

Review and Outlook of Chinese Manganese Mining Industry

Tao Min, Deputy Director, National Committee of Manganese Industry Technology, China
Tang Xiaozhuang, Deputy Director, National Committee of Manganese Industry Technology

According to the publication by US Minerals Survey in 1999, the total reserve of manganese ore in the world is 0.66 billion tons. See Table 1.

Table 1 World Manganese ore reserve(Mn metal weight, million tons)

Name of counties	Reserve in 1999
South Africa	370
Ukraine	135
China	40
India	34
Australia	26
Gabon	20
Brazil	18
Mexico	4
Others	small
Total	660

It is noted that manganese ore reserve in China ranks number 3 in the world. But it is much less than the reserve of the first two countries.

It has been more 100 years since Xingguo Manganese Mine, Hubei started its operation in 1890. At present, a great number of engineers in China is engaged in prospecting, mining, beneficiation and ore processing. The technology of manganese mining, which has been developed greatly, has its position in the world.

1 Manganese resource

1.1 Reserve

Till 1999, around 200 manganese mine in China were explored. It is known that there is hundreds millions tons manganese reserve in China. However, from the point of economy the recoverable manganese resource is 46% of the total reserve.

1.2 Geology Characteristics

The geology characteristics of the Chinese manganese ore is characterized that the major ore body consists of marine deposit of manganese carbonate, which takes more than 80% of the total reserve. The second is the layer controlled iron-manganese ore, the other ore like silver-lead-zinc ore and weathered leaching manganese ore and the manganese ore body of volcanic rock characterized as small and complicated ore deposit.

1.3 Distribution

Manganese ore bodies, mainly located in the province of Guangxi, Hunan, Guizhou, Sichuan, Yunnan and Liaoning in China distribute extremely uneven. There is less manganese ore reserve in the other places like coast areas and northwest areas.

1.4 Characteristics

The nature of manganese ore reserve is relatively poor. The average grade is 22%. Mn content in the ore of manganese carbonate is below 20%. High grade ore and good quality ore is extremely deficient. Phosphorous content in the ore is high. Some ore is high phosphorous ore. Another characteristics of the ore is high silica content. Some useful elements like iron, lead, zinc, cobalt, nickel, gold, silver, and etc. coexist in the some ore body.

Most manganese ore bodies needs underground mining. However, most of the ore layer is thin and deep in underground mining and very hard to mine.

The complicated structure, the fine grains and high silica of the ore make great difficulties in mineral separation.

Each year China imports a considerable amount of manganese ore to supply the Chinese iron and steel industry.

2 Development status

There are hundreds of manganese mines. Most mines are small and medium in size. The average mining recovery is 80%-86%. The average ore dressing recovery is 70%-75%. The general recovery is 60%-64%.

2.1 Mining

There are 3 mining processes – open pit mining, hydromining and underground mining.

(1) Open pit mining

There are not many open pits, such as Daxin Mine, Liancheng Mine, Xiaodai Mine, Jianshui Mine. The mines equip with drillers, loading machines and trucks. The level of most of the equipment is not advanced. Manual operation and part of manual operation are common in local small mines.

(2) Hydromining

Few mines use hydromining process. Bayi mine and Dongxiangqiao mine used hydromining.

(3) Underground mining

Underground mining is the major mining process. There are Zunyi Mine, Xiangtan Mine, Heqing mine, Dounan Mine, Huayuan Mine, Songtao Mine. Most of the ore bodies are thin declined or gradually declined. The thickness and the angle along the direction varies significantly. The other features are multi-layers, developed gap and unstable wall rock of roof and floor.

Based on the structure of the mines the mining process taken in most mines is openstope method. Some of the mines take the methods of filling mining and caving mining.

Initially, the major mining methods in stoping mining are methods of suspension roof support, shallow shrink and etc. The disadvantages of them are backward stoping process and less mechanic operation. Innovation and improvement has been made in 20 years. The improvement covers pre-support anchor prop(Zunyi), manual anchor prop(Heqing), anchor prop(Dounan), shallow shrink method and down section stoping process(Dounan Gakenan). It increased the recovery to a substantial extent and improved operation and safety.

