4B2. Efficient Co-production with Coal Flash Partial Hydropyrolysis Technology (ECOPRO)

Research and development: Japan Coal Energy Center; New Energy and Industrial Technology Development Organization; National Institute of Advanced Industrial Science and Technology; Nippon Steel Engineering Co.,Ltd.; Babcock Hitachi K.K.; Mitsubishi Chemical Corporation
Project type: Subsidized coal production/utilization technology promotion project
Period: 1. Coal utilization next-generation technology development survey, 1996-1999 (4 years)
2. Coal utilization commercialization technology development, 2003-2008 (6 years)

Technology overview

1. Technological objective

Clean coal technology-related development solely focused on a single industry in pursuit of a single product is reaching its limits in terms of efficiency and economy. This is necessitating the development of innovative technologies that could completely revolutionize energy and material production.

Efficient Co-production with Coal Flash Partial Hydropyrolysis Technology (ECOPRO) is a technology that causes pulverized coal to react rapidly under high pressure (2-3MPa) and in a moderate hydrogen atmosphere to highly efficiently obtain, from one reactor, synthetic gas that can easily be converted for use such as in integrated gasification combined-cycle (IGCC) power generation, indirect liquefaction (GTL), and chemicals, while co-producing light oil for utilization as a feedstock for chemicals and fuel.

The realization of a coal-based cross-industrial composite project, led by the electric power, chemical, and steel industries, with this technology as its core will hopefully bring a dramatic improvement to total energy utilization efficiency.

2. Technology overview

Figure 1 shows the total process flow of this technology. At the partial oxidation section of a coal flash partial hydropyrolsyis reactor, pulverized coal and recycled char are gasified with oxygen and steam at a pressure of 2-3MPa and at a temperature of 1,500- 1,600°C to give hot gas mainly composed of CO and H_2. At the reforming section directly connected through a throat to the partial oxidation section, pulverized coal is injected together with recycled H_2 into the hot gas stream from the partial oxidation section to complete the reforming reaction (partial hydropyrolysis) instantly under the condition of 2-3MPa in pressure, 700-900°C in temperature, and approximately 30-50% in hydrogen concentration (H_2 in hot gas and recycle H_2 combined). At that time, hot gas from the partial oxidation section also functions as a source of the reaction heat required at the reforming section. At the reforming section, a hydrogenation reaction adds H2 to primary pyrolysis, such as tar released from pulverized coal, changing heavy tar-like matter to light oil. The gas, light oil, and char produced at the partial hydropyrolysis reactor follow a process where, after char separation at the cyclone and subsequent sensible heat recovery, synthetic gas (syngas) should be formed by way of oil recovery, desulfurization, and other gas purification processes. A portion of the syngas is

