Production of Alternative Fuel Using Biomass Gasification Technology

RYUTARO MORI*1 YOSHINORI OKI*1
KEIJI TAKENO*2 KEIGO MATSUMOTO*3
YOSHINORI KOBAYASHI*4 HIROMI ISHII*4

Recently, energy security has become an important issue worldwide due to surging oil prices. There are signs of intense competition for energy resources, such as the rise in resource nationalism and the efforts of many nations to secure their interests in foreign countries. Under such circumstances, the relative decline in Japan's buying power against developing countries like China and India together with a rapidly increasing energy demand seems unavoidable in the future. Therefore, improving the energy self-sufficiency ratio and securing highly convenient liquid fuel for transportation will become important issues in Japan. Liquid fuel production technology that uses biomass gasification as its key process, integrating several technologies that have been developed by Mitsubishi Heavy Industries (MHI), constitutes one solution to these challenges.

1. Reducing the oil dependency ratio and improving the energy self-sufficiency ratio

Japan imports 96% of its primary energy needs. In FY2005, this amounted to almost 16 trillion Japanese yen paid to foreign countries. Furthermore, the dependency of primary energy on oil amounts to 50%. Hence, the current rise in oil prices is having a large impact, not only on people's lives, but also on the industrial competitiveness of Japan. Under these circumstances, for the continued development of Japan, it is necessary to further reduce its dependence on oil, and to increase the non-oil ratio of primary energy. However, considering the intense competition for natural gas, coal, and even uranium resources worldwide, it is necessary to improve the self-sufficiency ratio of energy by utilizing renewable energy and to realize a nuclear fuel cycle.

2. Oxygen-blown gasification and fuel synthesis of biomass

2.1 The importance of utilizing biomass

In the transportation sector, which accounts for about 40% of the total oil consumption in Japan, liquid fuel, because of its high energy density and portability, will remain the main fuel in use until the full-scale introduction of electric vehicles or fuel cell vehicles. Simultaneously, biomass is the only renewable energy resource that can be utilized as a carbon source for liquid fuel production. Therefore, the technology to synthesize liquid fuel from biomass will play a significant role in improving the energy self-sufficiency of Japan.

In addition, Japan's target under the Kyoto Protocol is a 6% reduction in CO_2 emissions from 1990 levels by 2012. As much as two-thirds of this, or 3.9%, is expected to come from forest absorption. However, this is possible only for forests that are properly maintained. To attain this target effectively, forest administration is necessary, such as expanding the use of wood material and the use of thinned wood.

2.2 MHI's biomass gasification and liquid fuel synthesis technology

Mitsubishi Heavy Industries' biomass gasifier makes use of an entrained-bed gasification system that features less tar yield and high slagging resistance. It is also capable of controlling the composition of gasification gas through biomass gasification with steam and oxygen in order to produce gas suitable for methanol synthesis. In a project sponsored by the New Energy and Industrial Technology Development Organization (NEDO) in partnership with Chubu Electric Power and the National Institute of Advanced Industrial Science and Technology (AIST), MHI has verified gasification and methanol synthesis using woody biomass (Japanese cedar, broad leaf trees, bark, wood, driftwood, scrap building wood) as feedstock in a test plant (refer to **Fig. 1** and **Table 1**). In the demonstration plant, which can process two tons of biomass per day, we have succeeded in building an integrated operation from biomass preparation to methanol synthesis using woody biomass and a thermally self-sustained gasifier. The methanol weight yield also reached the target level of 20%, and has the potential to reach a maximum of 50% in a commercial plant through improvements in thermal loss. As development of a pre-drying processing device, a project sponsored by the Ministry of Agriculture, Forestry and Fisheries, and development of a by-product recycle system, a project sponsored by NEDO, have been completed, MHI is currently developing the technology to synthesize alternative light oil fuel by combining Fischer-Tropsch (FT) synthesis together with the National Institute of Advanced Industrial Science and Technology.

Other than gasification, ethanol fermentation is another method for synthesizing liquid fuel using biomass material. However, in view of the diversity of feedstock, the processing time, and the equipment size, gasification has a high potential

*1 Technology Planning Department, Technical Headquarters
*2 Takasago Research & Development Center, Technical Headquarters
*3 Nagasaki Research & Development Center, Technical Headquarters
*4 Power Systems Headquarters

