# ● Research and Development on Coal Pyrolysis

## 1. Purpose

Coal is generally used as an energy source by direct combustion, and also its gasification and liquefaction, etc. are under technology development with regard to its energy conversion. Fundamentally, these are all targeted to extract a single component from the coal. However, in the use of coal, it is necessary for us to establish a comprehensive coal utilization system in avoiding sticking to either using it only for an energy source or limitedly for chemical stuff materials.

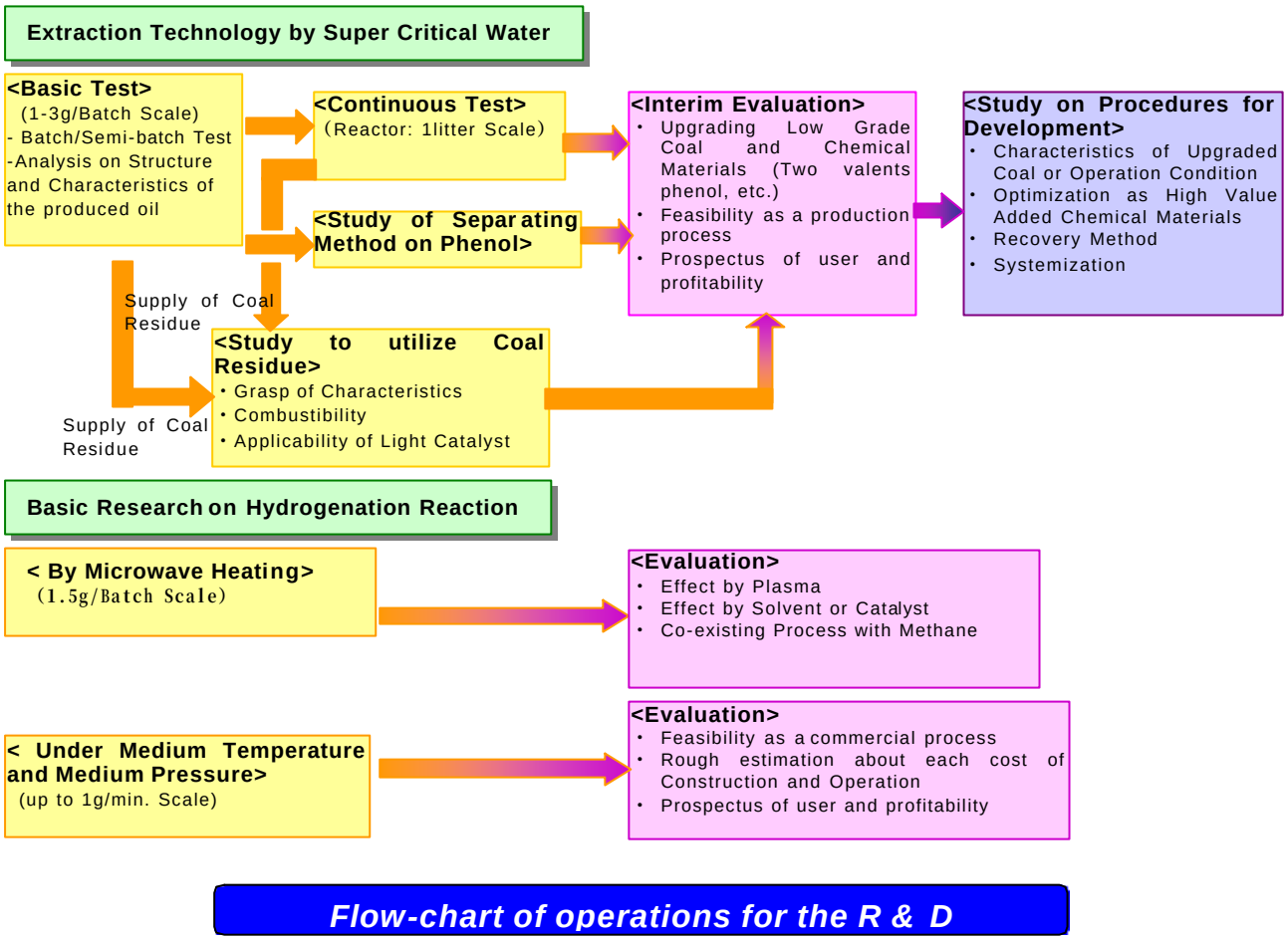
From this viewpoint, the R & D intends to develop, as of its purpose, a high liquid extracting coal pyrolysis technology in covering Chemical, Gas, Steel and other industries. It aims at a most optimum utilization of the products with higher energy conversion efficiency, and also at a massive production of light oil products with advantageous economic efficiency.

