This paper was originally written in January 2020

MIDREX® Process: Bridge to Ultra-low CO_2 Ironmaking

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Abstract

Midrex Technologies Inc. - a wholly owned subsidiary of Kobe Steel since 1983 - has been the market leader in direct reduction of iron for nearly 45 years. This success is based on a simple and efficient process, years of continuous innovations and improvements, the excellence of plant operators, and the support from Kobe Steel.
With the emphasis on reducing greenhouse gas emissions following the ratification of the Paris Agreement, direct reduction is the only commercially-proven process that can achieve significant reduction in CO_2 emissions for the iron and steel industry today, using natural gas or liquified natural gas (LNG). The MIDREX H_2™ is an evolution of the MIDREX® Process that can produce iron with almost no CO_2 emissions; but it requires amounts of hydrogen that are not currently available from renewable sources today. This article describes the MIDREX® Process and significant improvements made over the last 50 years and offers a vision of ultra-low carbon ironmaking that can be realized in the hydrogen economy.

Introduction

Midrex Technologies, Inc., which owns the process technology for direct reduced iron ore (the MIDREX Process), began operation of its first unit in Portland, Oregon, USA in 1969 and celebrated its 50th anniversary in 2019. Meanwhile, it became a wholly owned subsidiary of Kobe Steel in 1983 and achieved the milestone of a cumulative production of reduced iron (direct reduced iron, hereinafter referred to as "DRI") of 1 billion tonnes in 2018. In addition, the annual plant capacity was increased from 150,000 tonnes to 2.5 million tonnes (**Fig. 1**).

Most of the 90 plus plants hitherto constructed are still in operation. For example, the plant constructed in Hamburg, Germany in 1971 is the oldest one currently in operation. In 2018, this plant achieved a production capacity of 564,000 tonnes and an uptime of approximately 8,000 hours with its initial design production capacity of 400,000 tonnes.

The latest plant is Tosyali Algérie with an annual production capacity of 2.5 million tonnes. It was constructed near Oran, Algeria. Its first product was made in November 2018, and just eight months later, in July 2019, it set a world production record of 7,700 tonnes per day. In addition, a plant with a 2.5 million tonne annual capacity is under construction (as of July 2020) in Belara, Algeria, for Algerian Qatari Steel (AQS); and most recently, another plant with an annual production capacity of 1.6 million tonnes, is under construction in Toledo, Ohio, for Cleveland-Cliffs Inc.. Therefore, two new plants are scheduled to begin operation in 2020.

The greatest factor that has driven the expansion of the DRI market is the increasing utilization of recycled scrap in various places and the worldwide shift from the conventional ironmaking method with integrated blast furnaces to the method using electric furnaces. In order to maintain the quality of electric furnace steel made from scrap, it is necessary to use iron sources derived from ore (ore-based metallics: OBM) in combination. For these reasons,

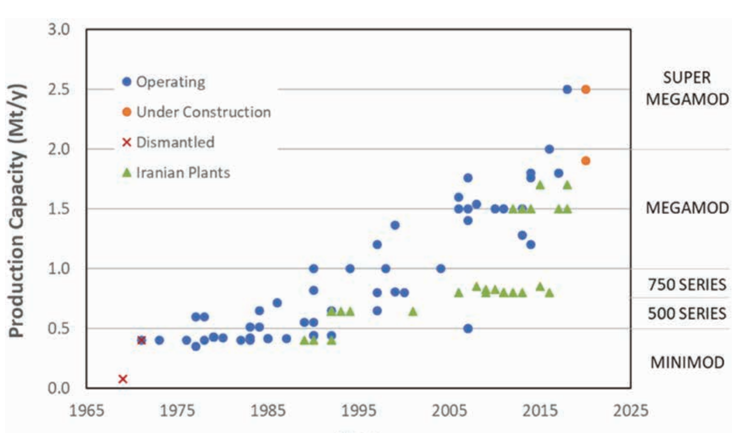

Fig. 1 Evolution of MIDREX® Module sizes over the last 50 years

the demand for DRI is increasing worldwide.

In the future, the market for DRI is expected to expand due to environmental concerns, since electric furnaces using scrap together with DRI reduced by using natural gas or hydrogen lead to CO_2 reduction.

