

# 中国不锈钢发展及锰需求分析

## Research on Development of china's stainless steel market and Mn market demands

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# 一、我国不锈钢产销量近几年得到快速发展

## china's stainless steel sales enjoyed rapid growth in recent years

- 2001年国内不锈钢消费量为225万t，超过美国和日本，成为世界最大不锈钢消费国。
- Domestic stainless steel consumption in 2001 was 2.25 mil tons, exceeding the US and Japan, making China the largest stainless steel consumer in the world.
- 2006年我国不锈钢产量为560万t，居世界第一。
- China achieved an output of 5.60 mil tons in 2006, ranking first in the world.
- 2007年全国不锈钢产量为800万t，占世界产量的30%。
- In 2007, china's stainless steel output reached 8 mil tons, accounting for 30% of the world's total.
- 2008年不锈钢产量为960万t，比2007年增长20%以上。
- In 2008, china's stainless steel output jumped to 9.6 mil tons, an increase of 20% compared with 2007.
- 2009年产量将突破1000万t。
- The output of 2009 will reach 10 mil tons

目前中国人均不锈钢消费量仍仅有7公斤，相较于发达国家人均10公斤的不锈钢消费量，中国的消费水平仍然较低，未来中国的不锈钢消费量仍存在巨大的增长空间。

However, the current per-capita stainless steel is only 7 kilograms.

Compared with the per-capita 10 kilograms in developed countries, China's stainless steel consumption is still relatively low, which indicates that there is much potential for future growth in china's stainless steel consumption.

## 二、锰对不锈钢的影响 Effect of Mn on stainless steel

### 1. 锰对奥氏体不锈钢的影响 Mn Effect on austenitic stainless steel

具有强烈的稳定奥氏体的作用。锰在铬镍奥氏体不锈钢中的作用除脱氧外，一是希望它能稳定奥氏体；二是能改善钢的热塑性，三是借助锰和硫的较强亲和力形成硫化锰MnS，既有利于钢中硫的去处，又有利于消除钢中残余硫的有害作用。

Mn shows outstanding performance in stabilizing the austenitic structure.

Besides deoxidization, Mn is also used in the austenitic stainless steels in order to stabilize the structure, improve the steel thermoplastic and form Mn sulfide with sulfide on the basis of their affinity chemical property. Not only would this Mn sulfide process help preserve sulfide in a safe way, but would help eliminate the harmful effects caused by residual sulfure as well.

## 2 锰对奥氏体+铁素体双相不锈钢的影响

### Impacts of Mn on austenite + Ferritic duplex stainless steel

当Mn $\geq$ 5%后，钢的硬度有所提高，这与钢中 $\sigma$ 相及其它析出相的存在有关；在750-950°C时效ageing，Mn有强烈促进 $\sigma$ 相形成的作用并显著降低钢的韧性；随钢中锰量增加，其耐点蚀性能下降，这些性能的下降低与MnS的形成或 $\sigma$ 相析出，铬的贫化有关。

When Mn exceed 5%, the hardness of steel has increased, which is related to related to  $\sigma$  (sigma) phase steel, and the presence of other precipitation. at between 750-950°C, Mn has a strong role in promoting the formation of sigma phase and significantly reduce the toughness of steel. With the increase of Mn steel and its resistance to pitting corrosion performance degradation, the decline in these properties is related to the sigma phase precipitation and chromium depletion.



