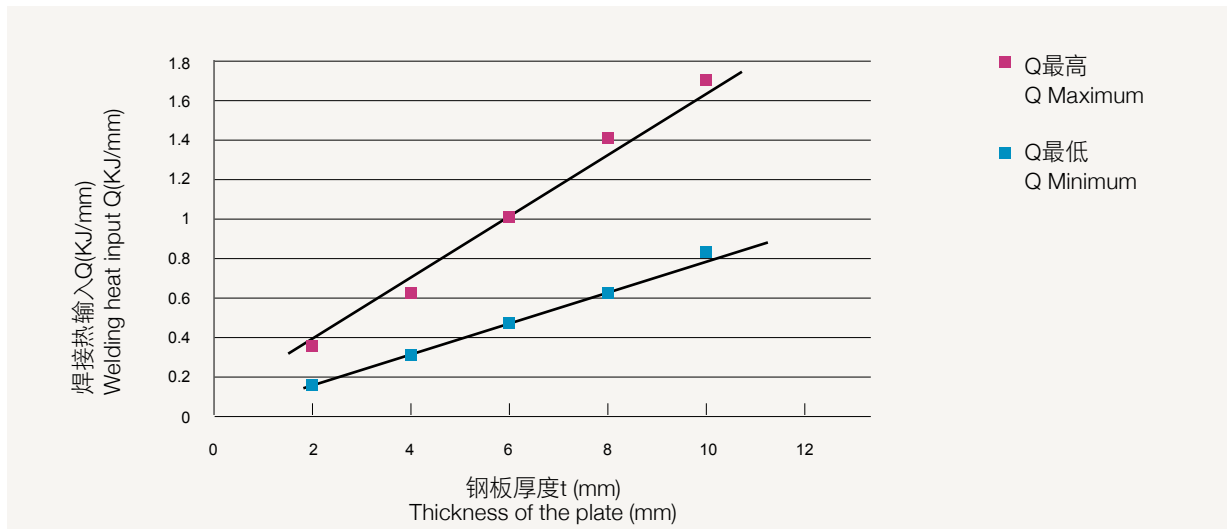
Welding heat input can be calculated by the following formula:

$$Q = \frac{K \times U \times I \times 60}{v \times 1000}$$

Q=焊接热输入 [KJ/mm]	焊接方法热效率: k	Q=Welding heat input [KJ/mm]	Welding heat efficiency: k
U=焊接电压 [V]	MAG 0.8	U=Welding voltage [V]	MAG 0.8
I=焊接电流 [A]	SMAW 0.8	I=Welding current [A]	SMAW 0.8
v=焊接速度[mm/min]	SAW 1.0	v=Welding speed [mm/min]	SAW 1.0
k=焊接方法热效率	TIG 0.6	k=Welding heat efficiency	TIG 0.6

下图为按钢板厚度推荐的最佳焊接热输入范围：

The following graph shows the best welding heat input range according to the thickness of the plate:



在厚度一定的条件下宝钢汽车用热轧高强钢的许用焊接热输入范围很宽，具有优良的焊接性能。

Baosteel hot-rolled high strength steel for automobile has good weldability as it has wide range of welding heat input for a certain thickness.



## 坡口形式 Groove shapes

宝钢汽车用热轧高强钢适用于多种接头型式的焊接, 常用的接头型式有: I型坡口、V型坡口

Baosteel hot-rolled high strength steel is suitable for various types of welding joint. Usually I shape groove and V shape groove are used.

## 焊接材料 Welding material

在焊接接头力学性能满足构件要求的情况下, 为避免接头处的应力集中、降低焊缝的内应力, 应尽可能选择强度不超过推荐值的焊材。

To reduce the stress concentration at the joint and the welding seam, it is advised to use welding material with strength no higher than recommended standard on condition that the mechanical properties of the joint can satisfy the requirements of the case.