1. DRI: Raw material for steelmaking adding value to products

DRI is a high-grade iron source derived from natural iron ore from which chemically bound oxygen has been removed without melting iron ore pellets or lump ore. Therefore, DRI consists of a high concentration of iron and little tramp elements such as copper, and nitrogen, which often adversely affect steel quality. In other words, DRI is said to be a raw material effective for diluting impurities contained in scrap. Hence, it is used in electric furnaces that produce high-quality steel products such as steel sheets for automotive bodies, deep-drawing steel, fine wire rods, special steel bars, forging steel bars, and seamless steel pipes.

DRI has been used most often in electric furnaces, but it has also been used in blast furnaces for many years. This is because DRI is mainly composed of reduced metallic iron, and when used in a blast furnace, it decreases the reduction burden in the furnace, which increases production volume and/or decreases coke consumption. For example, in the blast furnace at AK Steel in the United States, approximately 250 kg of DRI was used per tonne of molten iron.[1)]

2. Forms of DRI

DRI includes cold direct reduced iron (hereinafter referred to as "CDRI"), hot direct reduced iron (hereinafter referred to as "HDRI"), and hot briquetted iron (hereinafter referred to as "HBI") (**Fig. 2**), having favorable physical and chemical properties for use in electric furnaces, blast furnaces, and basic oxygen furnaces, respectively. A MIDREX Module constructed in the early days produced CDRI that had been cooled to around the ambient temperature after reduction and was used in an adjacent electric-furnace steel mill. As the advantages of using DRI prevailed, the demand for this high-grade iron source has grown worldwide, and Midrex Technologies Inc. has developed and commercialized two other forms of DRI, i.e., HDRI and HBI.

DRI at a high temperature after reduction has a lot of pores created by the oxygen removal and has the disadvantage that it generates heat and can catch fire when it comes into contact with air and is recombined with oxygen (reoxidation). Hence, it is compressed between a pair of rollers to produce HBI with a reduced pores rate. Therefore, HBI has an excellent reoxidation resistance, solves problems associated with long-term storage and marine transportation, and prevents a decrease in yield due to fines generation during handling. Having a form favorable for external sales, HBI is always available on the market with an established supply chain and is being produced in a place where the production cost is low and marine transportation is convenient.

