HYL process for direct reduction of iron ore using an on-site nitrogen generator

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The HYL process is designed to convert iron ore (pellet/bulk ore) into metallic iron by using reducing gases in a solid gas moving bed reactor. Oxygen (O2) is removed from the iron ore by a chemical reaction based on hydrogen (H2) and carbon monoxide (CO) to produce highly metallized direct reduced iron (DRI)/hot briquetted iron (HBI). the HYL process is currently marketed under the "Energiron" trademark.

The HYL process for direct reduction of iron ore is the result of research work started by Hojalata y L.mina， S.A. (later known as Hylsa) in the early 1950s. After a preliminary evaluation of the concept， it was decided to install a process using a tunnel furnace， and several runs were made. The first one was carried out on July 5， 1950 by using an old furnace (an already built heating plate). A portion of crushed ore with a size of 12 mm to 25 mm was mixed with 40% coke and 15% limestone with the same granularity as the ore. This mixture was placed in a clay crucible and two iron tubes， each with a diameter of 100 mm and a length of 1 meter. Twenty kilograms of high quality DRI was produced.

The first gas-based plant， with a design capacity of 50 tons per day， was unable to achieve acceptable levels of metallization. During its 18 months of operation， it underwent several changes， including the installation of a gas reformer to improve the reducing gas. Finally， in early 1955， its operation was suspended. After this frustrating attempt， several experiments were conducted and a pilot plant was assembled to test new ideas. When this pilot plant was put into operation， it began successfully producing high-quality reduced iron at a rate of 30 tons per day. It soon reached a system production of nearly 60 tons per day.

With the successful production of direct reduced iron from the gas-based HYL direct reduction process， studies were initiated to design the first commercial plant with a capacity of 230 tons per day of DRI. The first industrial-scale direct reduction plant was commissioned on December 5， 1957.The Hylsa Monterrey 1-M plant was a fixed-bed reactor or intermittent process with an initial capacity of 75，000 tons of DRI per year.It continued to operate until 1991， just short of 35 full years of production.In 1978， the American Metals Council designated Hylsa 's HYL Process Plant 1-M as a historical milestone because it was the first successful industrial implementation of direct reduction ironmaking technology. However， the competitiveness of this technology was limited due to its batch nature.

By the end of 1970， total world DRI production in 1970 reached 790，000 tons，680，000 tons of which were produced by the HYL process plant. However， HYL foresaw that the competitiveness of this technology would be limited due to its batch nature. For this reason， a research program was initiated in 1967 to develop a continuous (moving bed) process， and the first industrial plant was launched in May 1980 at Hylsa in Monterrey，Mexico， 23 years after the success of its first HYL plant. The new continuous vertical furnace process was called HYL III. The new process concept resulted in higher plant productivity， higher DRI quality， lower energy consumption and simpler plant operations.

The name HYL III was chosen to represent the third generation of HYL technology. The second generation (HYL II) is essentially a modification of the original fixed bed process designed to increase efficiency and reduce natural gas consumption. During the development phase of the process， two important modifications were made， namely (i) the use of high-temperature alloy tubes in the reduction gas reheater， allowing the gas to be heated to higher temperatures， and (ii) the reduction of the number of heater units from the original four to two. In the HYL II process， the reducing gas (rich in CO and H2) is produced by nickel-based catalytic reforming. However， the HYL II process was never commercialized because of the significant advantages offered by the advent of the HYL III process.

Since then， several improvements have been made in the HYL III moving bed process. 1986 saw the addition of a CO_2 removal system to the reducing gas circuit， which led to significant improvements in productivity， energy consumption and DRI quality. The modification resulted in a reduction of gas consumption by about 50% and an increase in productivity of the shaft furnace by about 50%.

In 1995， partial combustion technology was incorporated into the HYL plant by injecting O_2 into the transfer line between the reducing gas heater and the shaft furnace inlet. This option allowed a significant increase in reducing gas temperature and in-situ reforming. This reduced reforming gas consumption by about 25% and increased the productivity of the shaft furnace. in 1988， the total gas feed and O_2 injection into the shaft furnace (reduction reactor) led to the "HYL self-reforming scheme" in which the reforming gas make-up was reduced to zero. This reformer less scheme was named HYL ZR process and was successfully applied at Hylsa 4M plant in April 1998 and at Hylsa 3M5 plant in July 2001.

The coating of spherical/bulk ore for direct reduction was introduced in 1988. 1993 saw the introduction of a pneumatic transport system (Hytemp technology) and hot DRI feeding to the EAF. 1994 saw the start of HYL production of high carbon (C) DRI with a C content of 3 to 5%. 1997 saw the commissioning of the world's first dual discharge (DRI and HBI) plant design.

During 2000， 100% of the lump ore was successfully used on a conventional basis. 2001 saw the introduction of a mini-module (200，000 tonnes/year) plant based on HYL's ZR (Zero Reformer) reformer-free technology. A HYL ZR process plant based on coal gasification and coke oven gas (COG) was also introduced. In addition， a single module DR plant with a design capacity of 2.5 million tons/year was offered during the year. Between the mini-module and the single module with a capacity of 2.5 million tons per year， modules