2B4. Integrated Coal Gasification Fuel Cell Combined Cycle Electric Power Generating Technology (IGFC)

Technology Overview

1. IGFC process flow

The integrated coal gasification fuel cell combined cycle (IGFC) gasifies coal for use in triple combined power generation, which combines three different types of generation systems: fuel cells, gas turbines and steam turbines. This high-efficiency power generation technology is expected to provide power generation efficiency of 55% or higher, if successfully developed, and to reduce CO_2 emissions by approximately 30% from the level of existing pulverized coal-fired power generation systems. IGFC is expected to become a coal-fired power generation technology of the future, although there are still many challenges to be overcome for commercialization, including the development of inexpensive high-efficiency fuel cells (Fig. 1).

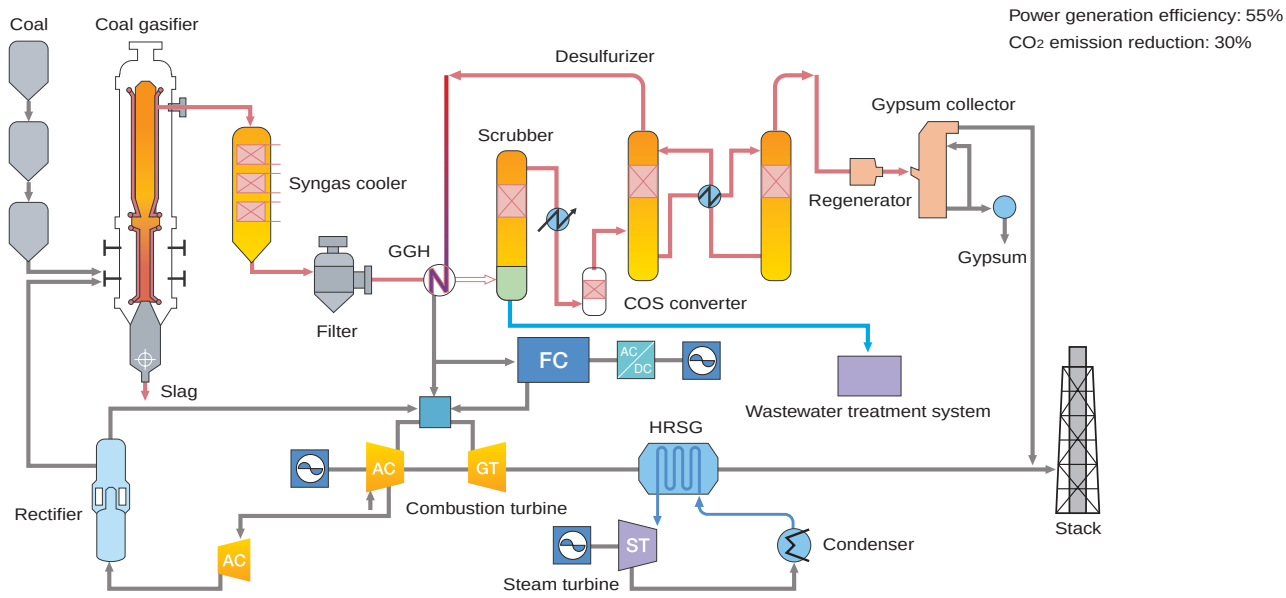

Fig. 1 IGFC process flowchart

2. Types and features of fuel cells

Fuel cells employ the electrochemical reaction between hydrogen and oxygen to directly generate power. With their high-efficiency and excellent environmental features, fuel cells are now in the limelight. They can be classified by electrolyte material into phosphoric acid fuel cells (PAFC), molten carbonate fuel cells (MCFC), solid oxide fuel cells (SOFC), and solid polymer electrolyte fuel cells (PEFC).

Type	Phosphoric acid (PAFC)	Molten carbonate (MCFC)	Solid oxide (SOFC)	Solid polymer electrolyte (PEFC)
Electrolyte	Phosphoric acid aqueous solution	Li/Na carbonate	Stabilized zirconia	Solid polymer membrane
Ionic conductor	H^+	CO_3^{2-}	O^{2-}	H^+
Operating temperature	Approx. 200°C	Approx. 650 to 700°C	900 to 1000°C	70 to 90°C
Generation efficiency (HHV)	35% to 42%	45% to 60%	45% to 65%	30% to 40%
Raw materials and fuels	Natural gas, methanol, naphtha	Natural gas, methanol, naphtha, coal	Natural gas, methanol, naphtha, coal	Natural gas, methanol, naphtha
Application	Co-generation and distributed generation	Co-generation and distributed generation, substitute for thermal power generation	Co-generation and distributed generation, substitute for thermal power generation	Co-generation and portable power supply, automobiles

Among the fuel cells above, MCFC and SOFC operate at high temperatures and are expected to be highly-efficient technologies for next-generation large-scale power plants due to the following features: (1) they can be used in combination with gas turbines, and (2) they can accept coal gas.

SOFC produce power through an electrochemical reaction between hydrogen, which has been derived from gasified fuel, and oxygen in the air. This mechanism is the reverse process of the electrolysis of water.

The traditional power generation system burns fuel to generate heat and converts the heat into electrical energy. Unlike this system, fuel cells derive electrical energy directly with lower energy losses and higher generation efficiency.

SOFC, consisting of ion-conducting ceramics, generate heat at temperatures as high as 900°C to 1,000°C during the chemical reaction. Combined with gas turbine generation, SOFC can provide higher generation efficiency than other types of fuel cells. Besides coal-gasified gas, LNG, methanol or biogas can also be used as fuel.