

3A1. Coal Liquefaction Technology Development in Japan

Outline of technology

1. Background of Coal Liquefaction Technology Development

Since the Industrial Revolution, coal has been used as an important source of energy by humankind. Coal consumption surpassed that of firewood and charcoal for the first time in the latter half of the nineteenth century, making coal the world's major source of energy. In Japan, coal also became the predominant energy source in the twentieth century. In the 1960s, however, the presence of coal 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 highly of once again. With the oil crises as a turning point, the development of oil-alternative energy, particularly coal utilization technology, came under the spotlight amid calls for the diversification of energy sources. During that time, liquefaction of coal, which had been positioned as the strongest oil-alternative energy contender because of its huge 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 the lag of a decade or so behind Germany and the United States, slow but steady development progress led to the successful completion of operations of a 150 t/d-scale pilot plant for the liquefaction of bituminous coal in 1998 with substantial results, thereby drawing equal with Germany and the United States as well as establishing state-of-the-art coal liquefaction technology. Coal-producing countries such as China and Indonesia are also strongly interested in the commercialization of coal liquefaction technology, with high expectations for its future development.

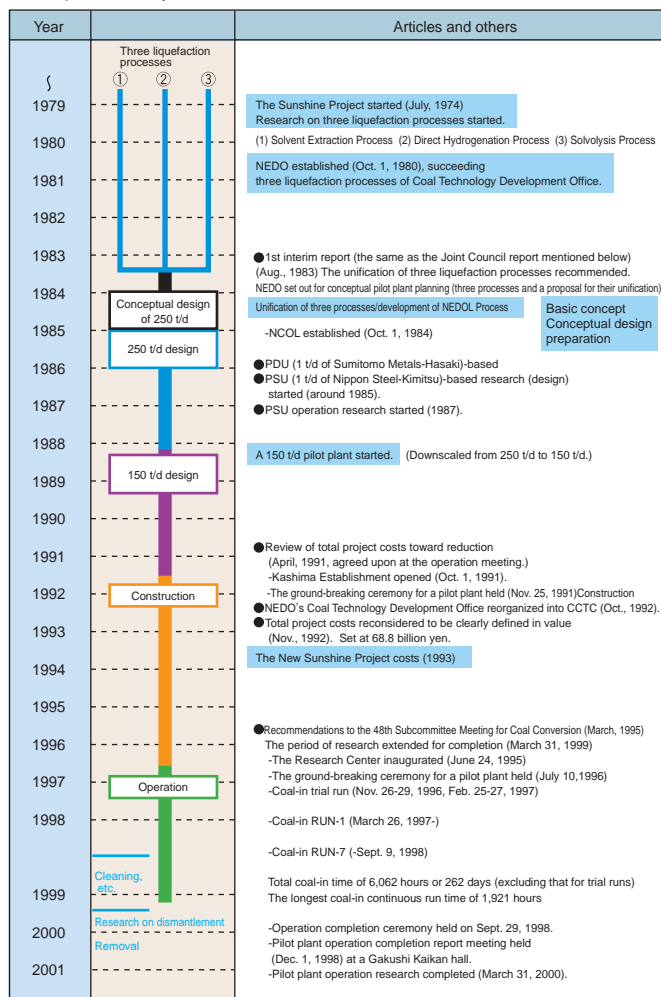
2. History of Coal Liquefaction Technology Development in Japan

2.1 Dawning of coal liquefaction technology development

Between around 1920 and 1930, 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 annually producing twenty thousand tons of coal oil was built at Wushun Coal Mine, China, and operated until 1943. In the meantime, Korean Artificial Petroleum Co., Ltd. succeeded between 1938 and 1943 at its Agochi factory in the continuous operation of a direct coal liquefaction plant capable of treating 100 t/d of coal. Production of coal oil at both of the above plants was suspended at the request of the military to use the plants for hydrogenation of heavy oil or to produce methanol.

At around 1930, besides the direct coal liquefaction method (Fischer Process), the Bergius Process was used as an indirect coal liquefaction method to study coal liquefaction technology and to produce synthetic oil. The Fischer Process was introduced into Japan upon its announcement in Germany in 1935 and, in 1937, plant construction started in Miike, winding up

Development History of NEDOL Process



in 1940 with the completion of an oil synthesis plant annually producing thirty thousand tons of coal oil.

Under the background of a wartime situation, 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 research into coal liquefaction, 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 high-pressure hydrocracking of coal, which was 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 has been undertaken for the three coal liquefaction processes of Solvolysis, Solvent Extraction, and Direct Hydrogenation to liquefy bituminous coal. R&D of brown coal

liquefaction processes has also taken place since the end of 1980.

2.3 Amalgamation of three coal liquefaction processes

With the oil crises as an impetus, the practice of 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, constant supply of liquid fuel; diversification of energy sources and development of oil-alternative energy held great significance.