## 2 锰对奥氏体+铁素体双相不锈钢的影响

### Impacts of Mn on austenite + Ferritic duplex stainless steel

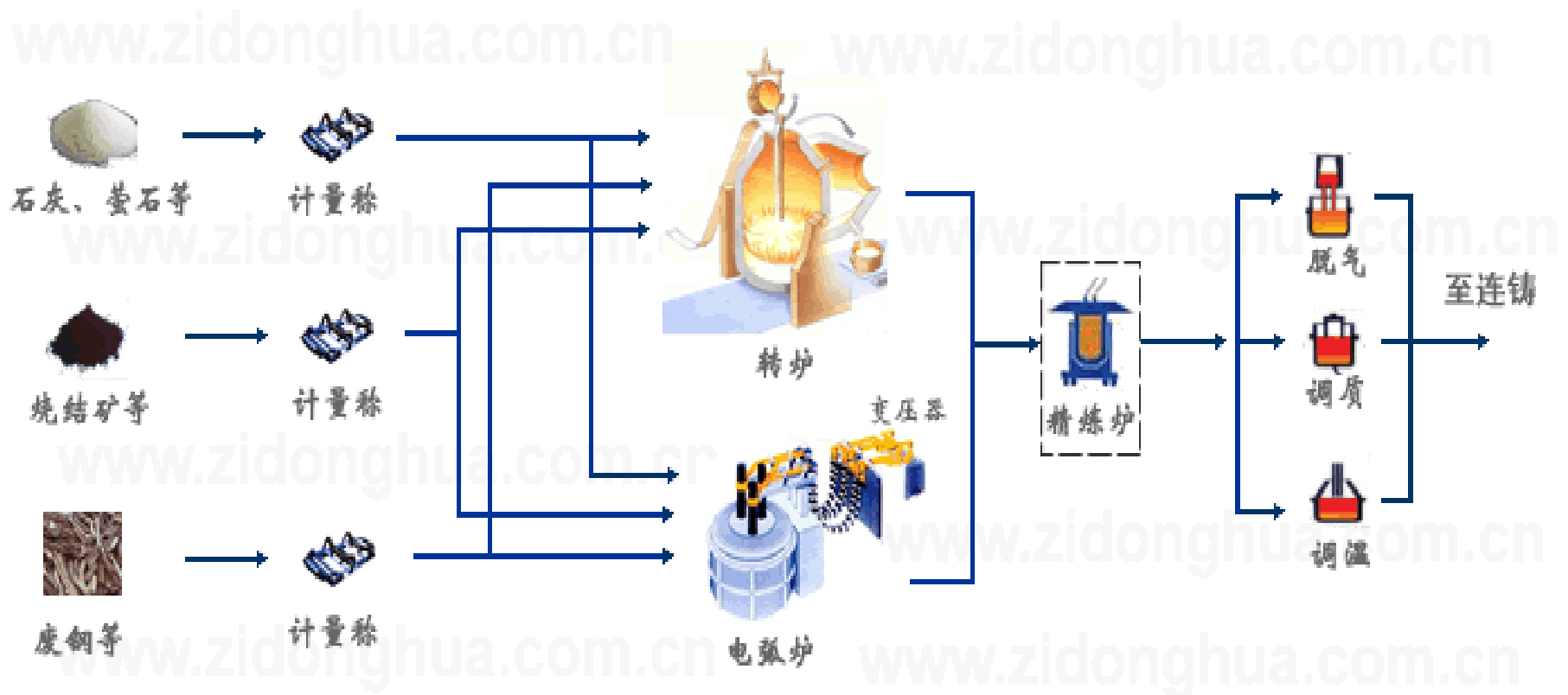
此外，要获得  $\alpha + \gamma$  双相组织结构，则所需的Mn, Ni, N元素的含量相对较少，钢的成本也相对较低，同时，还可具有  $\alpha + \gamma$  双相不锈钢的一些特性，这是Mn在双相不锈钢中的重要作用。

In addition, to obtain two-phase structure of  $\alpha + \gamma$ , the content of Mn, Nickel, N elements is relatively small, the cost of steel is relatively low. Meanwhile, it may have some features of  $\alpha + \gamma$  duplex stainless steel. This is the important role of Mn in duplex stainless steel.



### 3. 锰在不锈钢中的加入方式 How is Mn added to Stainless Steel

电炉、转炉系统炼钢生产工艺流程图



# Mn的作用 functions of Mn

- 加入13%以上的锰，制成高锰不锈钢，那么就变得既**坚硬**又富有**韧性**
- When 13% or more Mn is added to produce high manganese stainless steel, high manganese stainless steel will show strong toughness and hardness.
- 降低钢的临界冷却速度，提高钢的**淬透性**
- Mn can lower critical cooling velocity of steel and improve steel's HRC or quenching degree.
- 改善钢的**低温韧性**
- It can also improve low-temperature toughness of steel
- 在高含量范围内，作为主要的**奥氏体化元素**，降低 $A_{c1}$ ， $A_{c3}$ 线
- When used as the main austenitic element and with high content, Mn can lower the  $A_{c1}$  and  $A_{c3}$  temperature of steel.
- 提高**抗磁性**，Mn的含量与抗磁性成正比
- Mn can enhance the diamagnetic property of steel, for the content of Mn is proportional to diamagnetism.

## 不锈钢性能特点: Properties of SS

①高的耐磨性

high abrasive resistance

②高塑性和冲击韧性

strong plasticity and impact toughness/ductility

③良好的加工硬化性能

sound capability to bear work hardening

④高的耐腐蚀性能

strong corrosion [kə'rəʊzən] resistance

#### 4 铬锰不锈钢的发展前景 prospect of chromium-Mn stainless steel

铬锰不锈钢是一种比较适合现阶段中国国情的廉价经济型不锈钢,它节镍、经济、性价比高、质量也不错。如牌号1Cr17Mn6Ni5N 含Mn5.50 % ~ 7.50 %、Ni3.50 % ~ 5.50 % , 1Cr18Mn8Ni5N 含Mn7.50 % ~ 10.00 %、Ni4.00 % ~ 6.00 %。而且随着我国经济的发展、人们生活水平的提高和巨大农村市场的开拓,其应用领域和消费量还会进一步增加。

