International Journal of Management, Sciences, Innovation, and Technology IJMSIT

Review Paper

Vol.2, Issue.5, pp.01-10, Sep (2021) **ISSN:** 0000-0000

Iron Ore and Steel: Methods of Their Manufacture and Uses

Luigina Gallo [1]

[1*] Independent Research Scholar

[*]*Corresponding Author:* e-mail: *LuiginaGallo@dayrep.com*

Available online at: https://ijmsit.com/volume-2-issue-5/

Received: 06 Aug 2021 Revised: 7 Aug, 2021 Accepted: 29 Sep, 2021

Abstract— Iron ore usually refers to a rock or mineral that contains enough iron to make it suitable for mining. At times, the location of the iron deposit and some of its characteristics may preclude its exploitation as a source of iron ore. However, despite the poor location and the low grade of iron, the improvement of transportation and the development of mining technology, as well as the improvement of ore preparation and refinement processes, may lead in the future to an improvement in the properties of poor sediments, turning them into commercial deposits that can be used. An increase in the demand for iron, a rise in its consumption and a change in government policies, as well as a change in international trade conditions, can lead to the start of the use of new iron ore mines that were not economical in the past. Iron ores and its sources are available in large quantities in the world, despite the fact that the continuous steel industry consumes huge quantities of stocks of these ores. As a result of the use of rich iron ores and their near depletion, steelmakers have developed modern industrial techniques so that poor iron ores can be used.

Keywords— Iron Ore – Steel – Manufacture – Uses - mining

I. INTRODUCTION

Iron is always present in nature in the form of chemical compounds, where iron is combined with other elements, particularly the elements oxygen, carbon, sulfur and silicon. Many iron ores contain chemical compounds made up of iron and one or more other elements. The main iron ores from which iron is extracted include: hematite, magnetite, limonite, pyrite, siderite and taconite. Hematite and magnetite are the richest iron ores. They are two types of iron oxides, each containing about 70% iron, and hematite is found in the form of shiny crystals, granular rocks, or lose ground materials. Hematite can be black or red tinged with gray, while magnetite is black and has magnetic properties. The proportion of iron in limonite ore is about 60%. Limonite ore is yellowish brown and is hydrated iron oxide. Pyrite is composed of 50% iron and 50% sulfur. It has a shiny metallic appearance and is very similar to gold in its external appearance. Siderite is a grayish-brown compound containing about 50% iron in addition to carbon and oxygen. In the past, siderite was an important source of iron in both Austria and Britain. Each of the two countries has used up its reserves of this ore, and no reserves remain. Taconite is a hard rock that contains about 30% iron. Iron is present in this ore in the form of fine particles of magnetite, and in some cases the iron is in the form of hematite. Taconite has become one of the most important iron ore deposits.

II. IRON ORE DEPOSITS

The largest iron ore deposits in the world were formed as a result of various processes that began more than two billion years ago. Ore formation processes began in some areas of the globe, and then these areas turned into shallow surface seas, where iron compounds gradually began to precipitate from the sea water to the bottom. On the sea floor, the deposited iron ore was associated with both sand and fine grains of silt in rocky form. After that, earthquakes and earth crust movements raised the rocks formed at the sea floor to sea level. Iron ores with very high concentrations were formed in some regions of the world, as a result of water trickling through the rocks, as the falling water dissolved a lot of rock sand, leaving behind highly concentrated ores.

Other deposits of iron ores were formed in different ways than the aforementioned method. For example, as the temperatures of igneous rocks slowly decreased, iron ore deposits were formed, as happened when iron ores were formed in Sweden and some other regions of the world. It is also believed that the presence of microorganisms in the water led to the formation of iron oxides. It is currently known that iron oxides are deposited and accumulated in the marsh areas and near the beaches. Most of the iron deposits and mines in North America are located in the Great Lakes region. The richest iron ores in South America are found in the Minas Gerais province of Brazil, as well as in the Cerro Bolivar region of Venezuela. And the entire region formations of mountains of iron ore. Huge quantities of iron ores are found in the Hammer Sley basin in Western Australia, as well as in the Republic of Ukraine. Iron ore is available in India on the borders of the states of Bihar - Orissa, west of Kolkata. Iron ores in China are of poorly concentrated type, and the main ore deposits are in the southeast of the country. Although the ore is of poor quality, it is the main source of iron in China. Iron ore deposits are also found in large quantities in a number of other countries of the world, including South Africa.