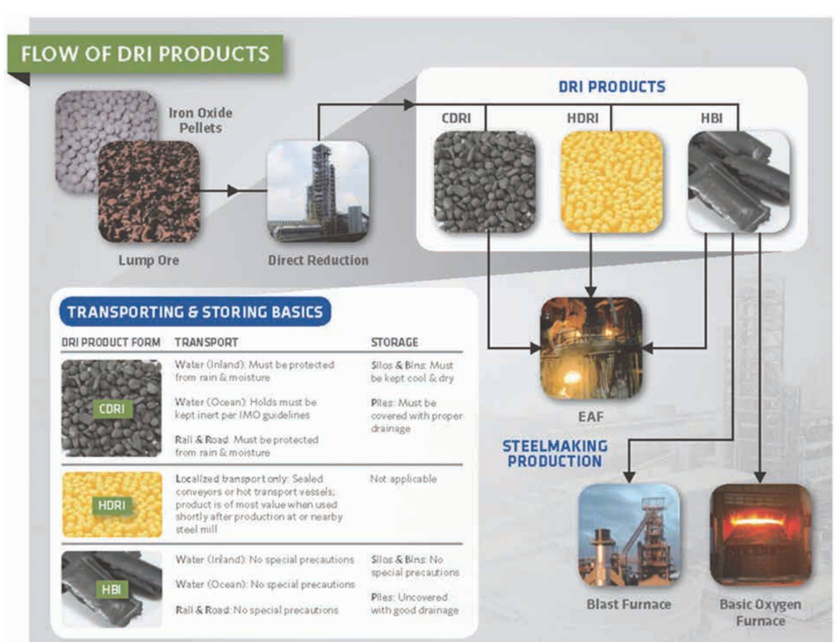

Fig. 2 Description and use of DRI products

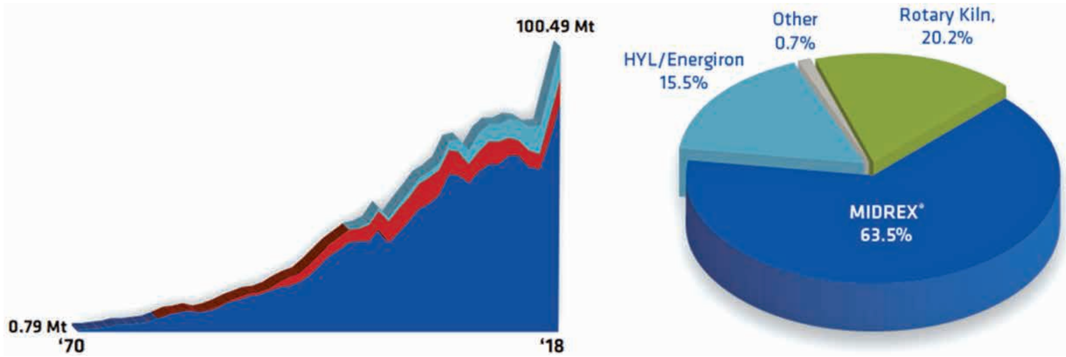

Fig. 3 Trends in world's annual DRI production[2)]

The plant for Cleveland-Cliffs Inc. mentioned above is a plant that produces HBI.

On the other hand, when the DRI produced by a MIDREX Module is used in an adjacent electric furnace shop, much of the energy required for melting in the electric furnace can be reduced by the use of the hot DRI, which has a temperature of 600℃ or higher after reduction. Therefore, Midrex Technologies Inc. has developed a technology to transport HDRI and charge it to an electric furnace. This has further enhanced the value of DRI. In the two latest plants in Algeria mentioned above, HDRI is produced and fed to an adjacent electric furnace.

Thus, the recent trends are the construction of a plant that produces HDRI adjacent to an electric furnace, and the construction of a large plant that produces HBI for external sales.

It should be noted that the term "DRI" referred to in this paper means comprehensive reduced iron products in all three product forms, CDRI, HDRI and HBI. This diversification of product forms in DRI also contributed to the increase in electric furnace production in the global steelmaking industry, and as shown in **Fig. 3**, the world DRI production in 2018 exceeded 100 million tonnes.[2)]

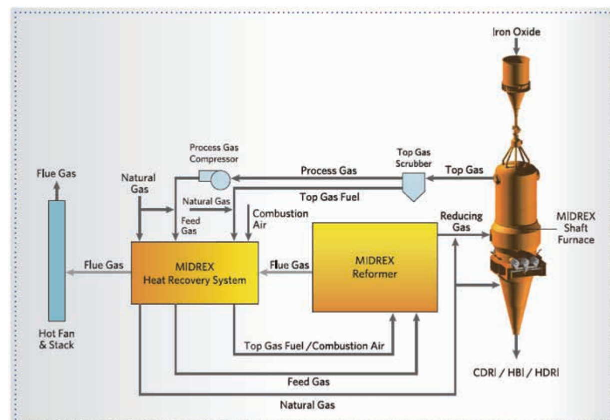

Fig. 4 MIDREX NG flowsheet

Fig. 5 Latest MIDREX NG plant: Tosyali in Oran, Algeria. (Reduction furnace in center with HDRI conveyor to EAF meltshop on left side.)

3. Overview of the MIDREX Process

Fig. 4 and **Fig. 5** show, respectively, the flowsheet for the standard MIDREX Process (MIDREX NG™) based on natural gas and an exterior photograph of the plant (Tosyali Algérie Steel Mill in Oran, Algeria). The MIDREX NG consists of two main units: a shaft furnace for reducing iron ore to metallic iron, and a reformer for producing the reducing gas required for the iron ore reduction in the shaft furnace.

In the shaft furnace, reducing gas is counter-currently fed to the packed bed of iron-ore pellets or lump ore descending therein. The iron-ore pellets are heated up, reduced, and carburized very efficiently by the ascending gas. The iron ore is charged at the ambient temperature from the top of the shaft furnace and discharged from the bottom of the shaft furnace as CDRI or HDRI. The oxygen, which occupies approximately 30% (weight ratio) of the iron ore, is removed by the reactions with carbon monoxide (CO) and hydrogen (H_2) at high temperature in the shaft furnace, leaving carbon dioxide (CO_2) and water vapor (H_2O).