In 1983, NEDO (the New Energy Development Organization, the present 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) Result from Direct Hydrogenation Process: Under any of certain reaction conditions, the better the catalyst function, the higher the liquid yield rate becomes.
- (2) Result from Solvent Extraction Process: Hydrogen offers liquefaction under mild conditions.

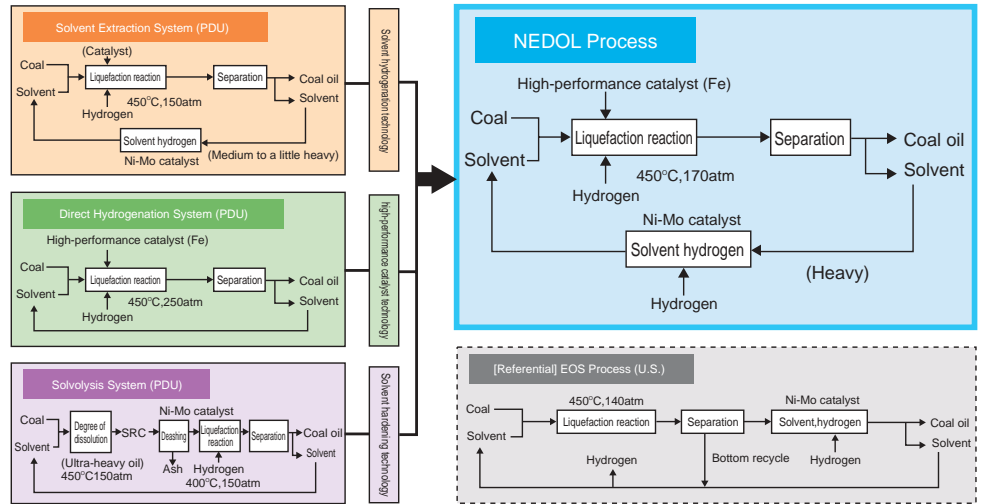


Fig. 1 Basic Philosophy of NEDOL Process

(3) Result from Solvolytic Liquefaction Process: For priority 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 [3A-2].

2.5 Brown coal liquefaction technology development (BCL Process)

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

3. Coal Liquefaction in the Future

China, expecting stringency in its oil supply-demand situation for sometime in the future, takes an active stance toward the development/adoption of coal liquefaction technology. NEDO, as part of its international cooperation program, installed 0.1 t/d liquefaction equipment in China in 1982 for subsequent utilization such as in liquefaction tests of Chinese coal, exploration of catalysts for liquefaction, and human capacity building. Since 1997, at the request of China, cooperation has been offered for the implementation of feasibility studies on the location of a coal liquefaction plant using Yilan coal of Heilongjiang Province. Furthermore, a survey entrusted by China estimates Shenhua coal reserves in Shenxi Province/Inner Mongolia Autonomous Region at as much as 200 billion tons, justifying high expectations for coal as an inexpensive source of energy.

It is further considered certain that Indonesia will become a net oil-importing country in the near future. In 1992, the Indonesian government requested cooperation in coal liquefaction research on Indonesian brown coal. In response, NEDO signed in 1994 a memorandum on cooperative coal liquefaction research with the Agency for the Assessment and Application of Technology of Indonesia (BPPT) and began a new round of brown coal liquefaction technology development that aimed at the realization of commercial plants for Indonesian brown coal.

Coal liquefaction technology development that has continued since the Sunshine Project was inaugurated in 1974 has now seen plant

operation concluded in a shift from the research stage to the commercialization stage. It seems that commercialization will be enhanced particularly through international cooperation with coal-producing countries such as China and Indonesia. In China, not only Japan but also the United States and Germany have embarked on feasibility studies of location with commercialization in mind.

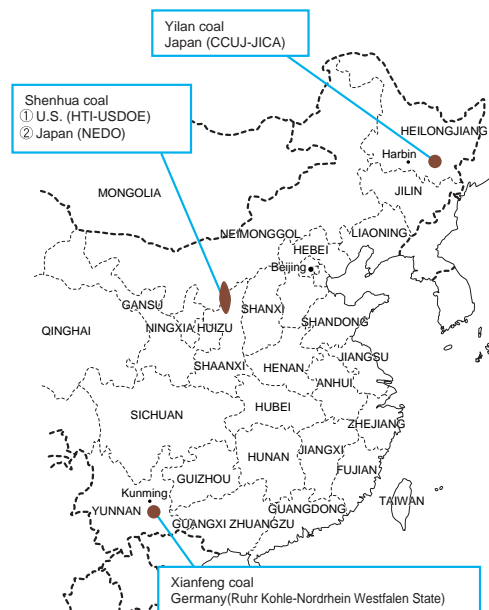


Fig. 2 Review of Coal Liquefaction for Commercialization in China

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