III. IRON ORE MINING AND PROCESSING

There are two main methods of mining iron ores, opencast mining and underground mining. After obtaining iron ore by any of the two mentioned mining methods, it must be processed and converted into a suitable form to extract iron from it.

Opencast mining

This method is used to obtain iron ore located near the surface of the earth. First, bulldozers, and other equipment, remove the dirt and any other rock that covers the ore deposits. The material removed from the surface of the ore is called the rock cover. The miners then break the ore blocks using explosives. The huge, powerful shovels then enter the ore chambers and pack it into carriages or railcars, where the ore is transported to central ore processing plants. Most of the world's iron ores are obtained from open-pit (open-cast) mines near the surface of the earth. The largest open ore mines extend for several kilometers, and the depth of ore can reach 150 m.

Underground mining

(Sub-mining). In this case, tunnels are dug through the deposits, and miners walk through the tunnels to collect ore. To mine iron ores very far from the surface of the earth, a vertical corridor is dug into the rocks near the deposits, and then miners dig horizontal tunnels from the vertical lane, at different horizontal levels, to reach the ore deposits. Then the ore is transported through horizontal tunnels to vertical corridors, either on moving belts or in special railway cars, where the ore is then transported through the vertical corridor to the surface of the earth in a bucket or hopper, and then shipped in ships to different destinations for processing and extraction or is conducted on it. Processing and refining operations beside the mine.

The cost of extracting iron ores from underground is much higher than the cost of extracting it from surface mines, and the risks of underground mining are high compared to mining ore from above ground. The method of mining ore from under the surface of the earth is rarely used nowadays, except for extracting highly concentrated ores, or for obtaining iron ores located near steel processing centers. Miners go underground to get iron ores from a mountain. They reach these deposits by digging horizontal tunnels on the sides of the mountain. This mining method produces large quantities of iron ore from the mountains, as in Western Australia.

Processing

The rich, highly concentrated iron ores need only crushing, sieving and washing processes to remove the fine particles that are difficult to exploit directly. Most of the global production of iron ores at present comes mainly from taconite and some other ores, and it requires a lot of preparation and preparation to raise the iron concentration in it. The most important operations that take place in this case is the crushing of the ore so that the grains rich in ore can easily be separated from the sand and the useless rocks. The rich ore resulting from the preparation is called the substrate, and the materials left over from the preparation process, which are useless, are known as raw ore.

The taconite must be crushed and ground to free the iron oxide crystals from the surrounding materials. The huge taconite blocks are broken into a fine powder by stirring the ore with huge steel bars or pellets in rotating drums. The crushing and grinding processes are followed by magnetic separation, which uses powerful magnets to separate the magnetite grains from the rest of the powder. When taconite contains hematite, which is nonmagnetic, the ore powder must be placed in chambers containing liquid mixtures where the waste granules remain suspended in the liquid while the iron-containing granules settle to the bottom of the ponds due to their high density. Iron oxide concentrates are removed from the treatment chambers and then dried.

The iron oxide extracted from the formation must be converted into a suitable form for shipment and use for iron production. The most widely used method is to moisten the substrate and mix it with the clay. This is done in rotating cylinders to form small pellets from the substrate. The diameter of the resulting pellets ranges from 1.2 to 5.2 cm. The pellet formation is followed by the drying process, whereby the product becomes a durable solid that is difficult to break during transportation.

Taconite preparation yields two metric tons of impurities or residues for one metric ton of iron oxide pellets. That is why iron ores are processed near the mines, so as to save on the cost of transporting huge quantities of waste materials and impurities.

