Chemical Plant Systems for Global Market

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OVERVIEW: Hitachi's chemical plants have a history that goes back more than 60 years. Furthermore, the markets in which they operate are experiencing major changes, with an increasing number of requests for joint development of bioplastic production processes, and more projects in Southeast Asia. Hitachi's core technologies used in processes for the continuous production of bioplastics include high-viscous material processing technology, simulation, and techniques for scaling up from pilot plants. Hitachi's EPC business, meanwhile, has built a reputation for high quality and management capabilities, and has achieved low costs through international partnering. It is currently engaged in the construction of a plant in Singapore for a customer, and is also establishing operations in China and Southeast Asia.

INTRODUCTION

"BIOPLASTIC" is a general term covering plastics produced from plant material and plastics that can easily decompose in the natural environment. Typical examples include polylactic acid (PLA)[*1], polybutylene succinate (PBS)[*2], and polybutylene adipate/terephthalate (PBAT)[*3]. Demand for these bioplastics is anticipated to expand, driven by factors such as the growing concern for the environment in recent years, regulations on use that are likely to be introduced in the near future in places such as Europe and Taiwan, sustained high oil prices, and an expanding range of technologies for compound reformulation.

Given this background, a number of companies have a strategic involvement in the production and sales of bioplastics, and others are seeking to use bioplastics as materials in their own products to enhance their value.

Hitachi has the tools and know-how to supply a range of solutions for bioplastics production. Also, having worked with overseas partners on numerous major projects outside Japan, the company can supply solutions at a competitive price that cover everything from trialing production processes to the completion of plant construction.

*1 A common bioplastic formed by the ring-opening polymerization of lactic acid produced by fermentation.
*2 Formed from succinic acid and 1.4-butanediol. Progress has been made on the elimination of oil as a raw material, and plans for the construction of a commercial plant have already been announced.
*3 Formed from terephthalic acid, adipic acid, and 1.4-butanediol. This bioplastic is experiencing growing demand in Europe especially.

This article describes the global activities of Hitachi in the field of chemical plant systems.

CORE TECHNOLOGIES FOR BIOPLASTICS

The following lists the characteristics of polycondensation reactions involving bioplastics, particularly those environmentally conscious synthesis reactions that do not use solvents.

(1) The chemical reaction cannot proceed unless reaction byproducts are removed by evaporation from molten polymers with high viscosity ($\leq$ 2,000 Pa • s).
(2) As the reaction temperatures are comparatively low, at only about 250°C, the viscosity of the polymers involved is very high.

The solutions that customers demand from plant suppliers include: (1) identification of recipes suitable for use in a continuous process at a commercial plant from recipes developed in the laboratory, (2) use of a pilot plant to verify quality, (3) up-scaling, and (4) preparation of basic designs.

By utilizing the following tools and know-how, Hitachi is able to deliver solutions that match these requirements.

(1) Technologies for the design and building of polymerizers with an optimal configuration for the purpose
(2) A polymerization simulator that can determine optimal polymerizer operating conditions and predict quality
(3) Pilot plant available for experimental testing
(4) Extensive experience and know-how in plastics production

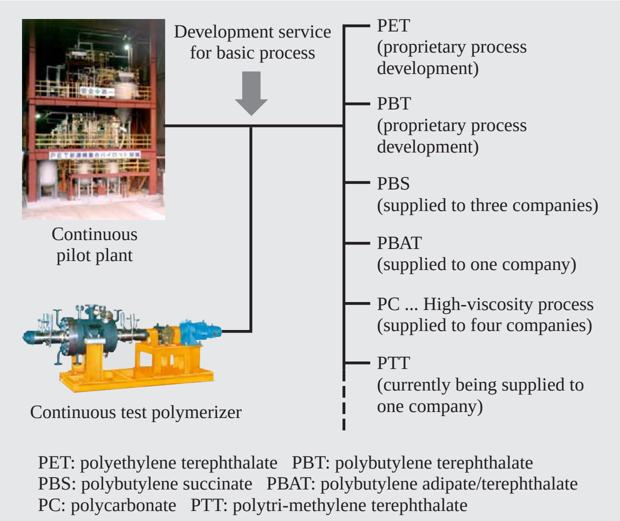

Fig. 1—Use of Pilot Plant to Supply Solution.
The polymerizer design and operating conditions were optimized for the process required by the customer.

Hitachi has worked on a wide range of projects both in Japan and Southeast Asia (see Fig. 1).