Because of the limit of the mine nature the major filling methods are escapment, a few use hydraulic back-filling. The major processes in caving method are wall-caving and slicing and caving.

The regularity of ground pressure was studied with the research of underground mining process. It provided technical data for the determination of structure parameters of mining areas and the treatment of worked-out section.

The progress in underground mining technology has been made. The typical ones are:

- (1) The recovery is increased to 80%.
- (2) Depletion and lean ore mixing has been reduced. The depletion has been controlled within 10% for low-angle dip and 12% for high-dipping. The quality of Mn ore has been improved.
- (3) Mines are to be in normalization
- (4) The backward process is eliminated. Work intensity has been improved significantly. Productivity has been increased.
- (5) Regularity of ground pressure was revealed.

2.2 Ore dressing

The ore dressing processes are gravity dressing, magnetic dressing and floatation. Because of the manganese ore exists in the form of fine grains it is hard to separate the monomer. Even though most of the monomer were separated it is difficult to solve the problem of the separation of the finest. Therefore, manganese ore dressing is aggregate dressing. So called aggregate is the mineral of relative high grade particles with coarse grains and easy to be separated. The disadvantage of it is low grade of concentrate.

(1) Washing and re-dressing

Manganese carbonate dressing with sprinkle on vibration screen(Hongqi zone of Xiangtan Mine)

Manganese oxide dressing with primary and secondary dressing in double screw trough washer(Dongxiangqiao Mine). Changsha Mining institute developed a new process of self-grinding size degradation process. It combines the process of grinding, erasing and wasing. It has been used in dressing of loose manganese ores. It is a creative development of dressing process.

The gravity dressing machine are jigging machine, shaking bed and high media drum separator, whirlcone, vibrating chute and etc.

High media – intensive magnetic separation is used for manganese carbonate.

Disposal of wall rock is in the first stage, deep separation is in the second stage(Xiangtan Mine).

(2) Magnetic separation

Intense magnetic separation is the most extensively and successfully applied process. It has been rapidly developed since China is open to the outside world. All of the major manganese mines applied the process. However, few of the mines use solely magnetic dressing. Most mines use combined process consisting of some of ore washing, gravity dressing, floatation and magnetic separation.

A lot of research work on magnetic separation has been carried out. The machine for separation of coarse, intermediate and fine particles, both permanent and electric-magnetic induction, were developed. Neodymium-iron-boron permanent magnetic is used

in medium-intense magnetic field separator of PMHS series. The magnetic field intensity of separation is 1.1 T. The upper limit of separation is as high as 50mm. CS-1, CS-2 and shp-mode is a better applications. The upper limit of separation is 5-7 mm, the maxim intensity is 1488kA/m for CS-1 mode. The upper limit of separation is 10-15 mm, the maxim intensity is 1390kA/m for CS-2 mode. The upper limit of separation is 1 mm, the maxim intensity is 640-1600kA/m for shp mode.

(3) Floatation and others

Floatation dressing is not common in the Chinese manganese mines. Zunyi Manganese Mine used a joint process of intense magnetic and floatation. The chemicals of petroleum sodium sulphate and oxidized paraffin soap are used to catch rhodochrosite in floatation dressing. Chemical dressing, selective precipitation and concentrate dehydration and other process were studied. However, it is far to be applied in production.

Through arduous effort in 20 years we have made great success in the research of manganese dressing. The major progress is as follows:

(1) Pre-separation and coarse particles dressing.

Intense magnetic dressing and gravity dressing of coarse particles are feasible for various ores of manganese carbonate. The recovery was 3%-5% increased thereby.

(2) Many types of intense magnetic dressing machine have been used. They are: 80-1, CGD-38, CS-1, CS-2, CGDE-210, PMHS, shp and so on.