These solid-gas reactions are shown in **Fig. 6**. The reduction of iron ore by H_2 is an endothermic reaction, while the reduction by CO is an exothermic

Reduction (removal of oxygen from iron ore)

1. $Fe_2O_3 + 3H_2 \longrightarrow 2Fe + 3H_2O$ (endothermic)
2. $Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$ (exothermic)

Carburization (addition of carbon to iron)

3. $3Fe + CO + H_2 \longrightarrow Fe_3C + H_2O$
4. $3Fe + CH_4 \longrightarrow Fe_3C + 2H_2$
5. $3Fe + 2CO \longrightarrow Fe_3C + CO_2$

Reforming (conversion of CH_4 to CO and H_2)

6. $CH_4 + CO_2 \longrightarrow 2CO + 2H_2$
7. $CH_4 + H_2O \longrightarrow CO + 3H_2$

Fig. 6 Major chemical reactions in MIDREX Process

reaction. Furthermore, the carbon contained in DRI is produced by a chemical reaction with CO or methane (CH_4). Blowing natural gas from the bottom into the shaft furnace increases the amount of carbon content in the DRI and cools the DRI in a CDRI plant.

The post-reduction gas emitted from the top of the shaft furnace at 350-450℃ is cooled and dedusted. This gas contains CO and H_2 in addition to the products of reduction reaction, namely CO_2 and H_2O. Approximately two-thirds of it is recycled as reducing gas, and the rest is used as the heat source required for the reforming reaction. The recycled gas is sent to the MIDREX Reformer after natural gas has been added. The MIDREX Reformer has a structure in which a tube filled with a special nickel-based catalyst is housed in a refractory casing. As the gas passes through the tube, the oxidized compound (CO_2, H_2O) and methane are reacted by catalyst and reformed into CO and H_2. Other DRI production processes that use natural gas employ conventional steam reformers. On the other hand, the MIDREX Reformer, which uses CO_2, a reduction product, as the main reforming agent, can produce gas with a low H_2/CO ratio. Using this as the reducing gas of the shaft furnace enables the furnace interior to be stably maintained at a high temperature, thanks to the heat associated with the reduction reaction with CO, which ensures stable operation and the production of high-quality DRI.

The MIDREX Process uses natural gas efficiently for the following three purposes:

(1) as the raw material of CO and H_2 required for the reduction of iron ore,
(2) as a heat source for the shaft furnace and reformer, and
(3) as an agent to enhance cooling and carburizing of the direct reduced iron.

In addition, the MIDREX Reformer has the equipment for recovering the sensible heat of exhaust gas for preheating reformer feed gas, combustion air, natural gas, etc., to realize high thermal efficiency.

Many years of experience have shown that the MIDREX Process is flexible with respect to the applicable iron ore and reducing gas. As for iron ore, it is possible to charge a high volume of lump ore, depending on the brand, in addition to iron ore pellets from all over the world. The MIDREX Process has an experience of using various reducing gases with H_2/CO = 0.5 to 3.5 in commercial plants, such as COREX® gas, coal gas, coke furnace gas and steam reformer gas. Although in a small scale, Midrex Technologies Inc. has the experience of operating a pilot plant built at its R&D center, from the late 1970s to the mid-1980s, and using reducing gas with H_2/CO = 4.2 at the maximum.

The main reason that the MIDREX Process has expanded in the DRI production process is its simplicity. For example, the process control can be easily done by performing the iron ore reduction and gas reforming in separate reactor vessels. In addition, the MIDREX Process employs low operating pressure, which results in stable and easy operation of the plant. As a result, many of the plants have achieved an uptime of over 8,000 hours per year.

4. Evolution of MIDREX Process by continuing innovation

The MIDREX Process has undergone many improvements, large and small, from the time that the first MIDREX Module in Portland, Oregon began operation in 1969 until the latest Algerian plant was launched in 2020. Innovative ideas have been adopted according to Kobe Steel's technical development assistance to Midrex Technologies Inc., a member of the Kobe Steel Group, feedback from the plant operations, and collaboration with technology partners. Thanks to this, the MIDREX Process has evolved into the most reliable, efficient, and environmentally friendly process to reduce the iron ore.

