Development of Highly Efficient Methanol Synthesis Process with New Catalysts

1. Introduction

In the world, some 30 million tons of methanol are produced annually. The consumption of methanol as a raw material for formaldehyde, acetic acid and other basic chemicals has been growing at a rate of about 2% a year. In recent years, since methanol is also attracting growing attention as a fuel for fuel cells, and an intermediate raw material of hydrogen and dimethyl ether (DME) which are clean energy sources, it is expected that the demand for methanol will continue increasing in the future (see **Fig. 1**).

Many methanol production bases are situated overseas in natural gas fields, from where methanol is transported to consumers, including Japan. Recently, more and more large-scale methanol production plants are being constructed. In China, where the demand for methanol has been growing markedly, methanol plants are being constructed one after another near the sites of consumption.

2. Problems in Methanol Production

Methanol is made from the synthesis gas ($CO + H_2$) which is obtained from natural gas, etc. {reaction formula: $CO + 2H_2 = CH_3OH$ –90.97 kJ/mol (exothermic reaction)}. Thermodynamically, the lower the temperature is and the higher the pressure is, the more favorable the conditions are for the reaction. In the conventional methanol production process, which employs the gas phase method from the standpoint of catalyst activity and plant cost, the prevalent reaction conditions are 5 to 10 MPaG in terms of pressure and 200℃ to 300℃ for temperature (see Table 1). The problems involved in the conventional production process are: getting the uniform temperature distribution, stabilizing the heat extraction and improving the catalytic activity (lowering the reaction temperature).

In particular, in the process, it is necessary to efficiently remove the reaction heat. Therefore, a heat exchanger type or gas-quenched type reactor is used. However, the low conversion of reactants per pass through the catalytic layer makes it difficult to use a large-scale reactor. Furthermore the development of the liquid phase method, which is advantageous in terms of reaction heat removal, has been reported. This method, however, suffers from a catalyst deactivation caused by the CO_2 and H_2O contained in the raw material gas.

3. Characteristics of the New Process

In order to meet the need for reduced production costs through the use of a larger, more efficient reactor, Nippon Steel Corporation has conducted research and development to lower the reaction temperature and secure sufficient resistance (against CO_2 and H_2O) through improvement of the catalytic properties and to allow for stable, efficient control of the reaction heat transfer through adoption of the liquid phase method. At present, the company's research institute and certain universities are jointly evaluating the basic performances of various catalysts and processes. They have already obtained the following results (see **Fig. 2**).

(1) Catalyst: A new cupper-based solid catalyst (added with promoter) has been developed by using the co-precipitation process.
(2) Reaction temperature: The catalyst has shown sufficient activity in the temperature range 150℃ to 200℃.
(3) With supplying CO_2 and H_2O continuously with raw material gases during reaction, it has been confirmed that the catalyst activity is stable. Thus, a catalyst offering sufficient resistance to CO_2 and H_2O has been created.

