# 2B1. Hydrogen-from-Coal Process (HYCOL)

Research and development: HYCOL Association [Idemitsu Kosan Co., Ltd. ; Osaka Gas Co., Ltd.; J-POWER; Tokyo Gas Co., Ltd.; Toho Gas Co., Ltd.; Nikko Kyoseki Co., Ltd.; The Japan Steel Works, Ltd.; Hitachi Ltd.; and Mitsui Coal Liquefaction Co., Ltd.]
Project type: NEDO entrusted project

## Technology Overview

### 1. Background and process overview

The Hydrogen-from-Coal Process (HYCOL) is a gasification technology utilizing an entrained bed, in which pulverized coal is gasified with oxygen under high temperatures and high pressure. Through the gasifier, medium calorific gas, rich in hydrogen and carbon monoxide, is obtained. The technology is called the "HYCOL process." Through the shift reaction, the gas yields carbon monoxide and converts steam to carbon dioxide and hydrogen. After separating the carbon dioxide, the gas is purified to become high-purity hydrogen.

Hydrogen is used in oil refineries and in the chemical industry, as well as in the coal liquefaction process. On the other hand, the gas containing carbon monoxide is expected to be used widely as a raw material for synthetic chemical products, as a fuel for fuel cells, and as a fuel in various industries.

The HYCOL process has the following features:

(1) The process uses a dry-feed, one-chamber, two-stage swirling-entrained-bed gasification furnace. Pulverized coal, pressurized in a lock hopper, is fed, to the gasification furnace via burners in a swirling mode. Four burners are utilized in each stage. The oxygen feed and the gasification rate at the upper stage and lower stage are separately controlled. Throughout the operation, high thermal efficiency is attained, and heavy load gasification is performed.

(2) Slag self-coating technology for the water-cooled tubes was applied. This technology prolongs the life of the tubes and improves the reliability of the gasifier.

(3) A swirling gas flow distributor was developed and adopted as a technology to easily and uniformly distribute coal to multiple burners.

(4) Ash in coal is melted in the gasification furnace. The melted ash is discharged through the slag hole located in the furnace's hearth. As a result of the swirling gas flow, a high temperature is maintained at the slag hole, ensuring a smooth flow of slag.

(5) The unreacted char discharged along with gas from the gasification furnace is separated by a cyclone or other such device to recycle the material to the gasification furnace in a high-temperature, high-pressure state, thus ensuring a complete reaction.

(6) Ash in the coal is recovered as slag, which does not elute toxic components. Combined with the advantage of an easy recovery of the sulfur and nitrogen components, in the form of $H_2S$ and $NH_3$, respectively, the ash recovery also significantly contributes to a reduction in the environmental burden.

Coal that has a lower fuel ratio (fixed carbon to volatile matter) is more easily gasified.

### 2. Progress and development results

The HYCOL association (made up of the nine above-listed private companies) carried out the research and development of the pilot plant, under entrustment from NEDO. Five private companies (Hitachi Ltd., Babcock-Hitachi K.K., Asahi Glass Co., Ltd., Shinagawa Refractories Co., Ltd., and NGK Spark Plug Co., Ltd.) carried out the basic study on the structure of the furnace and on the materials, also under entrustment from NEDO.

For establishing the process, a pilot plant was constructed at Sodegaura, Chiba. The operational study of the pilot plant was conducted from 1991 to 1994. The performance target was achieved, and the world's most advanced gasification furnace technology was established.

### 3. Issues and feasibility of practical application

The development of a coal gasification fuel cell system (IGFC) for power generation utilizing HYCOL technology began in 1995, (EAGLE Project).