A recent article from "Direct from Midrex"[3)] provides a comprehensive list of innovative technologies that have been used in the MIDREX Process. Six of them are exemplified below:

- Significant improvement in energy efficiency by enhanced heat recovery equipment.
- Preventing clustering and realizing high-temperature operation of the shaft furnace by coating the surfaces of iron ore pellets.
- Realizing high-temperature operation of the shaft furnace by blowing oxygen into reducing gas.
- Hot briquetting and cooling technologies to improve the strength, reoxidation resistance and

yield of the HBI.

- Reducing melting energy by directly charging HDRI to the electric furnace (HOTLINK® Note 1)) and thereby realizing improved productivity and cost reduction of the electric furnace.
- Expansion of plant scale by applying a large shaft furnace (MEGAMOD® Note 2)) (annual production of 400,000 tonnes in the 1970s → current annual production of 2.5 million tonnes)

Recently, the Midrex R&D team and Kobe Steel have collaborated to develop the following new technologies:

- Performance improvement technology for the MIDREX Reformer
  (1) Eleven-inch large diameter tube.
  (2) MA-1 alloy to suppress deformation at high temperature.
  (3) New catalyst (R7RWH, R17) that reduces pressure loss.
  (4) New burner system that reduces NOx emissions.
- Adjustable Carbon Technology (ACT™)
  A system for controlling HDRI discharge temperature and carbon content individually by blowing in a mixed gas of CO and natural gas at the bottom of the shaft furnace.
- DRIPAX and Expert system
  Computer tools for helping plant operators and engineers optimize the operations.
- MidrexConnect™
  Provision of services to remotely monitor plant equipment and analyze operation data. It accesses plant data in real time from Midrex headquarters via direct secured link to check process variables that affect plant performance and the impact on the entire production process. The information that the plant operator must immediately determine and take action upon is conveyed to the plant.[4]
- Integrated Plant Solutions (IPS)
  Provision of a comprehensive solution by which the plant equipment and operation are integrally analyzed to improve the utilization rate and productivity. Midrex Technologies Inc. currently provides water treatment facility management services to multiple plants.
- MIDREX H_2
  MIDREX H_2 will be explained in detail in Section 5.4.

Note 1) HOTLINK is a registered trademark of Midrex Technologies Inc.

Note 2) MEGAMOD a registered trademark of Midrex Technologies Inc.

In the last decade, Midrex Technologies Inc. worked with its collaboration partners to construct and operate nine plants. In addition, two more plants are currently under construction or being commissioned. All these new plants employ all or most of the technologies listed above. This is the achievement of Midrex Technologies Inc., which has developed innovative and meaningful products on the basis of various ideas.

The latest Algerian plant, mentioned above, with an annual production of 2.5 million tonnes, mainly produces HDRI, in which maximum productivity and minimum energy consumption are realized by continuous feeding to the adjacent electric furnace using a hot transfer conveyor. In addition, the plants constructed by Midrex Technologies Inc. adapt new technologies, such as a newly designed reformer with 8 rows of large diameter M1 alloy tubes, two-point gas feed to the reducing gas header, and 2 parallel reformer exhaust gas hot fans.

The 1.6 million tonne HBI plant under construction for Cleveland-Cliffs Inc. is the first plant capable of regulating HBI carbon content by adopting the ACT technology mentioned above.

5. Steps taken toward CO_2-free ironmaking by MIDREX Process

5.1 Iron and steel industry CO_2 emissions

The iron and steel industry is one of the major greenhouse gas emitters, accounting for approximately 7-9% of the total amount of emissions, especially because its ironmaking process relies heavily on coal. Approximately 70% of the crude steel produced in the world is blast furnace pig iron refined by converters.[5] Ironmaking in blast furnaces uses coke and coal as energy sources and reductants. Therefore, the blast furnace-basic oxygen furnace process emits a large amount of CO_2, 1.6 to 2.0 t/t-steel.

The MIDREX Process, on the other hand, uses natural gas as its energy source and reductant, enabling ironmaking with lower CO_2 emissions than blast furnaces. The following sections outline the steps to reduce the amount of CO_2 emissions by using the MIDREX Process.