IV. HOW IS IRON MADE?

To convert iron ore into iron ore, oxygen must be removed from the ore. This process requires heat and reducing agents. The reducing agent is a substance that can combine with the oxygen that is released from iron oxide during the manufacturing process.

Iron is made either by blast furnace or by direct reduction. In the blast furnace method, iron ore reacts with a reducing agent at high temperatures, and iron is then produced in a molten form. In the direct reduction method, the iron produced is in a solid form because the temperature during reduction remains lower than the melting temperature of iron.

Raw materials

Iron is extracted and produced by many other raw materials besides iron ore, and the most important of these materials are reducing agents. The reducing agent used in the direct reduction method is coal or natural gas. In the blast furnace production method, coke is the reducing agent. Coke is a solid substance that contains 90% carbon. Coke is manufactured in its own factories or in coking units within the iron and steel plant. Coke is made by heating coal without air in furnaces. The heat removes gases and tar from the coal, leaving coke behind.

Limestone is the second most important raw material in the blast furnace iron extraction process. The addition of limestone helps remove impurities from the iron ore. Often, many of the impurities present with iron ore do not melt at temperatures as low as the melting temperature of iron. But when limestone is mixed with iron ores, it makes a molten;

That is, it combines with the impurities, causing it to melt at a low temperature. The impurities formed from this union are called; any that float on the surface of molten iron, the name of slag.

The blast furnace also needs huge amounts of air and water. The air burns the coke, while the water cools the furnace and cleans the waste gases resulting from the iron manufacturing process, which rise from the furnace to the outside atmosphere.

Turn on the blast furnace

The blast furnace is a huge vertical cylinder made of steel lined with refractory bricks (refractory bricks). The height of some blast furnaces is about 30 m or more, and its diameter is within nine meters at the base. At the top of the kiln there is equipment for loading the raw materials into the kiln, and for the recovery and cleaning of exhaust gases. The blast furnaces operate continuously until the refractory lining bricks are completely eroded and finished. Some furnaces can operate for two years before being stopped for maintenance.

The term blast furnace has its origins in the high temperature of the hot air that is being blown from the bottom of the furnace to the top continuously. The air stream is heated in two or more huge stoves, each about 38m high. Air is blown in the stove until its temperature rises, and from the stoves the hot air is passed into the oven. The hot air stream enters the furnace through tubes distributed on the sides of the furnace. They are called tufts. The temperature of the air stream while being pushed into the furnace ranges between 760°C and 1150°C. While atmospheric air is forced into one of the stoves to raise the temperature of the air, the stove or other stoves are heated by pushing the hot exhaust gases from the blast furnace through them.

Workers load iron ore, coke and coal to the top of the blast furnace. The materials entering the blast furnace are called charge, and the loading process itself is known as feeding or charging. The charge is carried to the top of the furnace in open vehicles. These vehicles move up and down ramps or ramps called hoppers. At the base of the ramp, the hopper wagons are filled with weighed quantities, and in strictly defined proportions, of iron ore, coke and limestone. At the top of the crossing, the hopper wagon unloads its charge into the furnace.

As the charge makes its way from the top of the furnace to the bottom, it then comes into contact with the hot air flowing from the bottom of the furnace rising to the top. The stream of hot air combusts the coke by rapidly combining it with the oxygen in the air, generating carbon monoxide. The resulting carbon monoxide acts as a reducing agent, removing oxygen from the iron ore. The burning of coke also produces intense heat that is responsible for smelting iron. The temperature of the bottom of the furnace is more than 1,600°C, and this area is called the censer or the crucible. Liquid molten iron forms a lake with a depth of between 2.1 m and 5.1 m. A layer of molten slag floats on top of the molten iron lake, while waste gases rise to the top of the furnace. The gaseous residues rising from the top of the furnace are passed through gas cleaning equipment known as scrubbers. In it, the gases are cleaned of any dust or impurities to be released in a clean form, where they are then burned in stoves to be heated.