High-viscous Material Processing Technology

Polymerizers for bioplastics need to have a configuration that promotes the reaction, with a large evaporation area, high vacuum atmosphere, and sufficient piston flow. Continuous process plants, meanwhile, because they are designed to sustain operation for long periods of time, need to minimize any locations where polymer can accumulate. They also require agitation blade designs that can cope with high viscosity because of the need for a low reaction operating temperature to prevent loss of polymer quality. To satisfy these requirements, Hitachi has adopted its own design (see Fig. 2).

Simulation

The reaction simulations referred to above are proprietary to Hitachi, and extend beyond simple flow simulations to include quality prediction based on consideration of reaction progress.

They have also been enhanced in recent years to support a wider range of viscosities so that they can be used with bioplastics. These simulations can be used to scale-up the results of pilot plant operation or to offer plant performance guarantees (see Fig. 3).

Pilot Plant

In 1995, Hitachi built a pilot plant with a capacity of 100 kg/h that it used to demonstrate the production of polyethylene terephthalate (PET) (see Fig. 4). Hitachi went on to make numerous upgrades to the pilot plant, using it for projects such as developing its own process for producing polybutylene terephthalate (PBT) and testing continuous processes based on the batch process recipes used by customers. The following lists the main features of the pilot plant.

(1) Polymerizer components: four-barrel process comprising one esterification reactor and three polycondensation processors
(2) Process control: distributed control system (DCS)
(3) Capacity: 30 to 100 kg/h (depending on polymer being produced)
(4) Polymer viscosity: ≤ 2,000 Pa • s

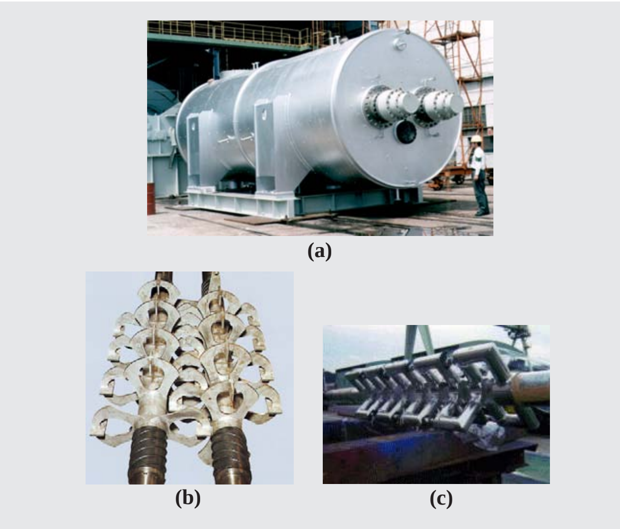

Fig. 2—Polymerizer and Agitation Blades.
These photographs show a polymerizer (a), spectacle-shaped blades (b), and lattice blades (c).

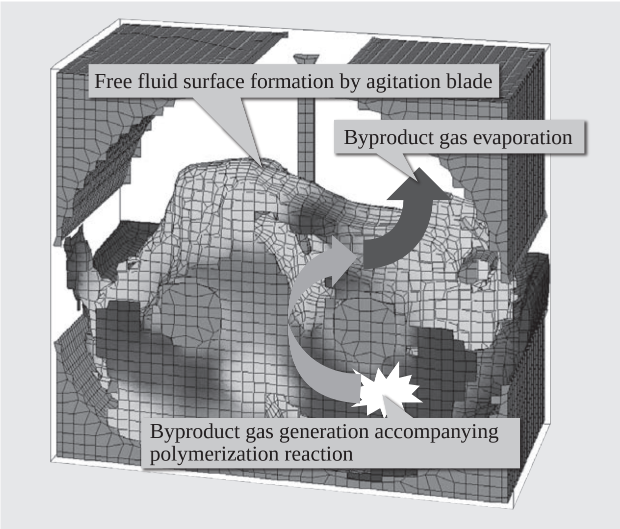

Fig. 3—3D Flow Simulation.
The simulation predicts phenomena such as evaporation and the changes in the surface.

Fig. 4—Pilot Plant at Hitachi.
The pilot plant can be used to test continuous processes.

Table 1. Chemical Plants Supplied to the Republic of Singapore
The table includes the plants supplied and the year of delivery.