In order to aim at the expected higher liquid extraction efficiency, it was presumed that stabilization of the thermo-analytical fragment radicals during their thermo-analytical process and its related restriction of their re-polymerization, furthermore, controlling of their succeeding secondary thermal analysis, etc. would become necessary. To cope with these issues, we thought it necessary for us to develop a unique technique, by which we could run the chemical reaction of the radicals in comparatively lower temperature to let them become stabilized by the activating hydrogen, and also to enable the liquid extraction by some solvent. As for the countermeasures to materialize the said purposes, the following category of technologies was selected for the R & D:

**① Extraction technology by Super-Critical Water**

**② Thermal Decomposition Technology by Microwave Heating**
**(Coal and Methane Combined Conversion method)**

**③ Medium temperature and pressure Hydrogenation Thermal Decomposition Technology**
**(Thermal analysis at rather gradual pressure and temperature in comparison with conventional gasification process by hydrogenation, in other words, Partial hydrogenation thermal analysis)**




***Flow-chart of operations for the R & D***

## 2. Schedule of Development

| | FY1996 | FY1997 | FY1998 | FY1999 | FY2000 | FY2001 |
|---|---|---|---|---|---|---|
| **Survey and Study** | Study of Applicability | | Data Collection & Selection | | Evaluation of the Process | |
| | *- Engineering , Construction and Operation of the Testing facility for Super Critical Water Extracting Technology* | | | | | |
| | *- Basic Study of Thermal Decomposition Technology using Microwave or Heating (including pretreatments for coal)* | | | | | |
| **Tests at Laboratory** | | | | | | |
| **(1) Coal Conversion Reaction by Super Critical Water (SCW)** | *Labo. tests on coal conversion reaction by SCW* | | | | | |
| | *Tests on separation of phenol and characterization of the products* | | | | | |
| | *Utilization of chars for light catalysts* | | | | | |
| | | | | *Separation test of valuables from products of the process* | | |
| **(2) Basic Research of Hydrogenation Reaction** | *Tests on Thermal Decomposition by Microwave Heating or under Medium Temp. & Pressure* | | | | | |
| | | | | *Evaluatiuons of the both methods* | | |
| | | | | | *Tests using 100t/d facility* | |
| **(3) Structural analysis of coal derived oil by Super Critical Water** | *Joint R&D with AIST (National Institute of Advanced Industrial Science & Technology* | | | | | |

