

Analysis of Chinese Stainless Steel Industry and the Manganese Demand

China Metal Material Circulation
Association Stainless Steel Branch

Long Li

First, the stainless industry in china has undergone rapid growth in recent years, obviously seen from production and consumption.

- In 2001, china has already surpassed the United States and Japan to become the largest stainless steel consuming country in the world, with a domestic consumption volume of 2.25 million tons.
- In 2006, production of stainless steel in china reached 5.6 million tons, ranking first in the world.
- In 2007, this figure amounted to 8 million tons, accounting 30% of the world production.
- In the year of 2008, the production volume was increased over 20 percent compared to the previous year. With this obviously increasing stainless steel capacity in China, it is expected that the production of 2009 would break 10 million tons.

However, China's present per capita stainless steel consumption is only 7 kg, which remains a relatively low level compared to the average 10 kg consumption in the developed countries. The room for growth in china's stainless consumption is enormous from this point.

二、 The effects of manganese on stainless steel

1. Manganese effect on austenitic stainless steel

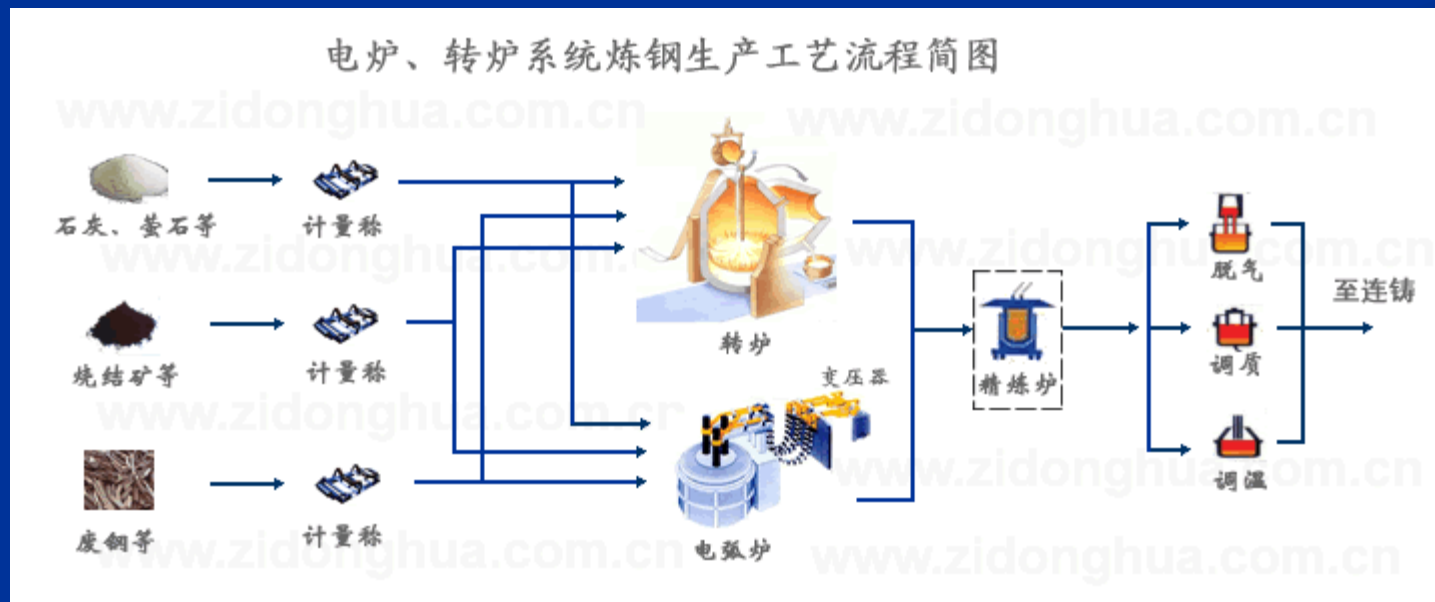
Manganese shows outstanding performance in stabilizing the austenitic structure.

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

2 Affects on austenite+ferrite duplex stainless steel by manganese

- When the Mn \geq 5%, the hardness of steel has increased, which is σ -phase steel, and other related to the presence of precipitates; in 750-950 °C aging, Mn has a strong role in promoting the formation of σ phase and significantly reduce the toughness of steel ; With the increase of manganese steel and its resistance to pitting corrosion performance degradation, the decline in these properties with the formation of MnS or σ phase precipitation, chromium depleted relevant.
- In addition, to obtain $\alpha + \gamma$ two-phase structure, thus the required Mn, Ni, N element content is relatively small, the cost of steel is relatively low at the same time, and with some features of $\alpha + \gamma$ duplex stainless steel. This is the Mn has the important role of duplex stainless steel.

