



Industrial Machine for The Quality of Life

HARUO HAGIWARA
YUJI KAMIMURA
TOSHIKAZU HORIUCHI
HIROFUMI TAKAHASHI

Most products of the Industrial Machinery Division of Mitsubishi Heavy Industries, Ltd. (MHI) are industrial machines for producing commodities necessary for living. MHI embarked on construction of film manufacturing plants and food and packing plants in 1950 when the scars of war were still left, and entered upon the injection molding machine business in 1961. In these three fields, it is required not only to improve the manufacturing speed and accuracy, but also to remodel the products into human- and environment-friendly products. The major three products on which the Industrial Machinery Division is engaged are introduced below.

I. Extrusion machines of yesterday, today and tomorrow

1. Introduction

MHI began to construct rayon and cellophane manufacturing plants and manufacture spinning machines through technical cooperation in 1950. Thus, MHI started as a textile machine manufacturer supported by the boom of the textile industry. After this, as the customers, textile manufacturers, started plastic film production one after another, MHI accumulated the plastic film production techniques. In 1959, MHI developed, fabricated and marketed single screw extruders in cooperation with one of MHI's customers in Japan and entered the plastic film manufacturing plant market.

At present, in the field of polypropylene film that is the mainstream packaging film, MHI's film manufacturing machines produce 80% or more of the film in Japan and 20% or more in other countries. For other plastic materials, MHI's extrusion machines are used widely to produce films and sheets for industrial use, for example food packaging and electronic device manufacturing. These films and sheets assist us in realizing the ultimate convenience of life in the current consumer society. The films and sheets including those that are unseen are closely related to our life.

2. Extrusion machines of yesterday

After 1955, as the result of postwar development of the petrochemical industry and expansion of use of plastic products, most of textile manufacturers that were MHI's customers started to manufacture plastic film products. To meet their demands for film manufacturing machines made in Japan, MHI supplied various products, such as biaxially oriented film manufacturing plants, cast film production machines, sheeting ma-

chines, blown film machines, laminating machines, plastic corrugating machines, rubber extruders, oriented tape manufacturing machines, pelletizers, T dies and other peripheral devices, through joint development, technical cooperation and independent development. After this, while the distribution revolution was breaking out and the Japanese economy was rapidly growing, the demand and use for plastic film products were remarkably increasing and expanding. Then, MHI scaled up and diversified the extruders and other products to meet the requirements of the times, enhancement of productivity, energy conservation and environmental protection.

3. Extrusion machines of today

Recently, the convenience-store industry has grown to change the life-style, and packaging materials have been diversified. Under these circumstances, MHI has led the packaging material industry in the world as a manufacturer of polypropylene plastic, nylon and polystyrene plastic biaxially oriented film manufacturing plants.

MHI's polypropylene plastic biaxially oriented film manufacturing plants realize a product film width of 8.3 m and an actual molding speed of 450 m/min. MHI supplies plants that have the highest performance in the world. To win the competition for high molding speed with a competitive German manufacturer, MHI has improved these plants developing and combining a function that enables control of thickness of 8.3-m-long and 19- μ -thick films with an accuracy of 1 to 2% (Figs. 1 and 2), extruder techniques, orientation techniques and urgent breakage preventive measures. MHI intends to improve the molding speed, stability, operability and maintainability to develop products that will gain technical predominance over other competitors' products including those in foreign markets.