The molten iron from the reduction processes is poured every four or five hours. To do this, workers burn a plug on the side of the furnace known as the iron notch. As soon as the notch is opened, a stream of hot white molten iron rushes through the furrows and flows into the hot metal cart. Each wagon has a capacity of about 135 metric tons of molten iron.

The slag is also discharged periodically, but the number of daily discharges is more than the number of iron ingots. The slag is removed through the slag notch, which is at a higher level than the iron notch. The slag flows into the slag ladle, a vessel mounted on a railroad car. Part of the slag produced is used in the manufacture of cement and some other products, but most of the slag is disposed of as solid waste.

Direct reduction

In this method, iron oxide is reduced to iron, but it is produced in a solid form. The product is called reduced iron by the direct method. There are several different methods of direct reduction, although all the basic methods and methods are based on the use of natural gas in the production of reducing gases. In all direct reduction processes, the reaction between iron ore and reducing gases takes place in large furnaces.

Direct reduction method is the main method of iron production in Mexico, Venezuela and some other countries of the world which have huge reserves and reserves of natural gas at low price. The direct reduction method cannot be expanded to other parts of the world, unless iron makers are able to use coal gases as a substitute for reduced gases from natural gas. Several methods for using coal gas in the direct reduction of iron ore are being studied and developed in order for this method to spread.

The direct reduction method for iron production is characterized by the ease and speed of building the furnaces needed for production. Furnaces are also less expensive to build compared to blast furnace and coke ovens. Another advantage of the direct reduction method is that the resulting environmental pollution is much less than that caused by blast furnaces or coke ovens. Coke ovens are the main source of environmental pollution from the iron industry. Despite the many advantages of the direct reduction method in iron manufacturing, it does not remove the impurities from iron ore as efficiently as they are removed when using the blast furnace. As impurities are not well removed from the steel produced by direct reduction, it must be separated by sieves and then cleaned by magnetic separation before being shipped to steel furnaces.

V. STEEL MANUFACTURING METHODS

Most of the world's steel is produced from molten alligator iron, direct reduction spongy iron, or scrap iron and steel. They mostly lag behind when manufacturing and producing steel from large quantities of scrap. Steel manufacturers use scrap from steel production, in addition to scrap recovered from leftover steel products such as cars and cans. The basis of steelmaking is to remove excess amounts of carbon and other unwanted alloying elements, while adding other required materials in well-controlled quantities.

Steel is made in three basic ways: 1- Basic oxygen method, 2- Electric furnace method, 3- Open hearth furnace method. In each of these three methods the raw materials are charged in a furnace, where the reactions necessary to produce a batch of pure steel take place. The rate of production varies greatly between the three methods mentioned. The basic oxygen furnace produces a batch of steel every forty-five minutes. As for the electric furnace, it takes four hours, while the process in the open hearth furnace takes about eight hours. The steelworks furnace capacities range from 45 metric tons to over 450 metric tons.

Steel working furnaces are connected to digital control panels, various gauges and other indication devices. Operators use this equipment to adjust the temperature, pressure, and other ambient conditions inside the furnaces. Workers also take samples of molten steel from inside the furnace at various stages for analysis and confirmation of the steel's composition. Each steel production plant is attached to a laboratory equipped with various equipment such as a spectroscope and an electron microscope, in order to analyze the samples and ensure their composition.

Basal oxygen method

Steel in this case is produced by forcing oxygen under high pressure through molten iron and scrap. The importance of this method has increased over time since it began in Austria at the beginning of the fifties of the twentieth century. In fact, the basic oxygen method has largely supplanted the old methods of steel production. It now produces about 60% of the world's total steel production.