3 The flow chart of how Manganese is added during steel-making



Uses of Manganese

- When 13% or higher level of manganese is added, high manganese stainless steel would be manufactured, which shares tough and flexible properties at the same time.
- To slow the cooling rate so that the products' quenching degree would get improved.
- To improve low-temperature toughness of steel
- when used as the main austenitizing element, Manganese can lower the Ac1 and Ac3 temperatures of steel.
- Enhance the diamagnetic property, as Manganese is proportional to diamagnetisms.

stainless steel features

- ① high abrasive resistance
- ② high plasticity and impact toughness
- ③ a good work-hardening properties
- ④ high corrosion resistance

4 The outlook of Cr-Mn Stainless Steel

Cr-Mn stainless steel is a cheap and economic type of stainless steel which suits china's present national conditions from some point. It is nickel saving, very economic, with reasonable price and of good quality. Products like 1Cr17Mn6Ni5N contains 5.5% to 7.5% high level of Manganese and 3.5% to 5.5% high level of Ni. 1Cr18Mn8Ni5N, another product name, bears 7.5% to 10% high level of Manganese and 4% to 6% high level of Ni. Besides, against the background that economy in our country is developing, that people's living standard is rising and that huge rural market is being expanded, we have enough reasons to believe that the Cr-Mn stainless steel application field and consumption volume is bound to grow.

三、 Analysis of the Manganese demand caused by stainless steel market

- China has always been a super market in demand of stainless steels. The dramatic growth of stainless steel industry, particularly the rapid growth of nickel-saving stainless steels that utilize a greater percentage of manganese instead of nickel brings the producers and suppliers related to electrolytic manganese unprecedented opportunities and far wider domestic consumer market. Also, it is undoubtedly a strong enough drive for electrolytic manganese industry.
- In this regard, EMM industry should make efforts to do some relevant jobs as to take full advantage of this opportunity. For instance, electrolytic manganese production enterprises with good working conditions should give consideration to further reduce impurities like C、 S、 P in the DJMnD category steel production process, narrow the fluctuation range, ensure the stability of its mass production, produce better raw EMM materials for the stainless steel.

Function of Manganese in Human Body

- Manganese has been identified as essential trace elements of humans about 60 years in history. Containing only small amounts in the body, but it play a very important role. At present, a variety of enzymes known to participate in the composition of manganese affect the enzyme activity. In vitro experiments proved that hundreds of kinds of enzymes are activated by manganese, such as hydrolytic enzymes, decarboxylase, kinase, transferase, peptide enzymes and so on..
- Manganese is related to a variety of physiological functions ,lack of manganese can cause a variety of pathological;
- 1, can affect the bones of normal growth and development. Feding female rats with fodder lacking Mn , young rats will be born out of proportion to bone growth. 4 Unit bones shortened, curved spine, the skull is also deformed.

Function of Manganese in Human Body

- 3, Manganese is essential in the maintenance of normal brain function, and has certain relation with intellectual development, thinking, emotion and behavior. Lack these things can cause neurasthenia syndrome. Manganese content in the hair and serum of those who suffer from Epilepsy, schizophrenia were lower than normal.
- □ 4, Manganese and aging: Some scholars have reported that mammalian aging may be related to the reduction of manganese peroxidase, antioxidant enzyme, which in turn may be related to high manganese longevity. In Longevity Commune in Bama County of Guangxi, the hair manganese content of the elders was significantly higher than that of other areas.
- □ 5, The relationship between manganese and cancer has attracted people's attention: In the epidemiological survey shows that cancer patients hair manganese content was significantly lower than that of average people. Induced cancer in animal experiments have also appeared, with the occurrence and development of carcinoma, liver, lung manganese content decreased, but tumor Manganese content increased. But, overall, more research is still necessary.

Stainless Steel with High Nitrogen and High Manganese

- Nitrogen N:
- Atomic number is 7, atomic weight is 14, Crystal structure: hexagonal lattice cell
- Most of the nitrogen in nature is based on a single molecule of nitrogen in the form of quality exists in the atmosphere, nitrogen gas accounted for 78% of the volume of air
- Nitrogen effect: ① to replace part of Nickel elements in order to save the precious Nickel
- ② solid solution strengthening to improve the strength of stainless steel, but no significant damage to the plasticity and toughness of steel
- ④ expanded austenite zone elements, reducing Ac1, Ac3 Line
- ⑤ enhance the tenacity and corrosion resistance of steel in microtherm, especially in localized corrosion resistance.