The scope of application of MHI's technologies has ex-

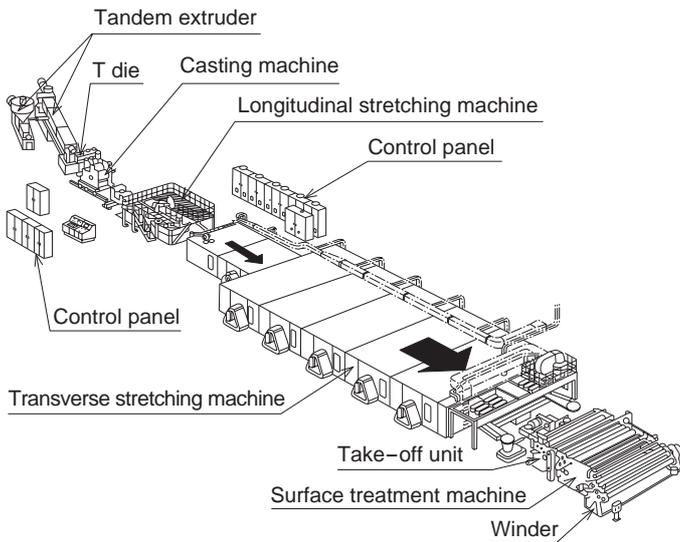


Fig. 1 Outline of biaxially oriented film manufacturing plant



Fig. 3 Examples of oriented film products

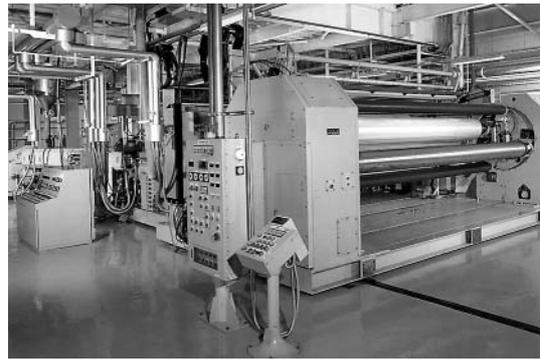


Fig. 2 Non-oriented film production line



Fig. 4 Bird's-eye view of synthetic paper plant

panded to construction of synthetic paper plants and polyester biaxially oriented film manufacturing plants for X-ray films through the biaxial orientation technique.

At present, MHI produces molding machines applicable to non-oriented film manufacturing plants for special films, such as LCD films.

Facing industrial globalization, customers in Japan in a state of deflation intend to continue the film product business by heightening the added value and discriminating their products from others against reduction in demand for films. MHI meets their requirements through its long-term experience in film plant construction and high-performance test equipment including the world's only high-speed biaxially oriented film manufacturing test plant (Fig. 3).

4. Extrusion machines of tomorrow

To enhance the competitiveness of plastic films to be used as packaging materials while globalization of the petrochemical product market is being accelerated, customers in the world including Japanese customers will demand for improvement of productivity of plastic film manufacturing plants. To meet their needs, MHI will promote establishment of high-speed molding techniques

including peripheral techniques, such as a technique to diminish the time after the start of operation until production stabilizes. From the viewpoint of customers, MHI intends to establish techniques to comprehensively improve the productivity and quality through enhancement of safety, operability, maintainability and recovery from nonconformance (Fig. 4).

For global environmental protection, MHI is positively promoting prevention of emission of dioxin and elimination of environmental endocrine disrupters. Used packaging films are normally treated as trash and incinerated. Unlike polyvinyl films that cause the problem of emission of dioxin, polyolefin plastic films including polypropylene films that MHI has handled mainly for a long time do not affect the environment when they are burnt. MHI proposes appropriate equipment for polyolefin plastic films to customers that will switch the film material from polyvinyl to polyolefin. Thus, it contributes toward promoting the environmental maintenance activities. In addition, since biodegradable plastics that naturally decompose and return to the soil after they are discarded are supplied to the worldwide market, MHI that is a plastic molding machine supplier designs the optimum film production systems to assist

the spread of use of the plastics.

For environmental protection, MHI will develop lateral orientation machine cleaning equipment that removes volatile organic substances generated in the film manufacturing process and develop expanded sheet machines to reduce the weight of sheets to be used for plastic food containers. MHI will contribute toward supplying environment-friendly machines.

MHI has embarked on investigation to meet the demand for plastic films that are environment friendly and easy to use. Films having high barrier properties against air, gas and water can be manufactured at a low cost by improving the technique to laminate various plastic layers during film molding. The technique enables to prevent deterioration of food and extend storage life, diminish the conventional manufacturing process and reduce manufacturing cost, and reduce film thickness, thereby decreasing the amount of films to be discarded. This laminating technique can be finally commercialized as molding machines through analysis of the fluidity characteristics of molten plastics in the flow channels and junctures and prediction and verification of optimum molding conditions. MHI continues to supply the most advanced manufacturing machines to stay in the forefront of development of applications of plastic materials and films, and actively develops the laminating techniques.

5. Conclusion

As a global plastic film manufacturing plant manufacturer, MHI will improve the convenience of films for consumers in the world who use plastic films in their life. MHI will make every effort to develop new techniques and products from the viewpoint of global environmental maintenance and contribute to the development of the society through manufacturing high quality plants.