Chromium-Mn SS is a relatively cheap and economical SS which is adaptive to china's current national situation. It is nickel-saving and economical with good equality. For instance, 1Cr17Mn6Ni5N contains 5.50 % ~ 7.50 % of Mn and 3.50 % ~ 5.50 % of Nickel. 1Cr18Mn8Ni5N contains 7.50 % ~ 10.00 % of Mn and 4.00 % ~ 6.00 % of nickle. With china's economic development, the ever improvement of its people's livelihood and the expansion of its enormous rural market, the application and consumption of chromium Mn Stainless Steel are bound to increase further.

### 三、不锈钢中锰需求分析 analysis on demands for Mn in SS

中国巨大的不锈钢市场需求,不锈钢产业的迅猛扩张,特别是以锰代镍、节镍型不锈钢的快速发展,为电解锰等原料的生产、供应带来了空前的发展机遇和更加广阔的国内市场,也为中国电解锰行业的壮大提供了强大的发展动力。

China's enormous stainless steel market and rapid development of the SS industry, plus the fast development of nickle-saving and Mn-chromium SS, have brought about unprecedented development opportunities and a greater domestic market to the production and supply of Mn and other raw materials.



### 三、不锈钢中锰需求分析 analysis on demands for Mn in SS

对此,电解锰行业应积极承接应对,做好相关的工作,若电解锰生产企业在条件许可的情况下,应考虑进一步降低DJMnD 级的C、S、P等杂质含量,缩小波动范围,控制其批量稳定性,生产更适合于不锈钢冶炼工艺要求的重熔锰锭,以适应提高不锈钢钢质纯净度和不锈钢产品实物质量档次(产品精度、表面质量、力学性能等)日益严格的要求,为不锈钢冶炼提供更优质的电解锰原料。

Thus, the EMM industry should actively respond to these changes and work out effective measures. Some EMM manufacturers, if conditions permit, can consider further lowering the content of impurities, narrow fluctuation scope, control stability and produce remelted spindle more fitted to SS smelting process. By doing so, we can ensure the stability of its mass production and produce better raw EMM for stainless steel smelting.

# 锰在人体中的作用 Function of Mn on Human Body

- 锰被确定为人类必需微量元素约有60多年的历史。在体内含量很少，但起着非常重要的作用。目前，已知锰参与多种酶的组成，影响酶的活性。体外实验证明有上百种酶可由锰激活，有水解酶、脱羧酶、激酶、转移酶、肽酶等等。
- Mn has been considered a dispensable Microelement for human since over 60 years ago. Despite its small amount in human body, it play a very important role. At present, it has been proved that Mn participate in the composition of a variety of Enzymes and affect their activity. Vitro experiments proved that Mn can activate over a hundred enzymes, including hydrolase, decarboxylase, kinase, transferase and peptide enzymes. [‘enzaim]



# 锰在人体中的作用 Function of Mn on Human Body

- 锰与多种生理功能有关，锰缺乏可造成多种病态；
- Mn bears on a variety of physiological functions and Mn deficiency can lead to a variety of symptoms.
- 一、可影响骨骼的正常生长和发育。用缺锰饲料喂养雌性大鼠，所生幼鼠骨骼生长不成比例。**四股**骨骼缩短，**脊骨弯曲**，颅骨也变形。
- 1.first, Mn affect the healthy growth and development of bones. If we use non-Mn feed to feed female **rats, their baby wistars will suffer from abnormal proportion of bones with shortened limbs, Spine Curvature and deformed Cranium/skull.**
- 二、可影响糖的新陈代谢。如豚鼠缺锰后，**葡萄糖耐受异常**，葡萄糖利用率下降，使胰岛素合成与分泌降低，可能是胰岛素肝细胞受到了破坏。也可见实验动物腹腔和肝脏的脂肪储存明显增加。
- 2. it affects the metabolism [mə'tæbəlɪzəm] of **sugar. For example, if a Cavia Cobaya has Mn deficiency, its glucose tolerance becomes abnormal and utilization of dextrose decrease, hampering the composition and分泌 of insulin. Maybe it's because hepatic cells are damaged, shown by the significant increase of fat reserve in animal's stomach and liver in experiment.**



# 锰在人体中的作用

- 三、锰在维持正常脑功能中必不可缺，与智能发展、思维、情感、行为均有一定关系。缺少时可引起神经衰弱综合症。癫痫病人、精神分裂症病人头发和血清中锰含量均低于正常人。
- Third, Mn is essential in the maintenance of normal brain function and has certain relation with intellectual development, thinking, emotion and behavior. Mn deficiency can cause neurasthenia syndrome. Mn content in the hair and serum of Epileptic and schizophrenia patients are below the normal level.



