

Operation of Cutting-Edge Coke Oven Having all of Durability, Safety and Efficiency

Next-generation coke oven resulting from the fusion of world-leading company's technology and IHI's engineering power

Coke is one of extremely important raw materials for iron-making.

While a blast furnace is operating, the stop of supplying the raw material is not allowed, and very stable supply is required.

Recently, Paul Wurth IHI Co., Ltd. has completed a coke oven first delivered in Japan.



Additional construction of coke oven at Kashima Works of Nippon Steel & Sumitomo Metal Corporation
(Courtesy : Nippon Steel & Sumitomo Metal Corporation)

Coke indispensable to iron-making process

Paul Wurth IHI Co., Ltd. (PWIHI) was established in 2012 as a joint company by the IHI's department specialized in industrial furnaces and Paul Wurth S. A. (PW) in Luxembourg skillful at the upstream process of iron-making. PWIHI has aimed to, together with IHI's achievements such as blast furnace design and equipment, and coke dry quenching systems, provide Japanese customers (mainly Japanese ironworks) with coke ovens of which technology is held by PW Italia of the Paul Wurth Group and which have a good reputation in markets around the world. In August 2016, at the Kashima Works (Ibaraki Prefecture) of Nippon Steel & Sumitomo Metal Corporation, a new coke oven was completed and is now favorably operating.

First of all, what the coke indispensable to iron-making is will be described.

In nature, iron exists in the form of iron oxide in iron ore. To extract pure iron from iron oxide, it is indispensable to heat iron oxide at high temperature as well as separating oxygen from the iron oxide, i.e., reducing the iron oxide. A substance serving as a reducing agent for the reduction is coke. The raw material of coke is relatively high-grade coal having high viscosity, called caking coal, and when heating the coal to high temperature without burning (this process is referred to as coal distillation), the coal melts once at 400°C or more. When further increasing temperature, the composition of the coal changes, and at 1 000 to 1 300°C, the molten coal again solidifies into coke.

A battery for heating caking coal is of a shape in which many ovens having a width of approximately 45 to 55 cm and a height of 6 to 7 m (in a high oven case) surrounded by bricks are connected. The coke oven delivered this time has 33 oven chambers (ovens), and oven chambers are usually counted as one oven, two ovens, and so on, so the coke oven is referred to as one battery consisting of 33 ovens (an annual production capacity of 340 000 t).

Coal is not directly heated in an oven chamber but carbonized surrounded by bricks heated to high temperature, i.e., "steamed." The resulting coke is pushed out by a machine called a coke pusher machine when the door of the oven chamber is opened, guided by a coke transfer car, collapsed down on a coke quenching bucket (for dry) or a coke quenching car (for wet), and conveyed to an iron-making process through a cooling process.

Four conditions required for good coke oven

Among coke prepared in this manner, good coke requires hardness, and when collapsing after being pushed out and conveyed from a coke oven, does not fine down too much but keeps granularity to some extent. Also, since coke is used as a reducing agent, oxygen content of course must be as low as possible.

Accordingly, the requirements for a good coke oven are that first the good coke oven is capable of producing coke having

hardness and second it has high sealability. If air gets in through a gap such as from the side of the door of an oven, coke is exposed to oxygen and reduces in quality, and therefore the oven is required to be tightly sealable. In addition, in an ironworks, once a blast furnace for making iron starts to operate, basically, it never stops before the end of its life. In other words, a coke oven is also required to keep operating for supplying coke as long as a blast furnace keeps operating. The third condition for the good coke oven is long-lived and capable of continuously operating.

One other thing that should not be forgotten is a gas collecting capability. When carbonizing coal into coke, volatile components contained in the coal are emitted as gas. The emitted hot gas (coke oven gas: COG) is not simply emitted but collected in a certain place to extract useful components such as tar, crude light oil, sulfuric acid, benzene, and ammonia and purify them. Then, the purified useful components are again made usable as fuel for a blast furnace or a coke oven. Such a gas collecting capability is not only for environmental conservation or energy saving, but can also reduce fuel cost and produce COG reusable as by-products and other organic substances, and is therefore an essential capability for a recent coke oven.

To construct safe structure while keeping height

The coke oven delivered by PWIHI this time is configured to have specifications for the domestic customer in terms of any of the capabilities described above on the basis of a high level of technology of PW, a world-leading company of coke ovens, together with IHI's achievements.

One of the features of coke oven construction this time is that a technology for constructing a high oven having a height exceeding 7 m was introduced. A coke oven must be long-lived; however, damage is gradually accumulated every time the push-out work is done. In order to increase the life of a coke oven and decrease the time and effort for maintenance, it is only necessary to reduce the frequency of the push-out work, and for this purpose, it is necessary to increase the size of an oven chamber and thereby increase the amount of coal carbonizable at a time. However, when increasing the width of the oven chamber, it is difficult to efficiently transfer heat to coal inside the chamber, and therefore the height of the chamber is increased to increase its volume. In fact, designing a refractory structure in a safe and durable shape is a special and high level of technology. PW have held that technology.