II. Injection molding machines of yesterday, today and tomorrow

1. Introduction

Nowadays, plastics are quality-of-life materials and used for daily necessities, cars, home electric appliances, etc. in all fields of food, clothing and housing. Recently, plastic parts have been used particularly for IT-related products, such as DVD players and cell phones. Most of the products are manufactured with injection molding machines. In an injection molding machine, a molten plastic resin is cast into a mold at a high speed and the molding is taken out after the resin cools.

Mitsubishi injection molding machines have been continually updated to meet the diversified customers' needs and apply constantly developed plastic resins.

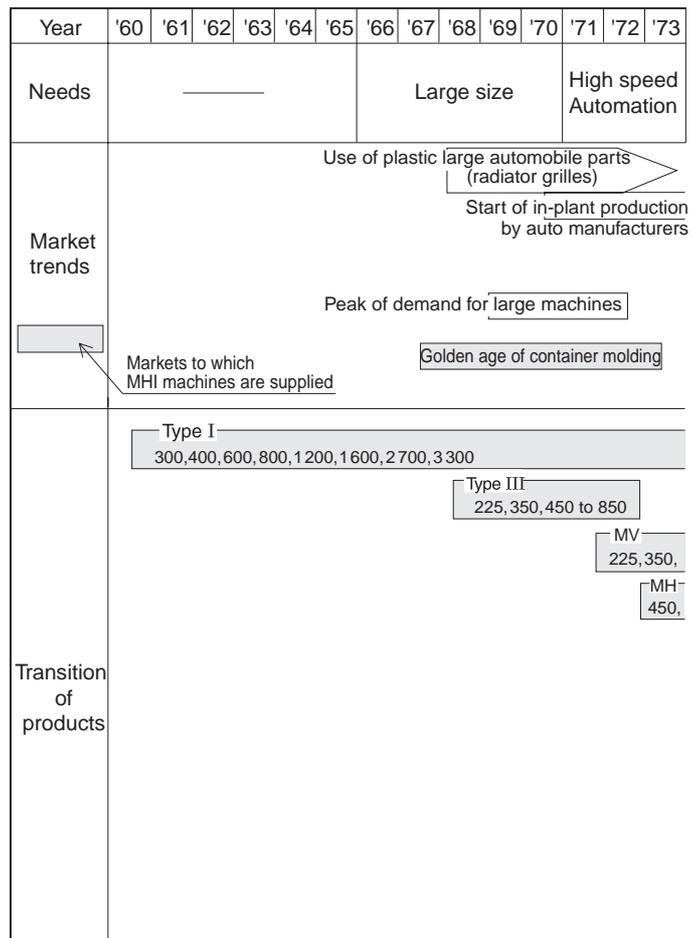
MHI supplies large injection molding machines that produce bumpers and interior parts of vehicles to many auto manufacturers and occupies the highest share in this field.

2. Injection molding machines of yesterday

The history of MHI started in 1961 in which MHI entered into a technical tie-up with National Automatic Tool Co., Inc. In the next year, MHI introduced medium and large injection molding machines that were provided with a variable displacement piston pump and had a mold clamping force of 300 to 1450 ton (Type I).

In 1984, MHI marketed for the first time small injection molding machines having a high injection power for precision molding at a mold clamping force of 220 ton or less. Thus, the full line-up from small to ultra-large injection molding machines, was prepared.

Then, MHI has supplied a series of injection molding machines since 1986. Small sized injection molding machines "MSII" and "MSIII" series using variable displacement piston pumps to save energy were introduced. After medium sized injection molding machines "MF series" were introduced, "MG," "MGII" and "MGIII"



series employing a direct clamping system were developed. "MM," "MMII" and "MMIII" series that were the most compact medium sized injection molding machines in the world using a 2-platen clamping mechanism were also put on the market.

Large sized injection molding machines at which MHI excels were developed as "MM series." They were the most compact large sized injection molding machines, using the same clamping system as that of the medium sized machines. They were highly appreciated in Japan because Japanese factories did not have enough space.

3. Injection molding machines of today

From 1998 to 2002, MHI have supplied midium sized injection molding machines "MSG" series and large sized



Fig. 5 Appearance of 450EM

injection molding machines "MMG" series and continually marketed ultra-large sized injection molding machines "MMIII" series.

In these years, the market of injection molding machine has been at an important juncture to switch from hydraulic machines to electric machines.

About 70% of small injection molding machines shipped by Japanese manufacturers are electric machines. To expand the share in this market, MHI produces Mitsubishi-Fanuc injection molding machines for Japanese customers based on the alliance with Fanuc Ltd. and exports MEt machines supplied by Toyo Machinery & Metal Co., Ltd. on an OEM basis.