Stainless Steel with High Nitrogen and High Manganese

- Capability of High Nitrogen Steels: ① high bending strength, stretching strength, good ductibility
- ② At the same time has high strength and high fracture toughness
- ③ high strain hardening capacity
- ④ low permeability
- ⑤ good corrosion resistance
- ⑥ to prevent the formation of deformation-induced martensite
- Application: power generation, shipbuilding, railways, low-temperature processes, chemical equipment, pressure vessels, medicine, oil and atomic energy industry.
- ① Of modern high nitrogen steel production trends
- ② high demand growth in prices continued to reduce

- Advantages: ① significantly lower raw material costs, because the price of nickel in steel accounted for 60% of the proportion of -90%. And nitrogen alloying direct or indirect, reduce costly conventional use of alloying elements such as nickel, 1Kg of nitrogen can replace 6-20Kg nickel.
- ② quality indicators significantly improved strength and yield strength increased a rate of 400%, G. Stein and T. Rashev Study Group of cold deformation, the strength of steel up to 2950-3000Mpa, also have high strength and plasticity, as well as other good overall performance.
- ③ can be used for strategic project or civilian areas, such as nuclear power plants, air
- ④ sound contact with the human body and ecology
- Production methods: liquid nitrogen under the alloying, electric arc furnace induction furnace → → bottom blowing gas liquid alloy → Argon Oxygen decarburization (AOD) → pressurized electroslag re-plasma arc melting furnace → → → arc electroslag melting hot isostatic pressure equipment in the high-pressure melting

- Issues faced:
- ① the choice of production method depends on the particular purpose, product application, naming, and many other features, the specific equipment and the area.
- ② lack of price advantage
- ③ high energy to digest
- ④ lacks some remelting ingots of industrial uniformity of flower production data
- ⑤ high equipment costs
- ⑥ nitrogen use, no use of the maximum nitrogen content of alloying
- ⑦ development of high nitrogen steel new steel slow, high cost
- ⑧ lack of economic information on high nitrogen steel is mainly used for the current strategy of engineering and defense industries

- Future trends - environment-friendly + low-power consumption:
- With regard to ecology, nitrogen is the only product from start to finish in line with the ecological laws and regulations made of alloying elements
- The improvement of labor safety, water and liquid metal contacts to explode, will be depressed metallurgy is the most secure method, followed by the traditional metallurgical methods - atmospheric conditions
- Related to reduced energy consumption, steel production and fixed nitrogen is essentially a depressed metallurgy and environment-friendly and energy saving technology

- Manganese Mn:
- Atomic Number: 25, atomic weight: 54.94, Crystal structure: unit cell for the body-centered cubic lattice
- 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.
- 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
- ③ to improve the low temperature toughness of steel
- ④ In the context of high levels as the main element of the austenite of lower Ac1, Ac3 Line
- ⑤ enhance anti-magnetic, Mn is proportional to the concentration and anti-magnetic

- High manganese steel properties: ① high wear resistance
- ② high plasticity and impact toughness
- 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.

- 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 × 20 × 300mm Pouring Water Quench directly after the trial bar, depending on its cold the angle of bending to test steel quality.

- 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. 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. 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. 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. Clean up: The cast could not knock down the casting, riser, you can cut the water after water toughening.

三、Development of The Production Technique of High-manganese Steel

1.精炼:为了提高钢水质量,炉外精炼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%。

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,它起内冷铁作用和增加结晶核心,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。

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在高锰钢上进行堆焊,以提高耐磨性,哈焊所高铬粉块堆焊效果也很好。

4.爆炸硬化:用滚压、喷丸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 3×10^7 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。

5.铸态水韧处理:高锰钢凝固后,在960℃以上利用余热进行水韧处理,可减少表层脱碳,缩短生产周期和节约能源,对壁厚的中小铸件,能采用此法,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。

6.沉淀强化: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,使高锰钢基体强化,并在基体上分布弥散的粒状碳化物,使耐磨性提高。

- 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. 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.
- 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.

- 4. The use of explosive produces a very short period of time 3×10^{-7} s at 107 KPa pressure to make high-manganese steel surface 40 ~ 50 mm 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. As-cast Water Quench: high manganese steel solidified at 960 °C and above the use of waste heat for water toughening treatment, can reduce the surface decarburization, 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. 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.

- 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.
- 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!

Thank you!