## 3. Targets of the R & D

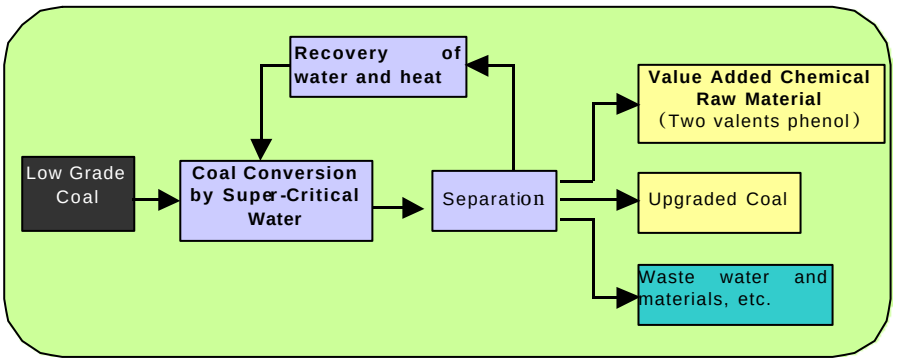
| R&D items | Targets |
|---|---|
| **I. R & D on main technical elements**<br>**(1) Coal Conversion Reaction by Super Critical Water (SCW)** | |
| a) Collection of basic data using small scale testing facility | - Liquid Extraction Ratio: 50% or more<br>- Light Oil (*) Production Ratio: 60% or more<br>(*) for High Value Added Chemical Materials (BTX, Phenol, Naphthalene, etc.)<br>- Supply of Activated Hydrogen utilizing the Liquefication Shift Reaction by partial oxidation of char (H/C=1.0 -->1.7) |
| b) Characterization of the products<br>- Cleansing ability by light catalyst<br>- Combustibility<br>- Structure of surface | - $CO_2$ Conversion Ratio: 20% or more (8 hours lighting)<br>Clarification of differences from the char made by conventional Thermal Decomposition method |
| **(2) Basic Research of Hydrogenation Reaction** | |
| a) Thermal Decomposition by Microwave Heating | - To keep Liquid Extraction Ratio 50% or more, the kind of Hydrogen (H2) and condition of its generation are to be specified. |
| b) Thermal Decomposition under Medium Temperature & Medium Pressure | - Establishment of the high efficiency process to keep Light Oil Production Ratio 30% or more and to guarantee High Calorie Gas. |
| **II. Survey and Study**<br>**(1) Study on basic engineering and cost estimation** | - Basic engineering of a reactor at 1m3 (several tons/day) scale<br>- Cost estimation of operation of the reactor (by SCW) |
| **(2) Study on commercialization in the future** | - Conceptual design of the reactor at commercialized scale |

## 4. Results of Research

### (1) Super Critical Water (SCW) Extracting Technology

① It has been found that as a characteristics of the SCW based coal extraction technology, both a high value adding chemical raw stuff of multi-valents phenol (in particular, two valents phenol) and an up-graded low calorie coal with less coal ash content have been found recoverable.

② In addition, the illustrated (at right hand) process has been considered in which some high value added chemical stuff materials could be by-produced during the manufacturing of the up-graded coal. SCW processing is rather fit for the low rank coal, and it needs no preliminary treatment such as drying of the coal.