For medium injection molding machines, motorization has been accelerated. In 2000, MHI introduced "ME series" that show a high injection rate using a toggle clamping mechanism and Fanuc servo motor. (Fig. 5)

This enabled MHI to remarkably expand the share in the automobile and home electric appliance fields in Japan. There is a greater demand for electric injection molding machines also in other countries. So that, it is expected that MHI will receive more orders.

MHI developed large electric injection molding machines "em" series that were the most compact large

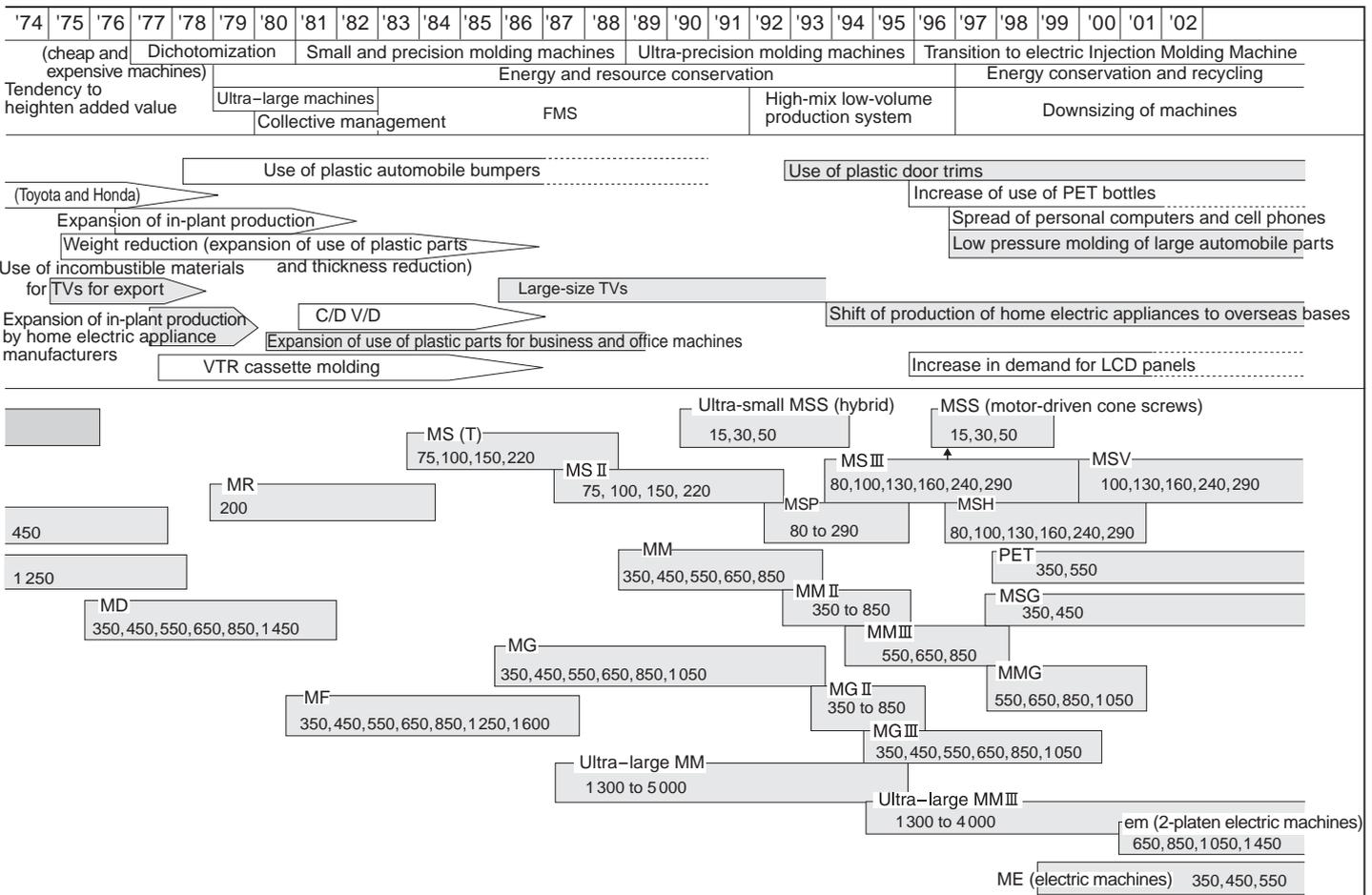


Fig. 7 Transition of injection molding machine series



Fig. 6 Appearance of 1050em

injection molding machines (Fig. 6) in cooperation with various laboratories, such as Nagasaki Research & Development Center. MHI applied for the first time in the industry a clamping mechanism (2-platen clamping mechanism) discriminated from the toggle clamping mechanisms that all competitors employed, and receives more orders from customers mainly in the auto industry.