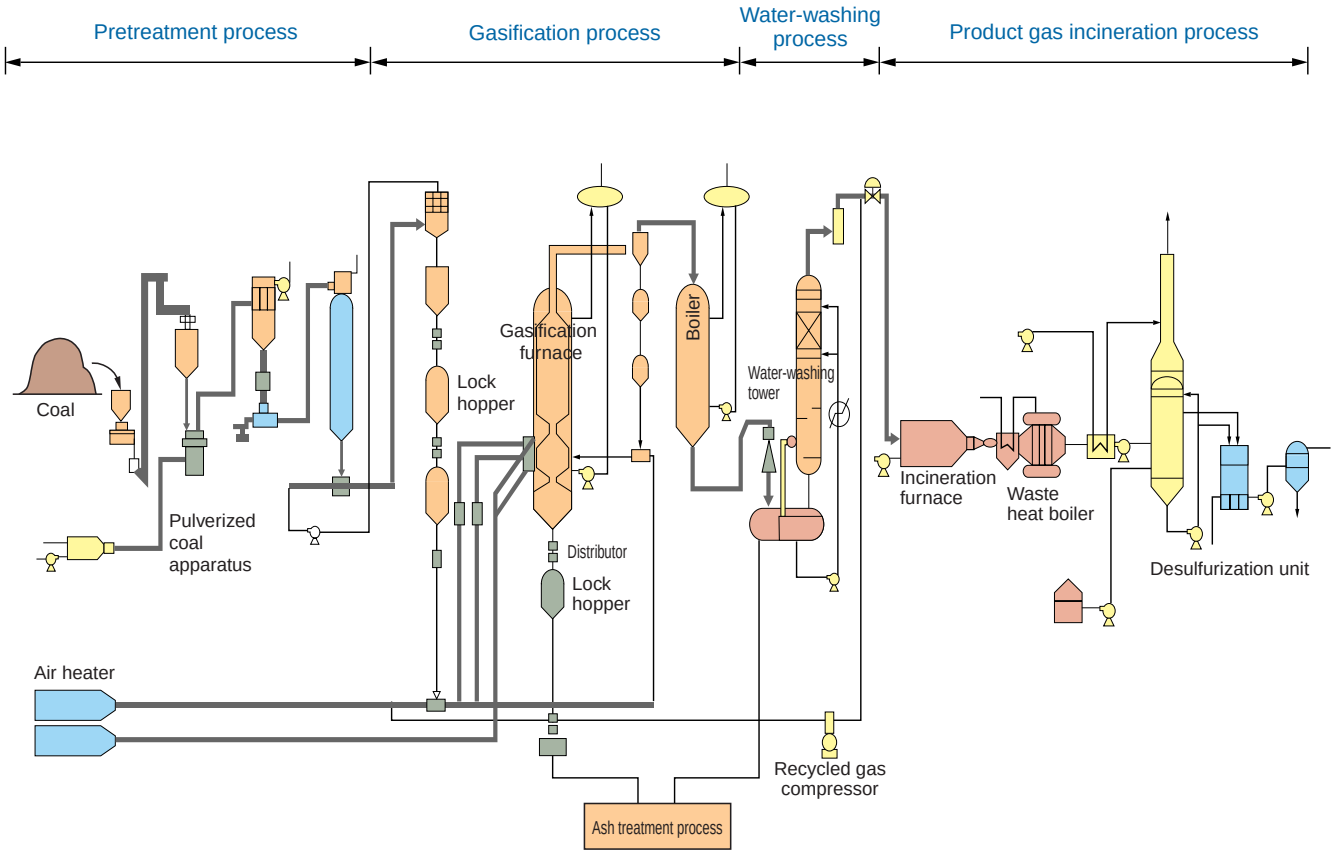


Fig. 1 Process flowchart of pilot plant

Pilot plant: Specifications and target performance

| | |
|---|---|
| Coal throughput | Max. 50 tons/day |
| Gasification agent | Oxygen |
| Gasification pressure | 30 kg/cm$^2$(G) |
| Gasification temperature | 1,500-1,800°C |
| $O_2$/Coal | 0.8-0.9 (weight ratio) |
| Produced gas volume | Approximately 91 kNm$^3$/day |
| Gas composition (design) | CO 61% |
| | $H_2$ 31% |
| | $CO_2$ 3% |
| Carbon conversion | 98% or greater |
| Cold gas efficiency | 78% or greater |