# 锰在人体中的作用

- 四、锰与衰老：有学者报道，哺乳类动物的衰老可能与锰—过氧化物酶减少引起抗氧化作用降低有关，因而长寿可能与高锰存在某些关系。我国广西巴马县长寿公社的长寿老人，发锰含量明显高于其它地区。
- Fourth, Mn and aging: some scholars have reported that mammal aging may be caused by cutback of mn peroxidase(POD) , antioxidant enzyme. In longerity community in Bama County of Guangxi province, the hair Mn content of the elders was significantly higher than other areas.
- 五、锰与癌症的关系已引起人们的关注：在流行病学的调查中可见，癌症患者发锰含量显著低于正常人。在动物诱癌实验中也看到，随着癌瘤的发生与发展，肝、肺中锰含量降低，但肿瘤部位锰含量升高。但总的来看，尚需进行更多的研究。
- Fifth, the relationship between Mn and cancer has aroused people's attention. The epidemiological survey shows that cancer patients hair Mn content was significantly lower than that of average people. In Induced cancer animal experiments, with the occurrence and development of carcinoma, Mn content in lung and liver decreased, but that in tumor grew. This conclusion is yet to be further testified .



# 高氮高锰不锈钢 Stainless steel with High-Nitrogen and Mn

- 氮 N:
- Nitrogen N:
- 原子序数7，原子量为14，晶体结构：晶胞为六方晶胞(文章：第三種常見的金屬晶體結構是具有六方立體晶格的單位晶胞，稱之為六方緊密堆積(hcp)一可能就是指六方晶胞了)
- atomic number is 7, atomic weight 14. It has crystal structure and hexagonal unit cell.
- 自然界绝大部分的氮是以单质分子氮气的形式存在于大气中，氮气占空气体积的78%
- Most of the nitrogen in nature exist in the air a in the form of single-molecule nitrogen. Nitrogen account for 78% of the air in terms of volume.



# 高氮高锰不锈钢 Stainless steel with High-Nitrogen and Mn

- 氮作用：Function of Nitrogen
- ①代替部分镍以节约贵重的镍元素外
- 1. It's used to replace part of Nickel element to save precious metal
- ②固溶强化solid solution strengthening, 提高不锈钢的强度, 但并不显著损害钢的塑性和韧性
- 2. solid solution strengthening to improve the strength of stainless steel, without significant damage to the plasticity and toughness of steel
- ③提高钢的耐腐蚀性能, 特别是耐局部腐蚀, 如晶间腐蚀, 点腐蚀和缝隙腐蚀
- 3. it can enhance corrosion [kə'ɹəʊʒən] resistance of steel, especially partial corrosion like spot corrosion and gap corrosion.
- ④扩大奥氏体区元素, 降低Ac1, Ac3线
- 4. it expands elements in austenitic zone and reduce Ac1, Ac3 line
- ⑤提高钢的低温韧性和焊接性, 增加时效敏感性
- 5. it enhance low-temperature toughness, capability to be welded and sensitiveness.



# 高氮高锰不锈钢

高氮钢性能: properties of high nitrogen steel

- ①高的屈服强度，拉伸强度，良好的延展性
- 1. high bending strength, stretching strength, good ductibility.
- ②同时具有高强度与高断裂韧性
- 2. it also has high strength and high fracture toughness
- ③高的应变硬化能力
- 3. high strain hardening capacity
- ④低的磁导率
- 4. Low permeability
- ⑤良好的耐蚀性
- 5. Good corrosion resistance



# 高氮高锰不锈钢

高氮钢性能: properties of high nitrogen steel

- ⑥阻止形成变形诱导马氏体
- 6. it can prevent formation of deformation-induced martensite
- 应用: 发电业, 造船, 铁路, 低温工艺, 化学设备, 压力容器, 医药, 石油和原子能工业。
- Application: power generation, shipbuilding industry, railway, low-temperature processes, chemical equipment, pressure vessels, medicine, oil and atomic energy industry.
- 现代高氮钢的生产趋势
- Production trend of high nitrogen steel in modern times
- ①需求高增长 ②价格不断降低
- 1. there will be high demand growth
- 2. price will continue to decrease



# advantages

- 优势：①明显降低了原材料成本，因为镍在钢价格中的比重占到60%-90%。与氮直接或简接合金化，减少了昂贵的常规合金元素如镍的使用，1Kg氮可以代替6-20Kg镍。
- (1) it significantly reduce raw material cost, because Nickel account for 60-90%, alloying with Nitrogen directly or indirectly, thus reducing the use of alloying elements like Nickle. 1 kilo of Nitrogen can replace 6-20 kilos of Nickle.
- ②质量指标显著提高，强度与屈服强度提高幅度达400%，G.Stein与T.Rashev研究组通过冷变形，是钢的强度达2950-3000Mpa，此外就有高的强度与塑性，以及其他良好的综合性能。
- (2) it improves the quality index. Strength and yield strength by 400%, after cold deformation, strength of steel can reach 2950-3000 Mpa and adopt plasticity and other sound overall performance.
- ③可用于战略工程或民用领域，如原子能发电站，航空
- (3) It can be used in strategic project or civil sectors like atomic power station and aviation.