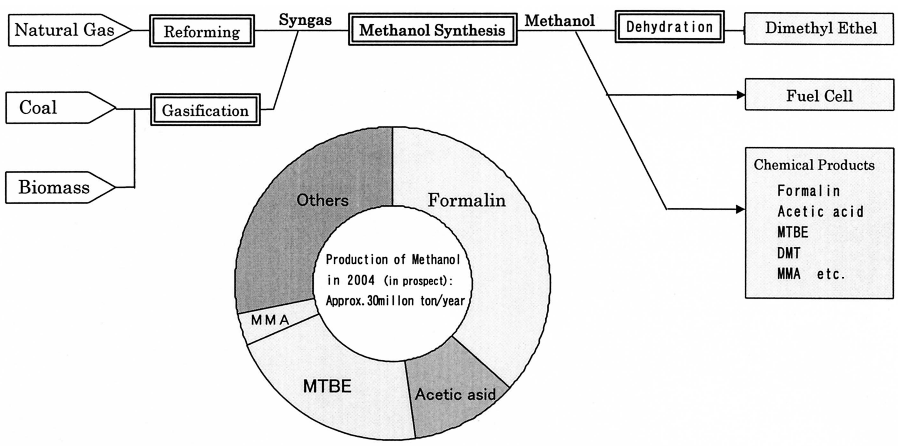
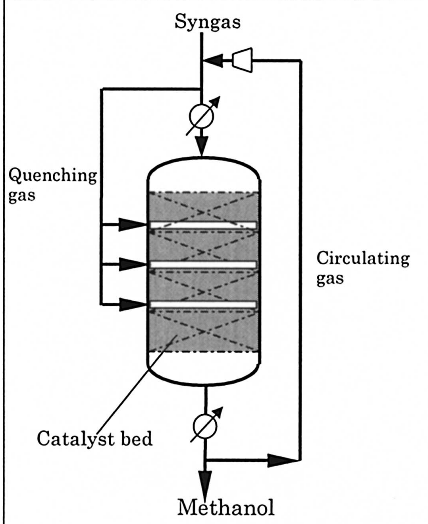
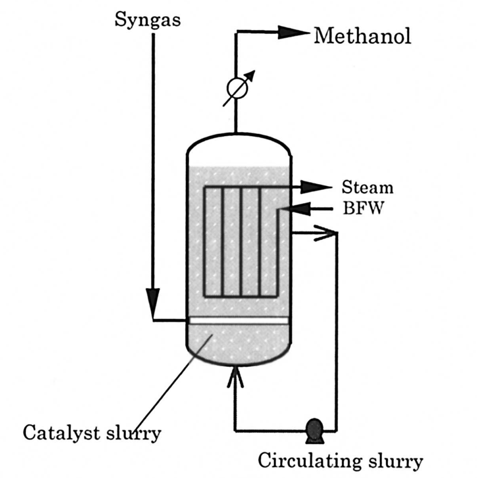


Fig. 1 Feedstock and use for methanol

Table 1 Features of methanol synthesis process

	Existent Process *1	NSC-developed Process
System	Gas phase method (Fixed bed)	Liquid phase method (Slurry Reactor)
Catalyst	Cu/ZnO cat.	Cu cat.
Condition	5 - 10MPaG 200 - 300℃	5 - 10MPaG 150 - 200℃
Flow sheet of reactor		
Feature	High conversion with gas circulation system Large thermal distribution in catalyst bed Limit of scaling up: Approx. 2500ton/day Fixed bed reactor: Rich experience for commercial plant Catalyst exchange: During plant stop	High conversion with active new catalyst (No-circulation system) Uniform thermal distribution in catalyst slurry Easy scaling up with Uniform thermal distribution Slurry reactor : Few experience for commercial plant Catalyst exchange: During plant operation CO_2 and H_2O proof catalyst

*1 : ICI Methanol process (The Japan Petroleum Inst.: Process Handbook)

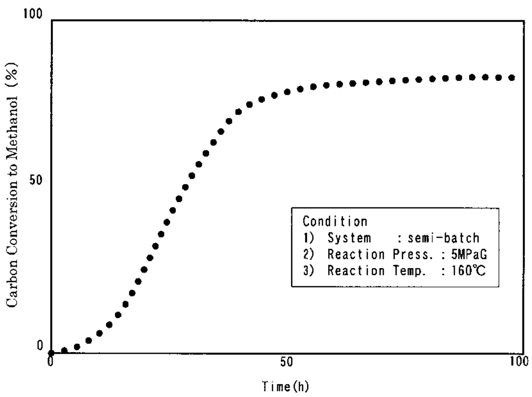


Fig. 2 Result of methanol synthesis test

4. Commercialization of the New Technology

When this new technology is applied to commercial methanol plants, it is expected that the following effects will be obtained. Therefore, the NSC has plans to verify the advantages of the new process and commercialize the process in the near future.

(1) The liquid phase method with higher conversion of reactants per pass through the catalyst layer permits (a) employing a smaller reactor (single train of large-scale plant) and (b) reducing the circulation line, hence cutting the initial investment cost.

(2) The lower reaction temperature helps improve the thermal efficiency and prolong the catalyst life. In addition, together with the effects mentioned in (1), it permits cutting the variable costs.

Although there are a number of problems that remain to be solved, this new technology offers the following possibilities:

a) For plants constructed in natural gas fields, reduced production costs through expansion of the process and reduction of the unit consumption of raw materials.

b) For plants constructed at consumption sites, securing a small or medium-sized economical process using coal, etc. as the raw materials.

Thus, it is expected that the new technology will contribute to promoting the utilization of methanol and the spread of clean energy.

For further information, contact
Project Planning & Development Div.