No.	Name	Year of delivery	Contract scope
1	LDPE manufacturing plant	1980	EPC
2	Plastics manufacturing plant	1994	EPC
3	Plastics manufacturing plant	1996	EPC
4	LDPE manufacturing plant	1997	EPC
5	Plastics manufacturing plant	1998	EPC
6	Hydrogen peroxide solution manufacturing plant	1998	EPC
7	“Electronic industries chemical for liquid crystal” manufacturing plant	2003	EPC
8	Super absorbent polymer plant	2005	EPC
9	Pharmaceuticals manufacturing plant	2008	EPC
10	Reactor upgrade at resin manufacturing plant	2009	EPC
11	Synthetic rubber plant	2012	EPC
12	Synthetic rubber plant	In progress	EPC

LDPE: low-density polyethylene
EPC: engineering, procurement and construction

Fig. 5—Synthetic Rubber Plant Under Construction in Singapore.
Hitachi supplied 10 plants to Singapore between 1980 and 2009. It currently has one plant under construction.

OVERSEAS EPC ACTIVITIES

Operations Targeted Specifically at Republic of Singapore

The practice of operating multiple plants at different sites has emerged in recent years as a means of enhancing product price-competitiveness. While decisions on where to operate such plants are made by assessing a variety of factors, including materials procurement, access to product markets, and operational costs (including utilities and labor costs), a comparatively large proportion of this activity has taken place in China and Southeast Asia.

The Republic of Singapore, in particular, is taking vigorous steps to attract corporations, including promotion by its Economic Development Board of the competitiveness and sustainability improvements of Jurong Island, and Japanese companies have active plans for establishing operations.

Hitachi meanwhile, has its Asian base in Singapore, and has been involved in the supply of numerous plants (see Table 1). Drawing on this experience, Hitachi operates a business that handles engineering, procurement, and construction (EPC) for Japanese companies establishing plants in Singapore.

Fig. 5 shows an overview of a synthetic rubber plant currently under construction that is one of the examples listed in Table 1. This plant has achieved one million man-hours of operation without an accident (see Fig. 6). Outside Singapore, Hitachi also operates EPC businesses in China, the Kingdom of Thailand, and Malaysia.

EPC Partnering

The following lists the ways in which EPC business conducted overseas differs from that in Japan.

(1) Engineering: whereas design studies are carried out at the customer’s headquarters, consent applications are made in the destination country. Accordingly, they must comply with the laws and international standards applicable in that country.

Fig. 6—Celebration of One Million Accident-free Man-hours at Synthetic Rubber Plant in Singapore.
The customer and local staff celebrated the achievement of one million accident-free man-hours.

(2) Procurement: an emphasis on cost means that international procurement is used.
(3) Construction: while predominantly local subcontractors are used, for reasons of cost-competitiveness, selection of the construction company also considers companies from other than the destination country.

These factors make working with overseas partner companies (including companies from other than the destination country) essential for a variety of tasks.

For example, Hitachi's construction partner for the synthetic rubber plant project in Singapore was China National Chemical Engineering Third Construction Co., Ltd., which was subcontracted to carry out the installation of machinery, pipework, and electrical and instrumentation systems.

Other partners include Chinese engineering company, Wuhuan Engineering Co., Ltd., and Thai EPC provider Toyo-Thai Corporation Public Co., Ltd.

FUTURE ACTIVITIES

The strategy adopted by Hitachi for expanding sales of core technology includes publication of information on a dedicated web site as well as its existing activities in sales and the making of presentations to scientific societies. This has resulted in an increase in the number of inquiries and facilitated early contact with customers. In response, Hitachi is increasingly participating in customer projects from the planning stage, including seconding or posting staff to work with the customer as required.

As part of its strategy of using partnering to increase sales of large overseas EPC contracts, and in addition to the projects currently in progress in Singapore, Hitachi is seeking to undertake projects in places such as Thailand, Malaysia, and the Middle East while also continuing to offer low-cost solutions that match customer needs by establishing this strategy as standard practice for project execution while also working on its further expansion and development.

CONCLUSIONS

This article has described the global activities of Hitachi in the field of chemical plant systems.

With increasing environmental awareness expected to drive growth in demand for bioplastics, Hitachi is able to offer a variety of solutions for their production. These solutions are underpinned by high-viscous material processing technology that is essential for production, simulation techniques for use in production process design, and a pilot plant available for process testing.

Hitachi also offers EPC contracts that handle all aspects of production plant construction, and this article described an example of such a contract in Singapore. Hitachi is responding to customer requirements by working with appropriate overseas partners through each of the engineering, procurement, and construction phases.

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