# advantages

- ④生态学及与人体的无害接触
- (4) contact with human body is harmless.
- 生产方法：液态下氮合金化liquid nitrogen alloying , 感应炉induction furnace → 电弧炉arc furnace → 底吹bottom blowing 气体液体合金化 → 氩氧脱碳工艺 (Argon-Oxygen Decarburization --AOD) → 增压电渣重炉pressuried electroslag melting furnace → 等离子电弧熔炼 → 电弧电渣熔炼 → 热等静压HIP设备中的高压熔炼
- Are electros slag melting hot static pressure equipment in the high-pressure melting.



# Issue faced

- 面临的问题:
- ①生产方法的选择, 取决于特别的目的, 产品应用, 命名方式以及其他许多特点, 具体的设备和区域
- (1) the choice of production method depends on the particular purpose, product application, naming, and many other features, the specific equipment and area.
- ②价格优势不足
- (2) lack of price advantage
- ③较高的电能消化
- (3) relatively high electricity consumption
- ④缺少一些重熔工艺工业化生产的锭的均匀性数据
- (4) lacks data on ingots produced by remelting process
- ⑤设备成本高
- (5) expensive equipment
- ⑥氮的利用, 没有利用最大限度氮含量进行合金化
- (6) utilization of Nitrogen in alloying is low
- ⑦开发高氮钢新钢种速度慢, 成本高
- (7) Development of High-nitrogen steel and other new type steel is low and cost is high
- ⑧缺少经济信息 高氮钢目前主要用于战略工程及国防工业的
- (8) lack of economic information to for civil use, currently its mainly used in national defense..

- 未来发展趋势—环境友好+低能耗:
- Future development trend: environmental friendly + low consumption
- 生态方面，氮是唯一能使产品自始至终符合生态法规的合金元素
- Ecologically, Nitrogen is the only alloy element that meet ecological standards.
- 劳动安全的改善，水和液体金属接触会爆炸，定压下冶金是最安全的方法，其次是传统冶金方法-大气条件下
- To improve working safety and since water and liquid metal contacts will lead to explosion, depressed metallurgy is most secure, followed by traditional mettallurgy method under atmosphere condition.
- 相关能耗的降低，高氮钢生产及定压下冶金本质上是环境友好和节约能量的工艺
- To reduce energy consumption, high-nitrogen steel and depressed metallurgy is most envi-friendly and energy consuming.

■ 锰 Mn:

1. 原子序数: 25, 原子量: 54.94, 晶体结构: 晶胞为体心立方晶胞(體心立方晶體結構( Body-Centered Cubic [bcc] Crystal Structure) )

Manganese Mn:

- Atomic Number: 25, atomic weight: 54.94, Crystal structure: unit cell for the body-centered cubic lattice
- 2. 中国锰矿资源较多, 分布广泛, 在全国21个省(区)均有产出; 有探明储量的矿区213处, 总保有储量矿石5.66亿吨, 居世界第3位。
- Manganese ore resources of Chinese are more widely distributed in 21 provinces (autonomous regions) have outputs; a proven mining reserves of 213, with a total 566 million tons of ore reserves to maintain the world's No. 3.

3. 作用Mn: ①加入13%以上的锰，制成高锰钢，那么就变得既坚硬又富有韧性 ②降低钢的临界冷却速度，提高钢的淬透性 The role of Mn: ① to join more than 13% of manganese, made of high manganese steel, then it becomes both hard and very ductile ② lower critical cooling rate of steel to improve the steel hardenability
4. ③改善钢的低温韧性 ③ to improve the low temperature toughness of steel
5. ④在高含量范围内，作为主要的奥氏体化元素，降低Ac1, Ac3线  
④ In the context of high levels as the main element of the austenite of lower Ac1, Ac3 Line
6. ⑤提高抗磁性，Mn的含量与抗磁性成正比  
■ ⑤ enhance anti-magnetic, Mn is proportional to the concentration and anti-magnetic

- 高锰钢性能：①高的耐磨性 abrasive strength
- ②高塑性和冲击韧性
- High manganese steel properties: ① high wear resistance
- ② high plasticity and impact toughness
- ③良好的加工硬化性能
- 应用：高锰钢衬板、锤头、筛条、颚板jaw plate等是目前水泥厂最为广泛使用的铸钢件，它以高的耐磨性，良好的韧性和经济性深受欢迎，高锰钢具有以上特点，所以目前世界上还未有任何耐磨材料可完全代替高锰钢。
- ③ a good work-hardening properties
- Applications: high manganese steel liner, hammer, sieve of, a jaw plate and so is the most widely used cement plant steel castings, its high wear resistance, good toughness and economy of popular, high-manganese steel with the above characteristics, we now have in the world not have any wear-resistant materials can be completely replaced by high manganese steel.