The basic oxygen-method furnace for steel production is a pear-shaped vessel made of steel, with a slot at the top and lined with refractory bricks. The furnace is installed on a pivot around a horizontal axis (full axis), and thus can be tilted to carry out charging or discharging operations after treatment. Basic oxygen furnaces generally operate in pairs, one making the steel while the other is in the charging phase. The charge of the basal oxygen furnace consists of three parts of molten iron and one part of scrap steel. After tilting the furnace and charging it with scrap, workers add a ladleful filling of molten iron, and then return the furnace to its upright position. The workers then bring the tube of pure oxygen into the furnace to pass through the charge. The amount of oxygen pushed into the tube is about 850 m 3 per minute. The forced oxygen permeates the molten charge, reacting rapidly with iron and impurities. These reactions generate enough heat to complete the purification process. After the purification is completed, a substance is then added to help melt the metals, where the slag is formed quickly.

The constantly ejected oxygen combines with carbon and other impurities, turning the charge of iron and scrap into steel. The gaseous residues rise through the smoke hood placed on top of the furnace. The basal oxygen furnace is then tilted to pour molten steel from an opening near the top. The molten steel flows into the ladle carriage, and workers at these moments add alloy materials to it.

During the 1970s, some steelmakers started a newer method developed for the basic oxygen method. In this method, oxygen is blown through tubes at the base of the furnace.

This method began in Europe and then developed commercially in the United States of America. The name of this method refers to how oxygen enters the charge and affects it and makes it look like a fountain. The molten material is added to the charge in this case, in the form of a fine powder that is pushed along with the oxygen entering the charge. There is no need in the basal oxygen fountain units to the vertical oxygen tube. Therefore, these furnaces can be placed in low-ceilinged housing compared to the basement oxygen furnace housing. The production rate of steel by the modern basal oxygen fountain method is much higher than that of the basal oxygen method.

Both the basic oxygen and basal oxygen fountain methods produce low-cost steel because both methods do not require electrical energy and do not use petroleum-based fuels to produce heat, with the steel yields high in both methods. In addition to what was mentioned, the nitrogen content in the steel produced from them is low. The presence of nitrogen in steel has bad effects on the durability of some types of steel. Despite the many advantages of the two steel fabrication methods: the basic oxygen method and the basic oxygen fountain method, they are not able to precisely control the chemical composition of the steel produced as in other methods of steel production, and the amount of scrap used in both methods is limited.

VI. ELECTRIC OVEN STYLE

This method uses electric current to produce the heat needed to make steel. There are several different types of electric furnaces, but the most widely used is the electric arc furnace. In the early nineties of the twentieth century, electric arc furnaces largely replaced the old systems furnaces that were used to produce steel, in developed countries in the production and manufacture of steel. There is a steady increase in the use of electric arc furnaces in many steel mills; Because of its high efficiency in steel production, in addition to the lower cost of building its furnaces, compared to basic oxygen furnaces or open hearth furnaces.

The electric arc furnace consists of a shallow steel drum lined with refractory bricks. There are three holes in the roof of the furnace through which three rods of carbon called electrodes are passed. A strong electric current arcs (jumps) from each electrode to the charge material and then to the other electrode. These electric arcs produce huge amounts of heat that can melt the charge quickly, and the high temperature helps chemical reactions to take place, eventually producing large amounts of steel.

The electric arc furnace charge consists mainly of steel scrap and alloy materials. Steel production in this method is rarely dependent on crocodile iron, but the iron produced by direct reduction can be used as far as economically available conditions permit. The electric arc furnace is charged by lifting the furnace cover and moving it aside, and after the charge is melted, the molten agents and alloying materials are added through the charging door on one side of the furnace. Electric arc furnaces are mounted on easy-to-swing legs, so they can be tilted to pour slag out of the cargo door. After the manufacturing process is completed and the slag is removed, the furnace is tilted in the opposite direction as the molten steel is poured from the casting hole.

Electric arc furnaces are an ideal method for making some special alloy steels and tool steels. Special types of alloy steels require the addition of alloying elements that combine easily with oxygen, such as chromium and vanadium. These elements oxidize easily and quickly in open-hearth furnaces and in basic oxygen furnaces, thus losing important and expensive alloying elements with the slag. But on the contrary these elements are not oxidized in the electric arc furnace because the slag contains a small amount of oxygen.