In addition, we became to be able to propose an oven layout meeting the needs of the customer with the PW's technology as an option. As a result, the degree of freedom of selection was increased, for example, ① a fuel gas supply system, ② waste gas channel arrangement, ③ raw material coke charging direction, and so on.

We are showing out advantages as a leading company in the domestic iron-making field by, together with the introduction of such a new technology, supplying IHI's various technologies

such as a hydraulic technology as an engineering elemental technology, which has been fostered while accumulating achievements in the field of blast furnace design, and a raw gas bleeder system (a system adapted to safely transport raw gas which when retained, has an increased risk of explosion) to customers in combination with the entire oven design.

In particular, surely following daily-updated Japan-specific safety standards and constraint conditions has been a high barrier to entry even for a single foreign company having new superior technologies. Accordingly, by establishing the joint company PWIHI to combine the specialties of both companies, the coke oven can be smoothly and successfully introduced.

The construction of the new oven allowed a coke production amount, which had been reduced due to deteriorated equipment, to be increased, and also a customer's trust to be earned in terms of maintenance and operation. As a result, as the battery No. 2 of the Kashima Works, we are also proceeding with the construction of large equipment, i.e., one battery consisting of 65 ovens (an annual production capacity of 580 000 t) while aiming to launch it in 2018.

Stamp charge coke oven leading to cost reduction of caking coal

When surveying the current situation of steel manufacturing companies in Japan, a reduction in coke production amount is a problem to overcome because the lives of coke ovens intensively constructed during the period of high economic growth during which Japan's iron and steel industry rapidly grew are about to expire. In other words, PWIHI have an opportunity to lead to future business by utilizing the latest coke oven technology. However, we are not only taking advantage of such an opportunity, but also waiting for a chance to provide new technologies not yet employed in Japan.

One of such technologies is a stamp charge coke oven. Depending on a coal charging method, coke ovens are roughly classified into a top charge type configured to charge coal from above and a stamp charge type configured to charge coal from a side of an oven and put the coal into the oven while pressing the coal. In a stamp charge oven, coal is compacted into a rectangular parallelepiped cake in an oven chamber by a stamping machine. As described above, to make coke, high-grade coal having a high caking property is required as a raw material. However, in the stamp charge type, coal is pressurized when charged, and therefore even so-called low-grade coal having a low caking property allows the production of granular coke having the same hardness as that of coke produced by the top charge type. That is, the stamp charge type has the advantages of being able to reduce raw material cost and produce coke having high hardness even when low-grade coal is mixed without selecting a raw material.

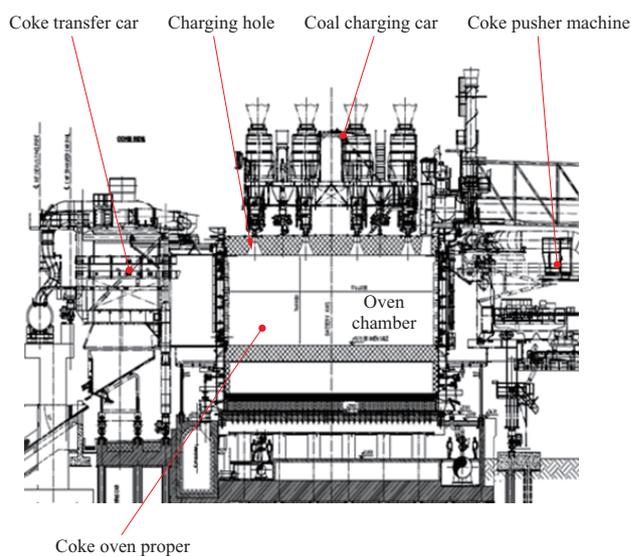
On the other hand, there is also a disadvantage of producing a larger amount of dust emission than the top charge type.

However, this can be prevented by installing a gas transfer car. In Germany having stringent environmental regulations, gas transfer cars have already really operated and acquired good reputation, and will operate in India as well.