## ■ 一高锰钢生产中的一些问题

1.冶炼：首先炉料要精选烘干，尤其对感应电炉更加重要，锰铁中磷较高，在选购锰铁时，要选择含磷低的锰铁合金。冶炼时，锰铁宜后加入炉内，以减少烧损量，后加入的铁合金要预先经过烘烤，出钢前还可用 $12 \times 20 \times 300\text{mm}$ 浇注后直接水韧处理的试棒，视其冷弯的角度来检验钢水质量。

## ■ Issues of high manganese steel production. Smelting:

■ 1.first drying furnace charge to be selected, especially for the induction furnace is more important, the higher phosphorus in ferromanganese, ferromanganese in the purchase, you should choose low-phosphorus manganese ferroalloys . Smelting, the ferromanganese furnace should subsequently joined in order to reduce the amount of burning, after adding the iron alloy in advance through the baking, a steel can also be used before the  $12 \times 20 \times 300\text{mm}$  Pouring Water Quench directly after the trial bar, depending on its cold the angle of bending to test steel quality.

## ■ 一高锰钢生产中的一些问题

- 高锰钢由于碳量高，导热性thermal conductivity低及结晶速度crystallization velocity较快，容易产生粗大的结晶组织，当传热有方向性时，往往形成柱状晶column crystal，在枝晶dendritic crystal之间存在显微疏松和夹杂物，影响钢的性能，尤其是标准高锰钢铸态晶粒的大小通过热处理是很难改变的。
- Due to the high carbon content , low thermal conductivity and crystalline fast, high manganese steel is easy to produce thick crystal structure, when the heat transfer directional, they often form a columnar crystal,Exists between the dendrite microstructure porosity and inclusions, affecting the performance of steel, in particular, the standard high-manganese steel as-cast grain size by heat treatment is very difficult to change.
- 根据建材部标准规定高锰钢铸件晶粒度astm不粗于2级，有的工艺文件还规定壁厚不大于20mm的铸件不允许有柱状晶，大于20mm的铸件，断面两边柱状晶厚度之和不超过该断面厚度五分之二者为合格，否则为不合格。因此在生产中要求高温冶炼，低温浇注，主要严格控制出钢温度。另外，浇注温度低还可以减少热裂缺陷、缩孔contraction cavities、粘砂、含气量air content和节约能源，是影响铸件质量的重要因素。
- According to the Ministry of standard building materials of high manganese steel casting requirements are not coarse grain size in two, and some craft paper also provides that not more than 20mm thickness of the casting does not allow columnar crystal, is larger than 20mm of the casting, the cross section on both sides of the thickness of the columnar crystal and no more than two fifths of the thickness of the sections were qualified, otherwise to be ineligible. Therefore, in the production of high-temperature smelting demand, low-temperature casting, mainly out of steel to strictly control the temperature. In addition, the low pouring temperature can also reduce hot crack, Shrinkage, sticky sand, containing gas and energy conservation is an important factor affecting the quality of castings

- 2.铸造:为了获得细铸态晶粒,减少碳化物析出量,除了控制浇注温度,对厚大件要放置外冷件(内冷铁一般不宜放),这样同时也提高了高锰钢铸件的致密度,减少缩孔、疏松。高锰钢体收缩大,但只要工艺控制得当,可以不出现缩孔,而以轴线疏松形式存在,由于它韧性好,基本不影响使用,这也是高硬度耐磨材料无法与之相比的。因此高锰钢铸件厚度小于25mm时,一般不用冒口,在大于50mm时,必须设置冒口。高锰钢难切割,浇注系统往往分散引入,冒口采用保温insulated feeder、细颈、易割三种冒口。在工艺上采用补浇,放发热剂heat generating agent的办法增强补缩feeding效果。高锰钢钢水中的MnO呈碱性alkaline,和型砂molding sand中的二氧化硅SiO<sub>2</sub>易产生化学粘砂,因此最好用镁砂Magnesium clinker高铝粉和铬铁矿粉做涂料,提高铸件表面质量。