宝钢汽车用热轧高强钢可选用的焊接材料详见下表

The following table is the welding material that can be used for Baosteel hot-rolled high strength steel for automobile

代表牌号 Typical designations	焊丝牌号 Welding wire designations	焊丝型号 Welding wire type		可供焊材企业 Suppliers of welding wire	焊丝直径 Welding wire diameter (mm)
		GB/TB	AWS		
B750L	HS80 BHG-4 GMn3Ni1CrMo	ER76-G	ER110S-G	上海宝焯 哈尔滨焊接研究所 法国 SAF (OERLIKON) Shanghai Baoxuan Harbin Welding Institute SAF (OERLIKON)	Φ1.2~1.6
B700L		ER76-G	-		
B650L	BHG-3	-	ER100S-G		
B600L	BH503	ER69-G	-		
		ER50-6	ER70S-6		

推荐典型焊接参数: (以Φ1.2mm焊丝、钢板厚度8mm为例)

Typical welding parameters recommended: (Φ1.2mm wire, thickness 8mm steel plate for example)

采用的焊接方法 Welding method	保护气体成分 Shielding gas	气体流量 Gas flow rate	焊丝干伸长 Length of welding wire	坡口 Groove
MAG	80%Ar + 20%CO <sub>2</sub>	15 L/min	12mm	V型60° V type 60°

焊接电流 Welding current (A)	焊接电压 Welding voltage (V)	焊接速度 Welding speed (mm/min)	焊接线能量 Welding heat input (KJ/mm)
200~280	22~28	350~400	0.8~1.4

焊接接头的力学性能

Mechanical properties of the welding joint

代表牌号 Designation (Thickness)	试验用焊丝 Welding wire	层、道数 Pass	热输入 Q Heat input (KJ/mm)	拉伸试验 Tensile test	
				抗拉强度 Rm (MPa)	断裂位置 Breaking point
B750L (8mm)	HS80	二层三道 2 layers 3 passes	0.8	835	热影响区 (HAZ)
B750L (8mm)	BHG-4	二层三道 2 layers 3 passes	0.8	835	热影响区 (HAZ)
B750L (8mm)	GMn3Ni1CrMo	二层三道 2 layers 3 passes	0.8	820	热影响区 (HAZ)
B700L (8mm)	BHG-4	二层三道 2 layers 3 passes	0.8	785	母材 (BM)
B650L (8mm)	BHG-3	二层三道 2 layers 3 passes	0.8	735	母材 (BM)

B550CL为汽车钢轮轮辋用钢, 其电阻对焊工艺参数为:

B550CL is steel for automobile wheel rim, the welding process parameters are:

步骤 Step	周数 (0.02s) Cycles (0.02s)	电流密度 Current density (KA/mm <sup>2</sup> )	压力 Pressure (KN)
1 预热 Preheating	4	80-100	53
2 焊接 Welding	4	100-200	53
3 回火 Tempering	2	60-80	37
4 保持 Holding	2	0	27

## 应用案例 Applications

部件 Component	原材料强度级别 Strength of the original material	用高强度钢级别 Strength of the high strength steel	减重 Weight reduce
牵引车大梁 Tow tractor beam	355MPa	700MPa	35%
自卸车车箱 Self-dumping truck carriage	355MPa	700MPa	33%
牵引车连接板 Tow tractor connection board	20钢 20# steel	700MPa	60%
传动轴 Drive shaft	235MPa+345MPa	700MPa	45.8%

## 结束语 Closing

宝钢一贯秉承“要善于学习，更要善于创新”的创业精神，在热轧高强钢的开发征程上勇于开拓进取，产品不断升级换代，技术不断突破创新，我们愿以更好的产品和服务全心全意地效力于国内外汽车行业的进步发展。

Baosteel has always been adhering to the entrepreneurial spirit: "To be good at learning, to be better at innovation". We will continue pioneering at the development of hot-rolled high strength steel, upgradation of our products and innovation of the technology. We are ready to provide better products and service wholeheartedly for the development of the foreign and domestic auto industry.

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