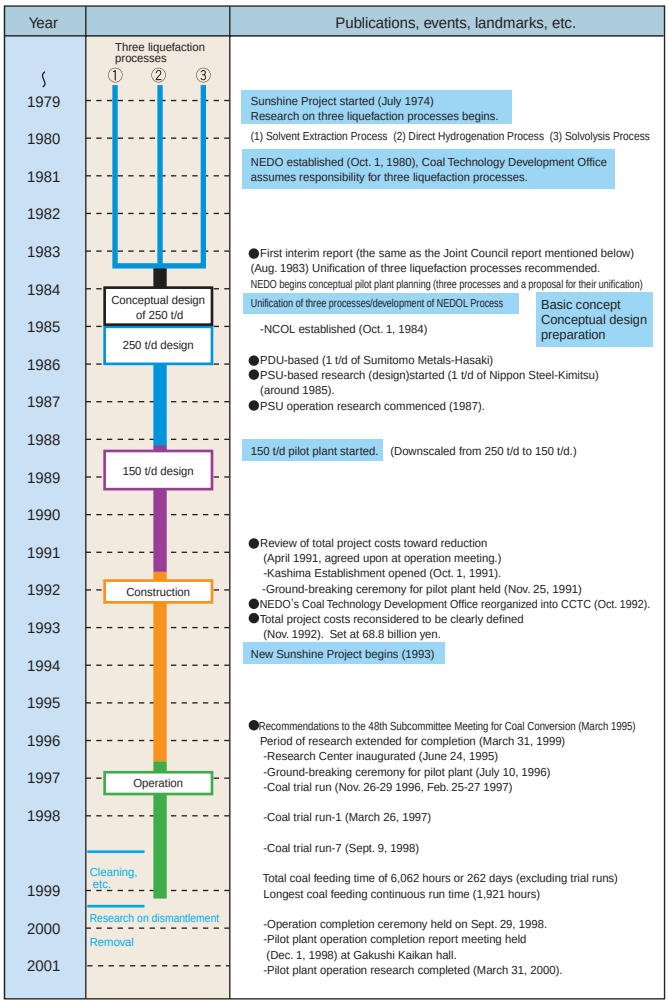
4A1. Coal Liquefaction Technology Development in Japan

Technology overview

1. Background of coal liquefaction technology development

Since the Industrial Revolution, coal has been an important source of energy. Coal consumption surpassed that of firewood and charcoal for the first time in the latter half of the nineteenth century, making coal a major source of energy. In Japan, coal also became a primary energy source in the twentieth century. In the 1960s, however, coal's preeminence gradually faded as it was replaced by easier-to-use oil. It was after the oil crises of 1973 and 1978 that coal was thought of highly once again. With the oil crises as a turning point, the development of oil-alternative energy, particularly coal utilization technology, came into the spotlight amid calls for a diversification of energy sources. During that time, the liquefaction of coal, which had been positioned as the strongest oil-alternative energy contender because of huge coal reserves, was undergoing development in many countries. Research in Germany and the United States involved pilot plants with the capacity to treat hundreds of tons of coal per day. In Japan as well, development of coal liquefaction technology was being promoted under the Sunshine Project mainly by the New Energy and Industrial Technology Development Organization (NEDO). Despite being a decade or so behind Germany and the United States, slow but steady development progress in Japan led to the successful completion of a 150 t/d-scale pilot plant for the liquefaction of bituminous coal in 1998. This drew Japan equal with Germany and the United States and also established state-of-the-art coal liquefaction technology. Coal-producing countries, such as China and Indonesia, have also expressed strong interest in the commercialization of coal liquefaction technology, with high expectations for its future development.

History of NEDOL Process



2. History of coal liquefaction technology development in Japan

2.1 Dawning of coal liquefaction technology development

Between around 1920 and 1930, the South Manchurian Railway Co., Ltd. started basic research on coal liquefaction using the Bergius Process, and around 1935 initiated operation of a bench-scale PDU (process development unit) plant. Based on this research, a plant with annual production capacity of 20,000 tons of coal oil was built at the Wushun coal mine, China, and operated until 1943. In the meantime, Korean Artificial Petroleum Co., Ltd. succeeded, between 1938 and 1943, in the continuous operation of a direct coal liquefaction plant capable of treating 100 t/d of coal at its Agochi factory. The production of coal oil at both of the above-mentioned plants was suspended at the request of the military so that the plants could be used for the hydrogenation of heavy oil or to produce methanol. Around 1930, besides the direct coal liquefaction method (Bergius Process), a second process, the Fischer-Tropsch Process, was used as an indirect coal liquefaction method to study coal liquefaction technology and to produce synthetic oil. The Fischer-Tropsch Process was introduced into Japan upon its announcement in Germany in 1935 and, in 1937, the construction of a plant commenced in Miike. This oil synthesis plant was completed in 1940, with an annual production capacity of 30,000 tons of coal oil. Under the backdrop of war, production of synthetic oil was continued until the end of World War II.