2. Cast: In order to obtain fine-grain cast, reducing the amount of carbide precipitation, in addition to control of pouring temperature on the thick bulky to be placed outside the cold parts (in general should not be placed inside the cold iron), so also increased the high manganese steel castings The density, reduce shrinkage, porosity. High manganese steel body shrink large, but as long as the process control properly, shrinkage may not occur, but in loose form of the axis, because of its toughness is good, basically does not affect the use, which is high-hardness wear-resistant materials can not be comparable. Therefore, high manganese steel castings is less than 25mm thick, generally without riser, at more than 50mm, you must set the riser. High manganese steel difficult to cut, Casting systems are often fragmented introduction, riser with insulation, Nematodirus, easy to cut three kinds of riser. In the process on the use of re-poured, put heating agent approach to enhance the feeding effect. MnO high manganese steel was molten steel in the alkaline, and in the silica sand is easy to produce chemical sticky sand, it is best to use a high magnesia and chromite powder aluminum powder coating done to improve casting surface quality.

- 3.热处理：加热温度在保证碳化物充分溶解的情况下，尽量选低些。入水温度不得低于950℃。零件与水量之比应达1：8，水温低于30℃。人们往往认为高锰钢淬透性HRC很高，我们发现厚度大于80mm的高锰钢件水韧后，心部冷速慢，析出了针状碳化物，使性能下降。为了减少高温下碳化物固溶的困难，降低能耗及缩短生产周期，对100mm以下厚度的简单铸件，可采用200℃入炉，以70~80℃/h速度升温，不进行650℃保温的水韧工艺。
- 3. Heat treatment: heating temperature to ensure adequate dissolved carbon as far as the election less. Into the water temperature of not lower than 950 °C. Parts and should have attained a 1:8 ratio of water, water temperature below 30 °C. People tend to believe that high-manganese steel hardenability is high, we found that the thickness of more than 80mm, high manganese steel parts water, tough, after the Ministry of cold heart rate slow precipitation of needle-like carbide, so that performance degradation. In order to reduce the difficulties of solid solution carbide at high temperatures, reducing energy consumption and shorten the production cycle, the thickness of 100mm below the simple casting, can be used 200 °C into the furnace, to 70 ~ 80 °C / h speed of warming, not to 650 °C Insulation Water Quench process.
- 4.清理：对铸态不能敲掉的浇、冒口，可以水韧后进行浇水切割
- 4. Clean up: The cast could not knock down the casting, riser, you can cut the water after water toughening.



# 三、高锰钢生产工艺的发展

1. 精炼refining: 为了提高钢水质量, 炉外精炼external refining工艺被愈来愈广泛应用, 从20世纪80年代起, 在高锰钢生产上也得到使用, 精炼后, 夹杂物减少, 分布改善, 使强度提高, 可由657MPa提高到834Mpa, 耐磨性也能提高30%。

1. Refining: In order to improve the steel quality, and secondary refining process has been more widely used 80 years from the 20th century onwards, the high manganese steel production has also been used, after refining, inclusions decrease in the distribution of improvement of the strength is increased, may be 657MPa to 834Mpa, wear resistance can be increased by 30%.

2. 悬浮浇注: 浇注温度对高锰钢性能的影响很大, 生产厂家往往炉子容量大, 浇注时间长, 控温较难, 虽然采取各样的措施, 仍不能避免晶粒粗大的弊病。人们研究在浇注时, 随钢水连续加入2%~3% (尺寸为0.15~0.3m) 铁粉或锰铁粉与铁粉的混合物, 它起内冷铁inner chill 作用和增加结晶核心Crystal Core, 改善高锰钢性能还使耐磨性提高30%~50%, 但要注意加入后使钢水流动性降低。

2. Suspension casting: pouring temperature has significant influence on the performance of high manganese steel, manufacturers tend to large-capacity stove, pouring a long time and temperature control is difficult, while taking various measures, they still can not avoid the drawbacks of coarse grains. When people study the casting with molten steel continuously adding 2% to 3% (size 0.15 ~ 0.3m) iron or ferromanganese powder with a mixture of iron powder, which played the role of and increase in the cold crystallization of iron core, improve the performance of high manganese steel wear resistance is also increased by 30% to 50%, but pay attention to make molten steel flow after the adding.

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3.表面合金化:为了既提高耐磨性又节约合金元素,采用表面加入合金的方法可以达到目的,具体措施是在铸型表面刷含合金涂料,撒锰铁粉或是贴上合金铸铁片,钢水浇入后熔化与熔接这些材料,提高了铸件表面性能,现在还有用含铬焊条welding rod在高锰钢上进行堆焊bead welding,以提高耐磨性,哈焊所高铬粉块堆焊效果也很好。

3. Surface Alloying: In order to both improve the wear resistance saves alloying elements, the alloy surface by adding ways to achieve their goals, specific measures are in the cast alloy surface, brush with paint, powder or paste scattering ferromanganese alloy cast iron pieces, steel water thrown into the post-melting and welding of these materials improve the surface properties of castings, there are still containing chromium electrode on the welding of high manganese steel to improve wear resistance, Kazakhstan and welding pieces of high-chromium powder surfacing effect is very好. 4. Explosive hardening: The rolling, shot peening, etc. to strengthen the effects of high manganese steel is not ideal.