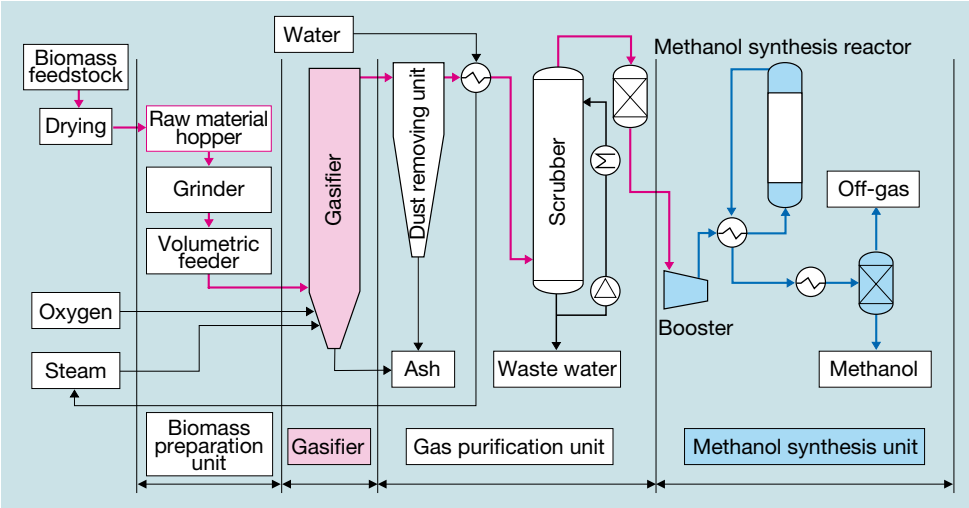

Fig. 1 Schematic diagram of the bio-methanol manufacturing system

Table 1 Target values and results obtained for cold gas efficiency and methanol yield of test plant and planned values for commercial plant.

Item	2 tons/day test plant (target)	2 tons/day test plant (results)	Commercial plant (planned)
Biomass processing capacity	2 tons/day	2 tons/day	50 – 100 tons/day
Cold gas efficiency*1	65% or above	60 – 67%	75% or above
Methanol yield (weight)*2	20% or above	18 – 21%	50% at a maximum

*1 Calculated based on a feedstock biomass heat value of 100 %
*2 Calculated based on a feedstock biomass weight value of 100 %

to replace ethanol fermentation. Furthermore, with regard to the type of biomass used, as the competition between fuel, human food, and animal feedstuff becomes more intense, it is likely that future biomass will be derived mainly from cellulose material from non-food substances. Hence, as this gasification system can also make use of cellulose material, its demand is expected to grow worldwide.

3. Proposing a system to reduce dependence on oil

Figure 2 shows the liquid fuel production process that adopts liquid fuel production technology using biomass as the feedstock. It also uses electricity from renewable energy or nuclear power and oxygen and hydrogen produced in water electrolysis. This technology can contribute to a large reduction in CO_2 emissions.

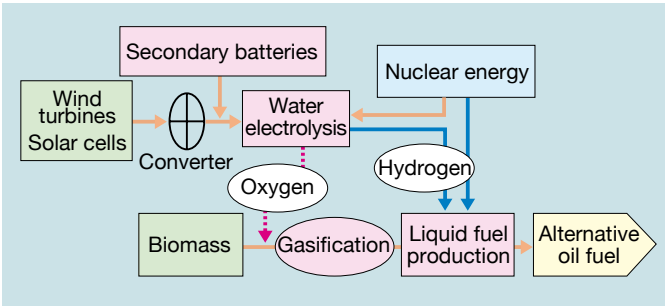

Fig. 2 Liquid fuel production chain

In addition to methanol synthesis with biomass gasification, MHI is also engaged in manufacturing wind turbines, solar cells, nuclear power generators, and the EPC (engineering, procurement and construction) of various types of chemical plants. Lithium ion secondary batteries and solid polymer water electrolysis are being developed. MHI will integrate these technologies to provide a single system to reduce dependence on oil.

4. The properties and applications of DME

A candidate product in the liquid fuel chain that can be produced by the above system is dimethyl ether (DME). It is obtained by methanol dehydration and can also be produced from various hydrocarbons. Therefore, it is a multi-source, multi-purpose fuel that can be used in various devices, such as gas turbines, boilers, diesel engines, and household burners. Further, because it does not produce ash dust or sulphur oxides during combustion, DME is environmentally friendly and is expected to be an efficient, clean fuel for automobiles when used with diesel engines, which are more efficient than gasoline engines.

Mitsubishi Heavy Industries has been promoting the development of technologies that use DME fuel, especially in equipment that consumes energy. In 2001, MHI established a company jointly with Mitsubishi Gas Chemical, Itochu Corporation, and JGC Corporation (Japan DME) to conduct feasibility studies in this area. MHI is also investing in Fuel DME Production, where the production of DME is targeted to begin in 2008. This plant will have an annual production capacity of 80,000 tons, and it is currently under construction at the Niigata site of Mitsubishi Gas Chemical Company. Through these activities, we are working toward the widespread adoption of DME in Japan.

5. Conclusions

This report has introduced MHI's efforts to develop liquid fuel production technology using biomass domestically. This is because using liquid fuel obtained from carbon-neutral biomass makes a big contribution to energy security and environmental protection. However, the practical use of biomass energy in Japan faces a big obstacle in the high collection cost of biomass. We believe that, instead of merely looking at the heat value of energy, evaluating the cost of energy based on the concept of the 3Es (Energy security, Environmental protection, and sustainable Economic growth) will become essential for the future sustainable development of Japan. In this model, money spent on importing fossil fuels from overseas will be weighed against the benefits of reallocating it domestically, such as by enhancing domestic agriculture, forestry and fisheries and revitalizing local communities. Therefore, along with technological development, we would like to contribute to the sustainable development of Japan by promoting this concept to the government and other involved parties.

Reference

1. Nakatani, H. et al., Development of Integrated System of Bio-Methanol Synthesis by Biomass Gasification, Mitsubishi Juko Giho Vol.42 No.3 (2005) p.130


Ryutaro Mori


Yoshinori Oki


Keiji Takeno


Keigo Matsumoto


Yoshinori Kobayashi


Hiromi Ishii