5.2 Replacement of blast furnace with MIDREX NG Process

As mentioned above, the MIDREX NG Process, which uses natural gas, enables ironmaking with a low amount of CO_2 emissions. When this process is combined with an electric furnace, the amount of CO_2 emissions can be 1.1-1.2 t/t-steel,[6] which is the lowest among the commercial processes that produce crude steel from iron ore. In other words, significant CO_2 reduction is possible by replacing the blast furnace– basic oxygen furnace process with the MIDREX NG–electric furnace process.

Furthermore, if CO_2 removal equipment is installed in the MIDREX NG Process and the removed CO_2 is stored deep in the ground (Carbon Capture and Storage, CCS) or used as a new product or energy (Carbon Capture and Utilization, CCU), the amount of CO_2 emissions can be reduced to approximately 1/3 of that of the blast furnace– basic oxygen furnace process.

The MIDREX NG Process has plenty of experience, including the use of CO_2 removal equipment, and by switching to this process, the amount of CO_2 emissions can be effectively and significantly reduced without taking any technical risks.

5.3 Partial replacement with hydrogen in MIDREX NG Process

The ultimate way to dramatically reduce the CO_2 emitted by the MIDREX Process is to use hydrogen produced from renewable energy (hereinafter referred to as "green hydrogen") instead of the natural gas used for fuel and reductant.

The first step is to replace some of the natural gas with green hydrogen when green hydrogen becomes available in an existing MIDREX NG Plant. **Fig. 7** depicts the flowsheet for adding hydrogen to the MIDREX NG Process. In the case of Fig. 7 (a), it is possible to replace up to 20 to 30% of natural gas with hydrogen without modifying the equipment. In a DR plant with an annual production capacity of 2 million tonnes, for example, approximately 20,000 Nm^3/h of natural gas, which accounts for approximately 30% of the total natural gas consumption, can be replaced by 60,000 Nm^3/h of hydrogen. For replacing even more natural gas, steam needs to be fed to the MIDREX Reformer. This steam can be produced separately in a boiler, or can be other steam sources available at the steel mills. Fig. 7 (b) is the flowsheet for this case. It is possible to make these steam-feeding modifications to an existing MIDREX NG Plant. Also, a newly constructed plant can be designed considering the future modifications.

If the amount of hydrogen available fluctuates daily or seasonally in the course of infrastructure changing from a carbon economy to a hydrogen economy, the MIDREX Process can flexibly change the energy source in accordance with the situation at that time. Hydrogen may also be produced within a plant site or be received from external producer.

5.4 MIDREX H_2 Process (based on 100% hydrogen)

Fig. 8 depicts the flowsheet of the MIDREX H_2 Process. Fig. 8 (a) shows the case where externally produced hydrogen is fed, and Fig. 8 (b) shows the case where the hydrogen production equipment is incorporated in the process. The MIDREX Reformer is no longer needed; only a gas heater is needed for heating up hydrogen to the required temperature. When an existing MIDREX NG Plant is switched to a MIDREX H_2 Plant, the MIDREX Reformer can easily be converted to a gas heater because the endothermic reforming reaction is eliminated, decreasing the heat load. In a newly constructed MIDREX H_2 Plant, the equipment specifications may be tailored to only heating up hydrogen. For the shaft furnace, by means of process model calculations and laboratory experiments it has been verified to be able to produce DRI by applying 100% hydrogen without changing the existing furnace design.