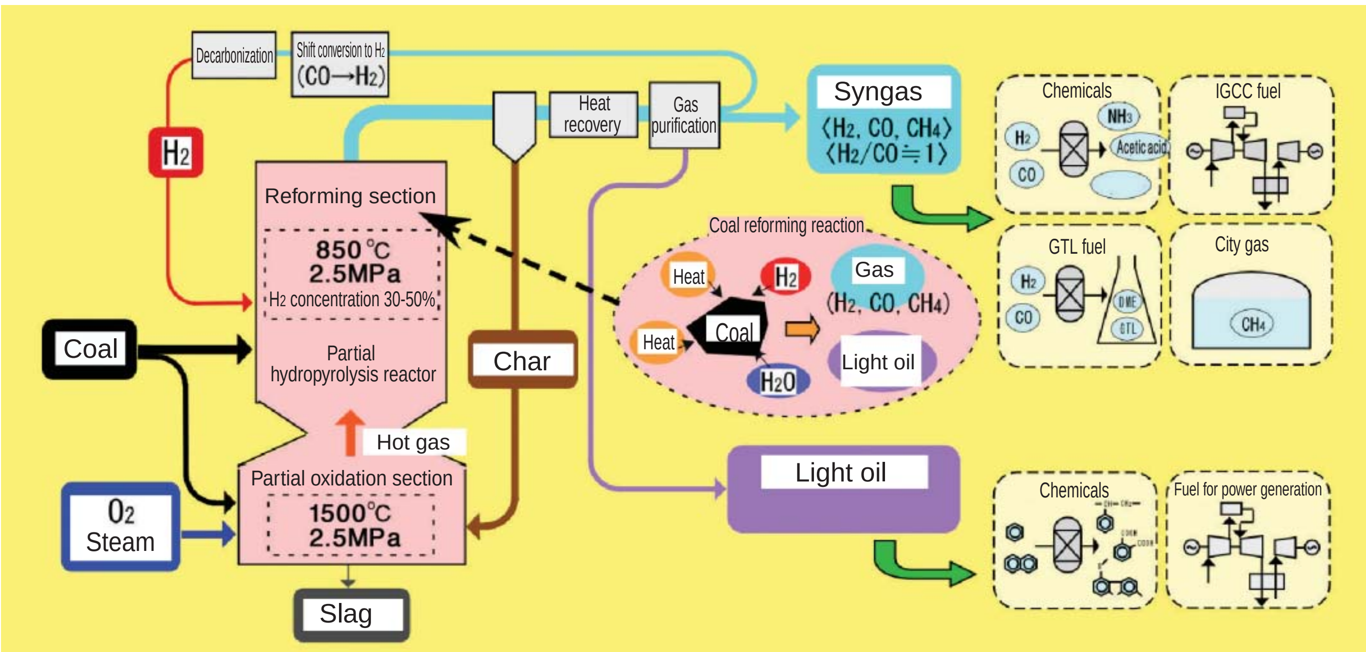


Fig. 1 Process flow chart

converted into H_2-rich gas, in the course of a shift reaction and decarbonization (CO_2 recovery). After pre-heated via a heat exchange, the gas is recycled to the partial hydropyrolysis reactor's reforming section. The final syngas product is characterized by its main composition of H_2, CO, and CH_4 as well as hydrogen-rich contents of $H_2/CO \fallingdotseq 1$ and is used as a source gas for IGCC, GTL, and chemicals. Light oil is mainly composed of aromatic compounds with 1-2 rings such as benzene and naphthalene, which have applications for chemical manufacturing or fuel for power generation.

The features of this technology include:
1. High-efficiency: The sensible heat of hot gas generated at the partial oxidation section is effectively used as a source of heat required at the reforming section, providing high energy conversion efficiency.
2. Flexible productivity: The reforming section temperature, as well as the amount of hydrogen injected, can be controlled, allowing the freedom to change the gas/oil composition and output ratio, thereby flexibly responding to consumers' needs.
3. Economy: The cost of producing syngas can be partially offset by the value of the of co-produced high-value-added oil.

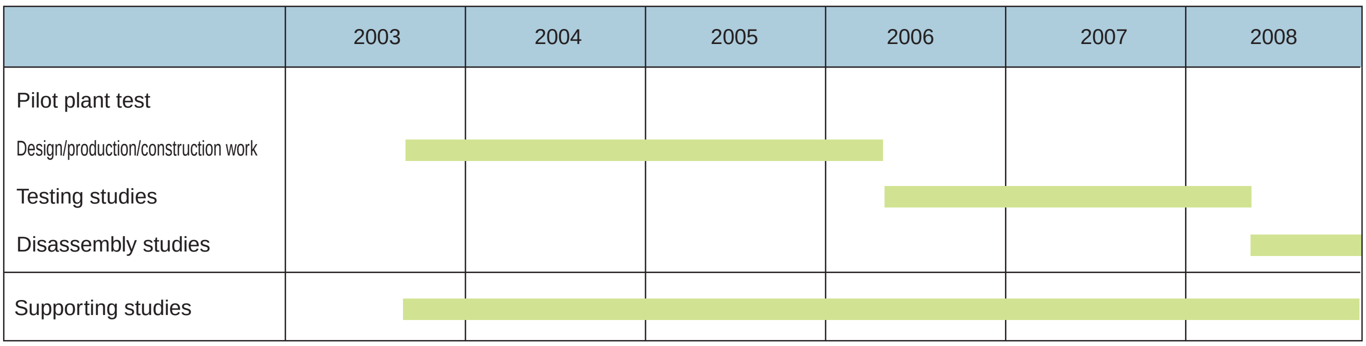
3. Progress and development results

1) Basic partial hydropyrolysis test (1996-1999, 1kg/day)
Using a small-scale test unit, the pyrolysis behavior of coal under the target conditions of this technology was reviewed, confirming that the hydropyrolysis of the primary tar released from the flash heating/pyrolysis reaction of coal was successful.
2) Process development unit (PDU) test (2000-2003, 1t/day Nippon Steel Engineering Co., Ltd. in-house research)
Using a reforming/partial oxidation-integrated PDU test unit, the basic performance of a partial hydropyrolysis reactor as the core of this technology was evaluated, clarifying the reaction in the reactor.
3) Pilot plant test (2003-2008, 20t/day)
Tests are being conducted using a pilot plant with a thermally self-supportable reactor combined with other ancillary process units to enable forecasts for a future demonstration unit (up to 1,000t/day).

Table 1 Development subjects for pilot plant tests

Technology to be developed	R&D topics
Verification of the reaction in the partial hydropyrolysis reactor/ establishment of reactor control technology	- Quantification of partial hydropyrolysis reactor reaction - Establishment of reactor conditions for optimum transition zone formation - Establishment of high-efficiency gasification (partial oxidation section) operational conditions
Development of process/factor technologies	- Establishment of technology to separate/recover char from gas - Establishment of technology to recover heat from gas co-existent with oil
Total system evaluation, etc.	- Establishment of extended continuous operation technology - Establishment of scale-up approach for demonstration unit design

Table 2 Development timetable



References
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2) H. Yabe et al., 2nd Japan-Australia Coal Research Workshop Proceedings, p. 257, 2002.