2.2 Post-war research on coal liquefaction

Immediately after the war, the U.S. Armed Forces Headquarters banned coal liquefaction research, alleging that it was military research. In 1955, coal liquefaction research was resumed at national laboratories and universities. This was not, however, research on coal oil production but the production of chemicals from the high-pressure hydrocracking of coal. This research continued until around 1975. The Sunshine Project was inaugurated in 1974 on the heels of the first oil crisis, encouraging efforts to devise liquefaction technology unique to Japan as part of an oil-alternative energy development program. Under the Sunshine Project, technological development was

undertaken for three coal liquefaction processes, (Solvolysis, Solvent Extraction, and Direct Hydrogenation), to liquefy bituminous coal. The R&D of brown coal liquefaction processes began at the end of 1980.

2.3 Amalgamation of three coal liquefaction processes

With the oil crises as an impetus, coal liquefaction technology development was incorporated for further promotion into the Sunshine Project based on Japan's international obligations and the need for a large, stable supply of liquid fuel, the diversification of energy sources and the development of oil-alternative energy. In 1983, NEDO (New Energy Development Organization, now New Energy and Industrial Technology Development Organization) assembled the R&D results thus far obtained from the three bituminous coal liquefaction processes as follows:

(1) Results of Direct Hydrogenation Process: Under certain reaction conditions, the better the catalyst function, the higher the liquid yield rate.

(2) Results of Solvent Extraction Process: Hydrogen offers liquefaction under mild conditions.

(3) Results of Solvolysis Liquefaction Process: To focus on the acquisition of light oil, it is effective to thicken the circulation solvent. These three processes were amalgamated on the strength of their features into the NEDOL Process.

2.4 Bituminous coal liquefaction technology development (NEDOL Process)

Bituminous coal liquefaction technology development is described in [4A-2].

2.5 Brown coal liquefaction technology development (BCL Process)

Brown coal liquefaction technology development is described in [4A-3].

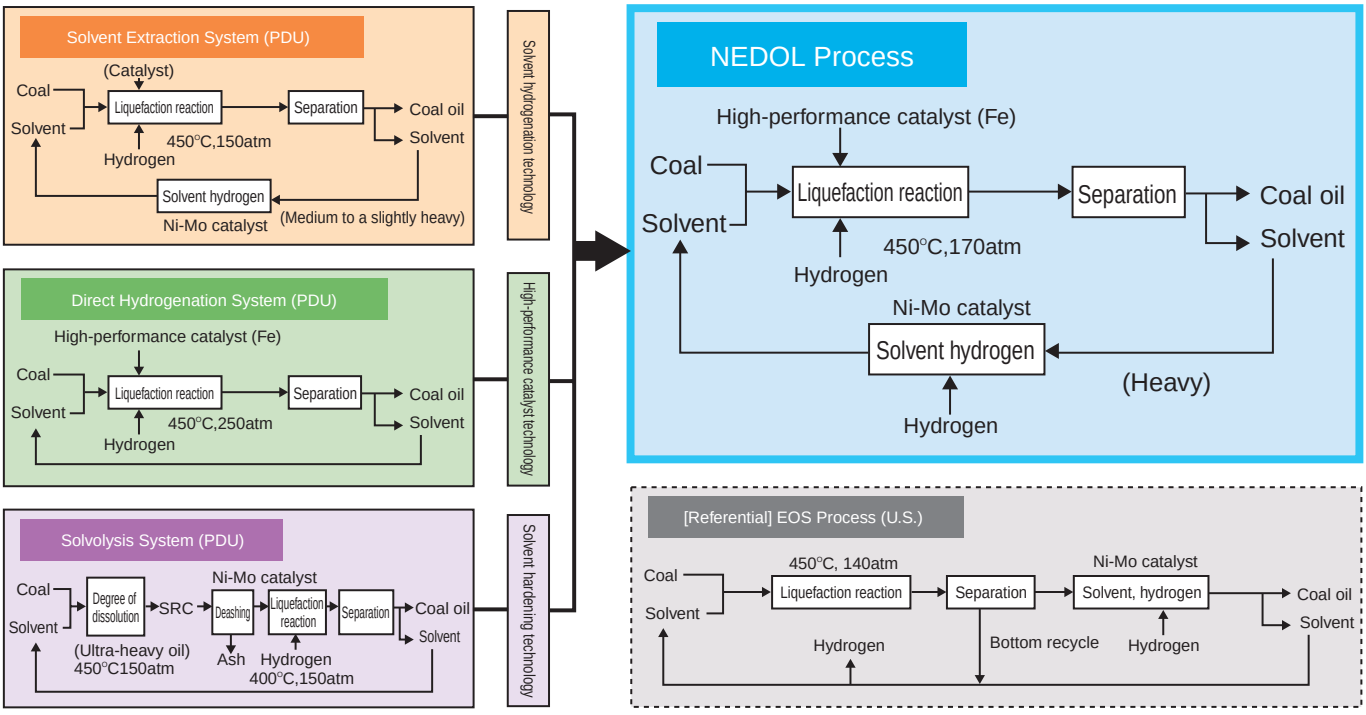


Fig. 1 Basic philosophy of NEDOL Process

References

1) Sadao Wasaka: "Bulletin of The Japan Institute of Energy," 78 (798), 1999.
2) "Development of Coal Liquefaction Technology - A Bridge for Commercialization," Nippon Coal Oil Co., Ltd.
3) Haruhiko Yoshida: "Coal Liquefaction Pilot Plant," New Energy and Industrial Technology Development Organization.