The hydrogen consumption rate in these

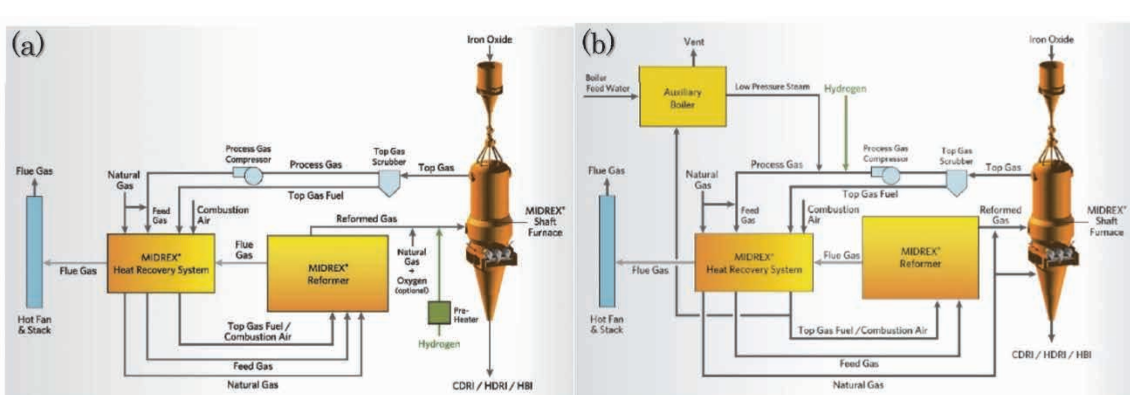

Fig. 7 MIDREX NG Process with hydrogen addition:
(a) less than 20-30% of natural gas displacement, (b) more than 30% natural gas displacement

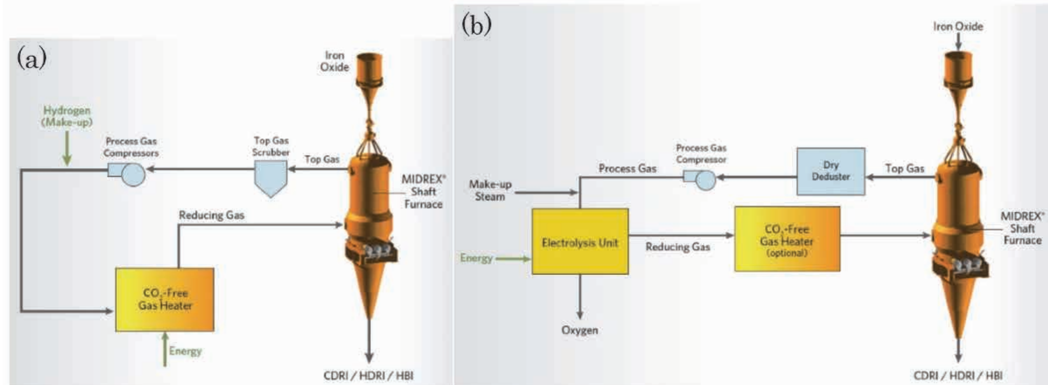

Fig. 8 MIDREX H_2 Process: (a) hydrogen supplied over-the-fence, (b) integrated hydrogen generation

flowsheets is approximately 650 Nm^3/ t-DRI. As the energy source for the reducing gas heater, hydrogen up to 150 Nm^3/ t-DRI, or another low CO_2 load heat source, such as waste heat, electricity, or natural gas, is required. By combining the MIDREX H_2 Process with an electric furnace, it is possible to reduce CO_2 emissions by 80% or more compared with the case where crude steel is produced by the blast furnace–basic oxygen furnace process, although the amount of reduction varies depending on the CO_2 load of the electric power used.

6. Challenges faced by hydrogen ironmaking

This section describes the challenges in the partial replacement with hydrogen in the MIDREX NG Process described in the previous section, and in the steps towards using 100% hydrogen in the MIDREX H_2 Process. As shown by the chemical reaction formula in Fig. 6, a large amount of hydrogen has already been used for iron ore reduction in the current MIDREX NG Process based on natural gas. Therefore, the partial replacement with hydrogen in the MIDREX NG Process or the MIDREX H_2 Process should be called an evolution from the MIDREX NG Process rather than a breakthrough in technology.

As can be seen, the hurdle to MIDREX H_2 is not high, but there are some challenges. One of them is the temperature in the shaft furnace. The increase in hydrogen in reducing gas causes a transition from carbon-monoxide reduction (Reaction 2 in Fig. 6), which is exothermic, to hydrogen reduction (Reaction 1 in Fig. 6), which is endothermic. This affects the heat balance in the shaft furnace, and it is necessary to increase the amount of heat supplied to the shaft furnace. The MIDREX H_2 allows several methods of responding in accordance with the situation of each project.