# 三、高锰钢生产工艺的发展

4.爆炸硬化explosive hardening:用滚压felting、喷丸shot blasting等方式予强化高锰钢效果不理想。利用爆炸极短时间内产生 $3 \times 10^7$ KPa高压使高锰钢表面形成40~50mm硬化层，硬化层硬度达到HB300~500，表层屈服强度yield strength可提高2倍，耐磨性提高50%，此种方法对标准高锰钢最为有效。

4.The use of explosive produces a very short period of time  $3 \times 10^7$ KPa pressure to make high-manganese steel surface 40 ~ 50mm hardened layer, hardened layer hardness reaches HB300 ~ 500, the surface can increase 2 times the yield strength, wear resistance increased by 50%, this method of Standard high-manganese steel are most effective.

5.铸态水韧处理:高锰钢凝固后，在 $960^\circ\text{C}$ 以上利用余热进行水韧处理，可减少表层脱碳decarburation，缩短生产周期和节约能源，对壁厚的中小铸件，可采用此法，唐山水泥机械厂曾用金属型铸造高锰钢衬板时利用了此法，但必须仔细控制入水温度。

■ 5. As-cast Water Quench: high manganese steel solidified at  $960^\circ\text{C}$  and above the use of waste heat for water toughening treatment, can reduce the surface decarburation, shortening the production cycle and save energy, the thickness of the medium and small casting, to adopt this method, Tangshan Cement Machinery Plant have used metal casting high-manganese steel liner when the use of this law, but must be carefully controlled in water temperature.

- 6.沉淀强化precipitation strength :标准高锰钢水韧处理后，不宜再加热，而加入合金元素后，就可以用沉淀强化热处理的方法，使高锰钢基体matrix强化，并在基体上分布弥散的粒状碳化物，使耐磨性提高。
- 6. Precipitation strengthening: Standard toughness of high manganese steel water after treatment is not appropriate to heating, while adding alloy elements, you can use precipitation strengthening heat treatment methods to strengthen the high-manganese steel matrix, and in the matrix on the distribution of diffuse granular carbide, so that wear resistance is increased.

1. 太钢Tisco成功冶炼出高锰高氮不锈钢新产品，有效探索出冶炼高氮不锈钢的新工艺方法，填补世界不锈钢冶炼史空白，为今后完成高氮不锈钢系列在常压下的冶炼奠定了坚实的基础。
2. 10Cr21Mn16NiN不锈钢，是开发节镍新型高强、无磁Non-magnetic奥氏体不锈钢钢种，它具有较高的强度及无磁性能，产品可以运用在电子电器元件、弹性材料elastic material、汽车支架、高强螺栓high strength bolt、耐磨丝网、沿海大桥钢筋、高强设备上。
  - TISCO smelt stainless-steel new products with high manganese and high nitrogen, effectively explore a new process for refining high nitrogen stainless steel ways to fill gaps in the history of the world's stainless steel smelting, in order to complete the next series of high nitrogen stainless steel smelting in the atmospheric pressure has laid a solid foundation for the .
  - 10Cr21Mn16NiN stainless steel, nickel-section is to develop a new high strength, non-magnetic austenitic stainless steel, it has high strength and non-magnetic energy, products can be used in electrical and electronic components, elastic material, vehicle frame, high-strength bolts, wear-resistant wire net, coastal bridge steel, high-strength equipment.

3. 为了能尽快开发和掌握这一高难度不锈钢冶炼技术，太钢专门成立了课题攻关组，认真研究探索，从以往的不锈钢冶炼技术上归纳总结经验，从品种特性上找出重点环节，从生产工艺上制定严密的规程标准，从操作控制上严细每一步控制点，探索和实践了该钢种电炉——氩氧炉——LF炉——连铸工艺路线的成功运用，从而使这一高难冶炼工艺终在该厂冶炼成功。

3. In order to expedite the development and mastery of this difficult and stainless steel smelting technology, TISCO has established a special task group in the subject and seriously study and explore, from the past experience in stainless steel smelting technology summarized from a variety of features to identify the key links, from the production process strict protocols on the development of standards, strict control from the operation of small control points every step, explore and practice of the steel EAF - AOD - LF furnace - continuous casting process of the successful use of the road, so that this highly - smelting plant smelting process was eventually successful.

谢谢!