Fuel gases used in the steel industry

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A fuel gas is a fuel that exists in gaseous form under ordinary conditions. Some of these gases contain hydrocarbons (such as methane or propane)， hydrogen (H2)， carbon monoxide (CO) or a mixture of these gases. These gases are a source of thermal energy that can be easily transferred and distributed directly from the source to the application via pipelines. Fuel gases are different from liquid and solid fuels， although some can be liquefied for easy storage or transport.

Fuel gases have different application areas in steel mills including (1) heat source (2) as a reducing agent， (3) power generation， and (4) cutting and welding applications. Fuel gases typically used in steel plants include (i) natural gas (NG)， (ii) liquefied petroleum gas (LPG)， (iii) by-product gases such as blast furnace (BF) gas， coke oven gas (COG) and converter gas， and (iv) acetylene. Figure 1 shows the types of fuel gases and their applications in steel plants.

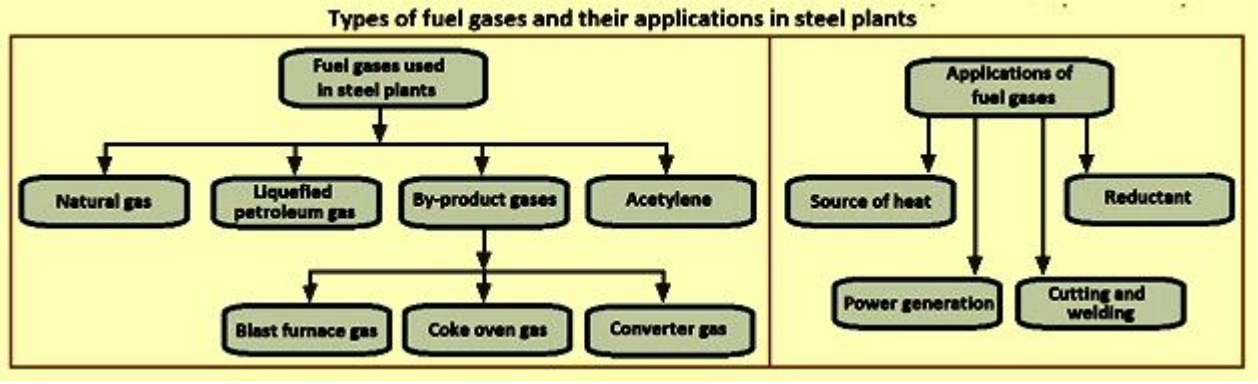

Figure 1 Types of fuel gases and their application in steel plants

Natural gas

Natural gas is an environmentally friendly， non-renewable， gaseous fossil fuel extracted from the earth's deposits. It is a clean fuel with high efficiency. It is transported over great distances (up to 5，000 km) through a network of pipelines. It is usually supplied to consumers in the form of (i) pipeline natural gas (PNG)， (ii) compressed natural gas (CNG) and (iii) liquefied natural gas (LNG).

Natural gas supplied to consumers by pipeline is PNG， and the pipeline pressure at the consumer's end is usually less than 16 atmospheres. Compressed Natural Gas (CNG) is a form of natural gas that is compressed (200 atm to 250 atm) into a container.LNG is made by cooling natural gas to a temperature of -162 degrees Celsius. At this temperature， NG becomes a liquid and its volume is reduced by a factor of 600.

Natural gas is a mixture of hydrocarbons consisting primarily of methane (CH4)， usually more than 85% by volume. other hydrocarbons in NG include various higher alkanes in varying amounts， such as ethane， propane and butane. It also contains water vapor (H2O)， or condensate， in varying degrees of saturation. It may also contain some small percentages of nitrogen (N2)， carbon dioxide (CO2)， hydrogen sulfide (H2S)， and helium (He).

Natural gas is an odorless， colorless， tasteless and non-toxic gas. It is lighter than air and when mixed with the necessary amount of air and ignited， it produces a clean blue flame. It is considered to be one of the cleanest burning fuels. When burned， it produces mainly heat， carbon dioxide and water.

The amount of natural gas is measured in normal cubic meters (equivalent to 0 degrees Celsius and 1 atmosphere) or standard cubic feet (equivalent to 16 degrees Celsius and 14.73 pounds per square inch of absolute pressure). The higher calorific value of a cubic meter (Cum) of natural gas ranges from about 9，500 kcal to 10，000 kcal. Its density is about 0.85 kg/m3.

The main use of natural gas in the production of iron and steel is in ironmaking， where it is used as a reducing agent. The use of NG in gas-based direct reduced iron (DRI) production requires the conversion of NG into a usable reducing gas with a high H2 and CO content. More than 90% of DRI facilities worldwide use natural gas. For DRI production， it is reformed to produce reducing gas， which is then used for iron ore reduction. The main reforming reactions are (i) 2CH4 + O2 = 2CO + 4 H2， (ii) CH4 + H2O = CO + 3 H2， and (iii) CO2 + H2 = CO + H2O.

NG is injected into the spigot of the BF as an auxiliary fuel. It is injected together with a hot O2 enriched blast. The purpose of injecting NG as an auxiliary fuel is to reduce the specific consumption of coke. The coke replacement ratio achieved by injecting NG gas in the blast furnace is between 1.3 and 1.4. The NG injected into the BF supplies the furnace with reducing gases consisting of H2 and CO which move around the furnace shaft and participate in the reduction reaction of iron oxides.

Liquefied Petroleum Gas (LPG)

LPG is extracted from crude oil. the main components of LPG are hydrocarbons containing 3 or 4 carbon atoms. the normal components of LPG are propane (C3H8) and butane (C4H10). small proportions of other hydrocarbons may also be present in LPG.

LPG is a gas at atmospheric pressure and ambient temperature， but it can be liquefied when moderate pressure is applied or the temperature is sufficiently reduced. It can be easily condensed， packaged， stored and utilized， which makes it an ideal energy source for a wide range of applications. Typically， LPG is stored as a liquid under pressure in steel containers， cylinders or tanks.

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