# Production of Liquefied Hydrogen Sourced by COG

## 1. Introduction

As the most effective measure to reduce the impact on the environment by motor vehicles, fuel cell vehicles (FCV) which emit neither carbon dioxide nor air pollutants are being pushed through development. Nippon Steel Corporation (NSC), which is involved in the "Japan Hydrogen & Fuel Cell Demonstration Project" under the auspices of the Ministry of Economy, Trade and Industry, constructed at its Kimitsu Works a demonstration plant for producing liquid hydrogen as a fuel for FCVs (**Photo 1**). This plant began supplying liquid hydrogen to Ariake Hydrogen Station in January 2004.

The demonstration plant was the world's first attempt to separate hydrogen from coke oven gas (COG) – a by-product of steelworks – and liquefy it. Since it was put into operation, the plant has been supplying liquid hydrogen as planned.

## 2. Characteristics of the Demonstration Plant

The plant employs the pressure swing adsorption (PSA) method to adsorb, separate and refine hydrogen, which accounts for some 55% of coke oven gas (COG). This process generates neither exhaust gas nor waste heat which would otherwise result from such chemical reactions as reformation. The residual gas after hydrogen separation is fed back to the COG or another by-product gas system and used as fuel for the steelmaking process. Thus, the COG-hydrogen production process is both an environment-friendly and energy-efficient process for producing hydrogen.

**Photo 1 Cover view of the plant**

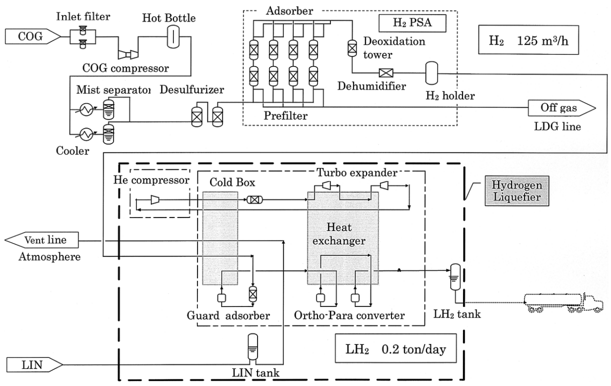


**Fig. 1 Process flow of the plant**

Table 1 Summary

| Description | | Specification |
|---|---|---|
| Feedstock | | Coke oven gas |
| Type of liquefaction system | | Helium Brayton cycle |
| Capacity | | 200kg/day*1 (aprox. 2,200Nm$^3$/day) |
| Liquid hydrogen | Temperature | 20 - 23K (aprox. –250 - –253˚C) |
| | Pressure | < 0.1MPaG (< 1kg/cm$^2$G) |
| | Purity | Hydrogen 99.999vol.%< |
| Major equipments | | • Cold box<br>• Helium compressor (screw type)<br>• Liquid hydrogen storage tank (super insulation)<br>• Liquid nitrogen storage tank (vacuum insulation) |

*1 Charge to FCV 40 - 60nos./day

The refined hydrogen (purity: higher than 99.99 vol%) obtained by the above process is first pre-cooled by liquid nitrogen and then liquefied by helium refrigerant and stored in a vacuum-insulated tank. When hydrogen is liquefied, its volume decreases to about 1/800. This means that liquid hydrogen occupies much less storage space and is easier to transport than gaseous hydrogen. In addition, liquid hydrogen is a clean fuel since impurities contained in hydrogen are thoroughly removed in the liquefaction process.

Furthermore, since the plant is installed at a steelworks, it can obtain the main utilities it requires, except for helium used as the refrigerant, from the existing steelworks infrastructure.

Nippon Steel recovers waste plastics from local municipalities and uses them as a source of cokes. Since about 40% of the waste plastics put into the coke oven are recovered in the form of COG, it may be said that the COG-hydrogen production process plays a part in the development of a resource-recycling-oriented society.

## 3. Activity to Put the Process into Practical Application

According to the "Report of the Society for the Study of Strategy for Putting Fuel Cells into Practical Use" published by the Ministry of Economy, Trade and Industry, the Ministry aims to have 5 million FCVs introduced by the year 2020. Hydrogen within COG generated at steelworks (8,000,000,000 Nm$^3$/year) has the latent capacity to supply a considerable portion of the fuel for such FCVs (6,200,000,000 Nm$^3$/year). When methane, which accounts for about 30% of COG, is processed, the latent capacity will further increase.

Through operation of its demonstration plant, Nippon Steel intends to study any technical problems involved in practical application of the COG-hydrogen production process and develop the necessary technologies and thereby contribute to the conservation of the global environment and to the development of a resource-recycling-oriented society.

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