SOPRECO® exhibits its power for gas collection

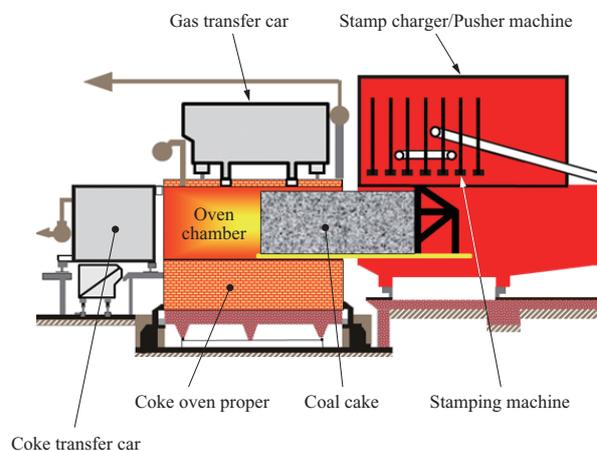
The second new technology we aim to introduce into Japan is a single oven pressure control (SOPRECO) system. As also described above, as a coke oven capability, it is important to collect COG produced as by-products at the time of coke production. SOPRECO is a system adapted to more reliably and safely collect COG.

In a coke oven, a piping installation (standpipe) for transporting produced COG to a collecting main pipe outside the oven is provided in each oven chamber. However, the pressures of respective oven chambers connected with standpipes are not uniform because of different operating



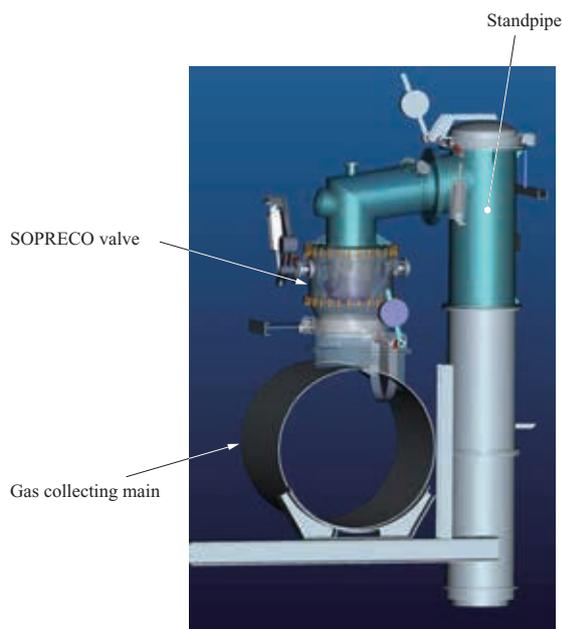
Coke oven proper

Top charge coke oven



Coke transfer car

Stamp charge coke oven



Single oven pressure control system SOPRECO

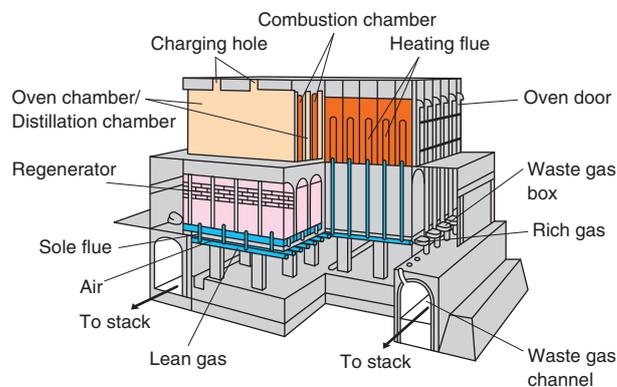
conditions. For example, consider that in the first oven chamber, distillation is in an initial stage, and gas is actively produced to increase the pressure inside the chamber, whereas in the second oven chamber, distillation is almost completed, and the pressure inside the chamber is decreasing. In this case, the first chamber has an increased risk of the occurrence of gas leakage, and the second chamber has a risk of air inflow (when air flows in, coal comes into contact with oxygen, reducing the quality of coke). In order to cope with such chamber-dependent non-uniformity in pressure, SOPRECO is configured to provide each standpipe connecting to a corresponding oven chamber with a valve for control. A valve main body and an operating part are both installed outside an oven, and therefore SOPRECO has the advantages of being able to be easily maintained and checked, and installed in an existing oven only by modifying a piping installation.

When introducing SOPRECO, COG can be efficiently collected and in addition, a load due to a pressure variation is not placed on any of sealing parts, thus contributing to a reduction in maintenance frequency during operation. Also, an oven chamber can be prevented from being brought into an excessive negative pressure state to cause air inflow through a sealing part, and consequently the quality of coke can be maintained and improved.

Nowadays, Japan's steel manufacturing industry is about to come up for rebuilding coke oven equipment built 40 to 50 years before, and therefore each ironworks is taking measures including oven rebuilding in haste in order to keep a production amount. In such circumstances, PWIHI actively introduces leading-edge knowledge and technologies such as ones related to environment, energy saving, and low emission, and proposes coke ovens together with conventional meticulous

engineering power, thus contributing to the stable supply of products of our customers, steel manufacturing companies.

Mini commentary



Schematic diagram of coke oven (example)
Source: "Handbook of Iron and Steel", The Iron and Steel Institute of Japan (1980)

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