VII. Special methods for purification processes

Furnace cast steels sometimes require additional technical and processing processes, and may also require an alloying process. In the simplest case, excess oxygen can be removed from the molten steel in the transport ladle by adding silicon, manganese or aluminum elements. But in some cases special operations are required, which may be more complex. In these cases, the molten steel is transferred to special refining vessels. For example, molten steel is poured into a pear-shaped vessel with reeds on its lower bottom. A mixture of argon and oxygen is pumped into these tubes to pass into the molten steel. The gases help remove the excess carbon in the steel without oxidizing the chromium. Steel makers use different vacuum systems to remove the dissolved elements in molten steel, namely hydrogen, oxygen, carbon and nitrogen.

Several complex and expensive purification methods exist. These methods are based on re-melting the steel after it has solidified into a metallic form. These purification processes help to raise the degree of purity of the steel, and it also works to ensure the uniformity of the chemical and structural composition of the entire steel produced, and thus the product becomes homogeneous in properties in all its parts. But the disadvantage of these methods is their high cost, so their uses are limited and their applications are limited to the production of small quantities of special steels.

Special methods of purification processes. Furnace cast steels sometimes require additional technical and processing processes, and may also require an alloying process. In the simplest case, excess oxygen can be removed from the molten steel in the transport ladle by adding silicon, manganese or aluminum elements. But in some cases special operations are required, which may be more complex. In these cases, the molten steel is transferred to special refining vessels. For example, molten steel is poured into a pear-shaped vessel with reeds on its lower bottom. A mixture of argon and oxygen is pumped into these tubes to pass into the molten steel. The gases help remove the excess carbon in the steel without oxidizing the chromium. Steel makers use different vacuum systems to remove the dissolved elements in molten steel, namely hydrogen, oxygen, carbon and nitrogen.

Several complex and expensive purification methods exist. These methods are based on re-melting the steel after it has solidified into a metallic form. These purification processes help to raise the degree of purity of the steel, and it also works to ensure the uniformity of the chemical and structural composition of the entire steel produced, and thus the product becomes homogeneous in properties in all its parts. But the disadvantage of these methods is their high

cost, so their uses are limited and their applications are limited to the production of small quantities of special steels.

VIII. CONCLUSION

Steelmakers produce most of the sheets and strips in large rolls that the consumer can cut to the desired dimensions. But besides producing rolls, some factories also produce sheets and strips of specific lengths. Most of the sheets and strips are used primarily in the automobile body industry. But there are also thousands of products that use steel sheets and strips.

Machines known as hot rolling units produce sheets and strips from rolled sheets and blocks. This process is known as hot rolling, because the steel is reheated before rolling to a high temperature of about 1,200 °C. In hot-rolling units there are several sets of rolls called stand-rollers, and these sets are arranged in a long production line. In each rolling stand, the rolls are closer to each other than the previous ones, meaning the thickness of the product is reduced. As a result, the steel is pressed into thinner sections as it passes through the hot-rolling unit. As a result of decreasing the thickness of the material increases its length.

The hot rolling unit can transform a plate 13 cm thick and 2.4 m long into a plate 1.6 cm thick and 430 m long. This process takes several minutes. The length of the production line of the hot rolling unit can be about 1.5 km. This much length is needed in the production line due to the large number of roll stands, and a very large increase in the length of the final product. Once the hot rolled steel product comes out of the last rolling stand, it is rolled into huge rolls.

After cooling the steel coils produced can be shipped directly to the consumer, and some other operations can also be performed on them. In most cases, hot-rolled sheets and strips are pickled and then cold-rolled. Pickling is carried out by passing the steel through huge vats containing acid. The pickling process aims to remove the oxide scales formed during the hot rolling process. In cold rolling mills, the steel is quickly passed at room temperatures through a series of dolphin stands, and then re-rolled into huge coils. The cold rolling process increases the product's ability to stretch and form without any scratches. It also helps in thinning the thickness of the steel and making its surface smoother.

Authors Profile

[1] Independent Research Scholar.