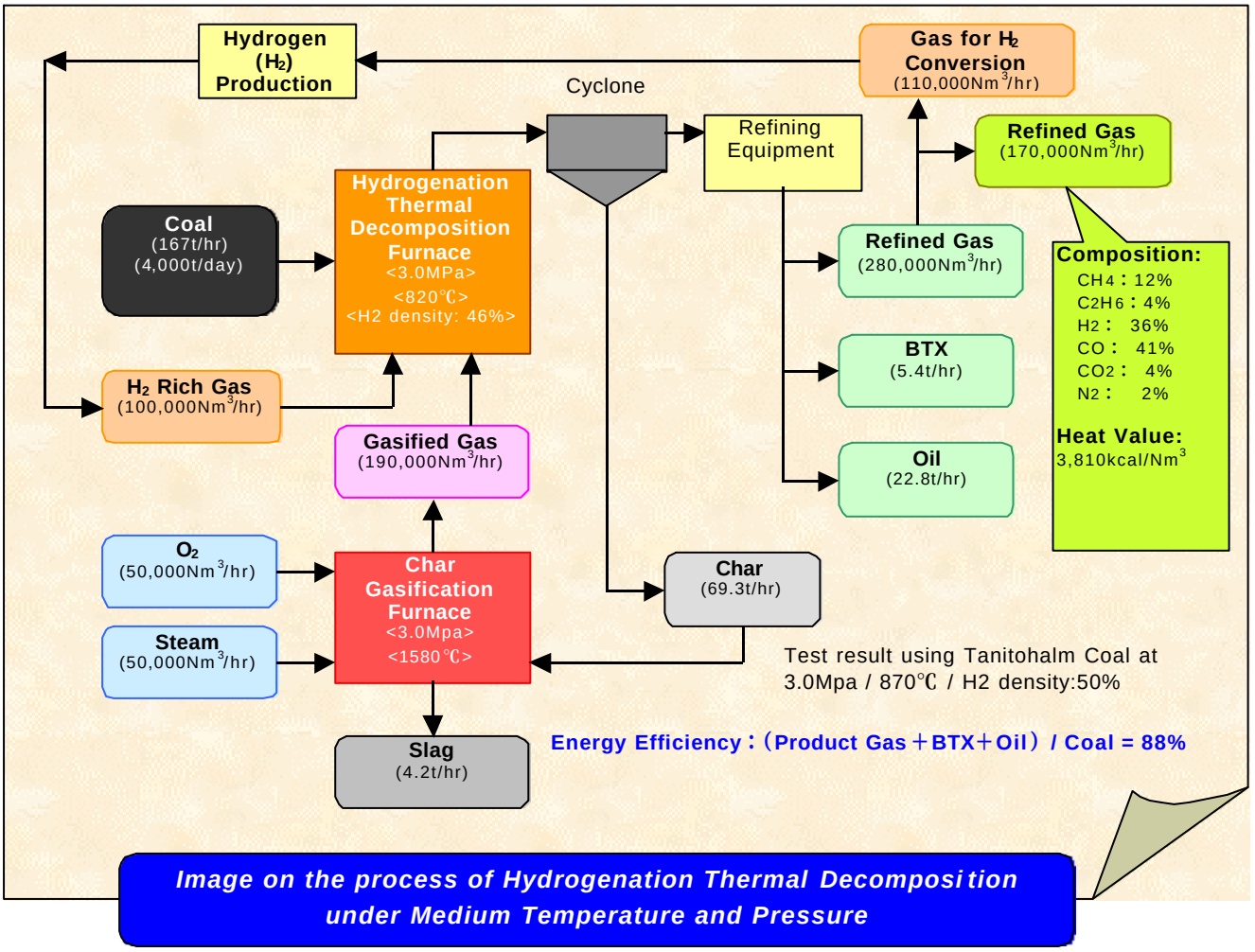
### (2) Thermo-Decomposition Technology by Thermo-Microwave Heating Method

The Microwave in the thermal decomposition has been found playing a role as a heat-conveying medium. Then, we have proposed a thermally decomposing process under methane gas atmosphere after considering both related experiments and the process itself.

### (3) Hydrogenation Thermal Decomposition Technology under Medium Temperature and Pressure

① Based on the testing results, a drafted image of the process has been proposed after reviewing total mass balance of the process and its related heat balance. The process has a potential in the use of 4,000t/day of coal to give a production of Gas of 4 million $Nm^3$/day (3,810kcal/$Nm^3$), BTX: 130t/day, Oil : 550t/day, in addition, it has given us a possibility that we would be able to establish a high energy efficiency (88%) method of coal energy conversion process.

② Regarding its products, by this process we can simultaneously produce both gas and liquid, and it will enable us to run a flexible operation of the process. For instance, in case of power generation, there is a possibility for us to introduce the technology to a new coal conversion processing facility, which will allow us to cope with a daily variation of electric power supply easily, during night and day, in sharply following the power demand.



## 5. Guideline for Tomorrow

As for the development requiring subjects, there could be such as follows:

① **Reviewing to find better upgraded Coal Characteristics and the most optimum Operation Condition of the Process**

② **Selection of the most Optimum high value adding Chemical stuff Manufacturing Method and Improvement of Recovering Method of each Product**

③ **Systematization Survey (Reviewing of both Outlines of the Complex System and its Economical Efficiency)**

In addition, some other issues are to be solved for commercialization of the process, which are as follows:

① **Technology development of Optimum manufacturing method of Upgraded Coal**

② **Optimization of Recovery rate, etc. regarding Low Grade Coal Upgrading technology for supplying Chemical raw stuff**

③ **Construction of Rational Processing Systems (Optimization from viewpoints of Energy and Costs, etc.)**