(3) Process of dressing of fine particles was successful.

(4) New process of comprehensive recovery of multi-elements manganese ore was successful.

(5) A lot was done on manganese mineralogy.

Mineral constituents of fine particles were defined by the quantity statistics of energy spectrum microprobe in the study of the states of manganese and phosphor and in the study of dephosphorization of high grade manganese ore. Forecast of theoretical specification of dressing was made by statistics of aggregate particles.

Mineralogy studies were carried out in 9 big and medium manganese mines. The basic conditions required for dressing process and specification were provided.

2.3 Subsequent manufacture

The subsequent manufacture cover three kinds of products.

(1) Ferroalloys. Such as FeMn, SiMn, and manganese metal.

(2) Manganese salts. Such as sulfate, carbonate and oxalate.

(3) Manganese oxides. Such as electrolyte manganese dioxide, chemical manganese dioxide, Mn_2O_3

2.3.1 Ferromanganese

Ferromanganese production has been developed since 1949. Now the annual production capacity is over 1 million tons.

2.3.2 Manganese salts

Manganese salt industry has been developed since 1949. The first Chinese manganese salt industry is Changsha Chemical Works established in 1957. The manganese industry has been developed from small to big, the products from single to varieties. The production distribution in big scale is based on the feature of manganese resource and demand of both international and domestic market through 40 years construction. The manganese salts, covering number of products, such as sulfate, oxalate, carbonate, acetate, nitrate, purple salt, has taken a position in the global market.

2.3.3 Manganese oxides

Manganese oxides have been developed to supply the demand of the industry of battery and electronics. Numerous of manganese oxides manufacturers, more than ten Mn_3O_4 producers, tens of electrolytic MnO_2 producers and several chemical MnO_2 and active MnO_2 producers, were constructed. At present, the production of Mn_2O_3 ranks number one in the world. The production of electrolytic MnO_2 ranks number two in the world.

The subsequent manufacture of manganese ore has been developed from blank.

The major progress in recent 20 years are:

(1) Product extension

Such as new products of electrolytic manganese in the form of powder and lumpy besides flake.

(2) Scope of new products has been extended

The products have been developed from single to multi-grades and series products to supply the demand of various customers.

(3) Equipment and quality has been improved.

Electrolytic manganese used titanium to replace graphite anode.

Flotation electrolytic process improved production and decreased power consumption.

Purification process in electrolytic manganese improved the product quality substantially.

Automatic and large in scale equipment was used in innovation.

3 Development policy and outlook

Manganese ore is an important raw material in iron and steel production. It plays essential role in the national economy. Regarding to the character of Chinese ore the policy of "Exploration high grade, enriching the lean ore and manufacture extension" should be carried out.

3.1 Administration of manganese resource

(1) To expand exploration and to increase manganese resource

(2) Restructure of the national economy to decrease the consumption of the resource.

- (3) To protect the natural resource and to prevent destruction and wasting the resource.
- (4) To carry out strategic policy and to use the overseas resource.

3.2 To improve mining and dressing technology

(1) The mechanic level of mining is still backward. Mining equipment feasible for manganese ore mining and new process should be developed. It is to study underground mechanic mining process.

In view of a great deal of safety pillars and wall pillars the study on the recovery of safety pillars is necessary in order to use fully the resource.

(2) In view of the character of lean, complicated and fine manganese ores it is important to develop new dressing process, new equipment and new chemicals to intensify separation. The Chinese iron ore possesses similar feature it is proposed to learn more from iron ore mining.

3.3 Manufacture extension of manganese ore products.

Among the Chinese manganese resource 80% of the ore is acid ore. It is available to produce manganese sulfate, electrolytic manganese metal and electrolytic manganese dioxide. Manufacture extension is favorable to the utilization improvement of the resource and to promote manganese ore production.

The accession of China to WTO brings the Chinese economy to the competition of the changeable international market. Opportunities exist with challenge. It is sure that the Chinese manganese industry will face the new development.