Another challenge exists in the carbon content of product DRI. Reduction with 100% hydrogen results in 0% carbon content in the DRI. The most common operations in electric furnaces nowadays actively exploit carbonaceous materials such as coke breeze or the carbon contained in ore-based iron sources (OBM) such as DRI and pig iron. This is because the carbon lowers the melting point of iron and is also required to reduce iron oxide remaining in the DRI. There also are advantages in combusting carbon with oxygen blown, to generate a great amount of energy and shorten the melting time. That is, without carbon, the efficiency of the electric furnace would be significantly reduced. Therefore, it is necessary to optimize carbon concentration in DRI for the electric furnace and DR plant as a whole and change the operating conditions accordingly, considering many factors including the cost of CO_2 emissions. The utilization efficiency of carbon contained in DRI is higher than that of carbonaceous materials such as coke breeze. Therefore, it may be necessary to add some carbon to the DRI in some DR plants. In such cases, it is possible to obtain 1.4% carbon in DRI, by adding the natural gas of 50 Nm^3/ tonne, for example.[7)]

The biggest challenge in realizing hydrogen ironmaking is to reduce the cost of green hydrogen and to stabilize its supply. Globally, most hydrogen is currently produced from fossil fuels through steam reformers, whereas green hydrogen is produced by the electrolysis of water, in which CO_2-free electricity is used. The water electrolysis technology is not new, and much development has been made in electrolytic cells. However, a large amount of electric power is required regardless of which technology is used [Note 3)], and electricity accounts for most of the operating cost of electrolytic cells. To replace the natural gas at the current price, the electricity unit cost must decrease to around \$0.01/kWh to be economically viable. Furthermore, even with the currently established technology, it

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Note 3) The amount of hydrogen that can be produced by 1 MWh of electricity is approximately 200 Nm^3 (18 kg).

is not possible to supply the required amount of hydrogen to DR plant. The most ambitious project recently announced in Europe has a plan to produce hydrogen by 100 MW of alkaline electrolysis.[8] This scale, however, must be increased by a factor of 6 to 8 to cover the hydrogen required for one MIDREX Module. Furthermore, even if the electricity unit cost comes down to $0.01/kWh, the equipment cost of electrolytic cells will need to be reduced to 1/3 to 1/4 of the current equipment cost in order to make the price of product hydrogen match the price of hydrogen produced from fossil fuels. Development aiming to increase the scale of electrolytic cells is also under way, but it seems that it will still take time to be economically viable even if the equipment costs are reduced by increasing the scale.

In order for hydrogen to be stably supplied and the hydrogen economy to be realized, it is necessary to work on the challenges of hydrogen infrastructure such as storage and transportation of hydrogen, in addition to the challenge of hydrogen production cost.

Yet another challenge in realizing hydrogen economy is power generation. For example, suppose that the current amount of crude steel in Japan is produced by feeding scrap and the DRI produced by MIDREX H_2 to an electric furnace at a ratio of 50:50. In this case, the DR plant alone would require approximately 25 GW of green electric power, corresponding to 300,000 ha of solar panels, 40,000 units of wind turbines (7,500 ha of land), or 20 nuclear power plants. Such a huge amount of green electric power is required, and this is considered as a challenge to be addressed at the national level.

7. Demonstration plant of MIDREX H_2 Process

In September 2019, ArcelorMittal, S.A. announced that it would work with Midrex Technologies Inc. to construct a demonstration plant for producing steel using hydrogen in Hamburg, Germany. The purpose of this project is to demonstrate that DRI produced using only hydrogen as a reductant can be used in an electric furnace to produce molten steel. In this demonstration plant, hydrogen contained in the furnace top gas of an existing MIDREX Module that uses natural gas as a reductant is recovered and is used to produce 100,000 tonnes of DRI annually. As future scheme, it is planned to produce a part or all of the hydrogen based on renewable energy. In this project, both companies plan to tackle technological challenges, including the physical characteristics and melting properties of DRI produced by hydrogen reduction.

Conclusions

The year 2019 marked the 50th anniversary of the birth of the MIDREX Process. At the same time, 37 years have passed since Midrex Technologies Inc. joined the Kobe Steel group. Continuing to improve and modify this simple and excellent process has enhanced its efficiency and has made its evolution in line with the market, which has led to the success of the business to date. Against the backdrop of recent trends in the iron and steel industry, the role of the MIDREX Process is expected to become greater than ever as a technology to produce high-grade iron source called DRI, which can meet the high demand for steel quality and at the same time greatly reduce greenhouse gas emissions.

The MIDREX Process is a well-established technology with a wealth of experience. It is considered to be the most reliable technology, whose introduction can not only reduce the amount of greenhouse gas emissions immediately, but also realize the even more significant reduction required in the future.

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