4. Injection molding machines of tomorrow

Environment-friendly electric injection molding machines can save 60% or more of energy as compared to conventional hydraulic machines. As a result, the production cost can be reduced, and the defect rate can be improved remarkably. In the field of ultra-large injection molding machines having a capacity of 1 000 tons or more, there is an increasing demand for development of electric injection molding machines.

To meet this demand, MHI has embarked on development of ultra-large electric injection molding machines that occupy as little space as possible. These models are progressive next-generation electric injection molding machines developed based on the 2-platen clamping mechanism highly appreciated in the auto industry and MHI's wide-range techniques, for example the power electronics techniques and tribology techniques. MHI is making every effort at developing the world's largest 2000 ton class electric injection molding machines using large-capacity, high-performance servo motors and MHI's unique drive control technique to place the machines on the market in 2003.

Since there is a tendency toward plastic products in the auto industry, module products attract attention as substitutes for metallic parts to reduce the weight for development of electric cars in the future.

In this respect, MHI is promoting development of the surface reforming technique in plastic foaming for weight saving and the plasticizing technique for plastics containing continuous glass fibers that are the major materials of module parts. MHI is not only a hardware manufacturer of injection molding machines, but also a manufacturer engaged in development of new molding techniques to meet the customers' demands.

As production bases of injection moldings are moving abroad, transmission of operation know-how to custom-

ers becomes a critical issue. MHI will endeavor to develop user support systems using Information Technologies and expert systems.

5. Conclusion

In the future, transition from metallic products to plastic products will be more increasingly accelerated, and medium and large sized injection molding machines will be rapidly switched from hydraulic machines to electric machines. As a result, orders for medium and large sized injection molding machines "ME" and "em" series will be increased in Japan and other countries.

To survive in the current molding industry, it is necessary to realize high cycle time and energy saving as well as to improve the product accuracy to win the cost competition. Under these circumstances, the demand for electric injection molding machines is growing, and expectations on MHI's electric machines discriminated from other manufacturers' machines are increasing.

In the auto industry in which large sized hydraulic injection molding machines "MMIII" series, are highly appreciated, MHI introduced 1450 em (mold clamping force of 1 450 ton), large sized electric molding machines, last year. MHI intends to become the world's top electric injection molding machine manufacturer in this field.

III. Food and packaging machinery of yesterday, today and tomorrow

1. Introduction

MHI's food and packaging machinery includes various machines, such as machines that fill and package beer, juice and alcoholic drinks in bottles, cans and PET bottles, machines that fill pharmaceutical products, coffee flesh, jam and seasonings in bags and cups formed from film, and beer storage and fermentation tanks.

MHI supplies machines for filling and packaging various products, such as automobile oil and liquid detergent.

As stated above, most of products created by MHI's food and packaging machinery are consumed directly by general consumers. These machines can be regarded as quality-of-life machines, and have the potential to fill and pack various foods and liquids in various containers. Application possibilities are limitless.

2. Food and packaging machinery of yesterday

The history of MHI's food and packaging machinery originated from delivery of the initial bottle filler for soda pop in 1950. After this, the consumption of beer and soft drinks increased rapidly, and customers' needs for high-efficiency filling machines increased. MHI positively introduced techniques from overseas manufacturers, promoted development of its original machines and developed a bottle filler having the world's highest

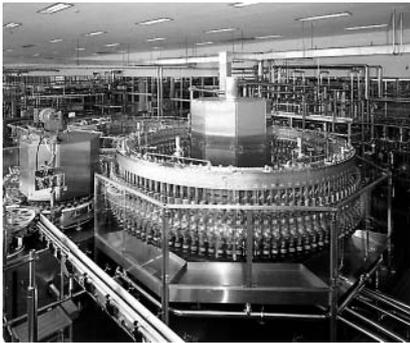


Fig. 8 Flow meter type PET bottle filling machine (1 000 bottles/min)

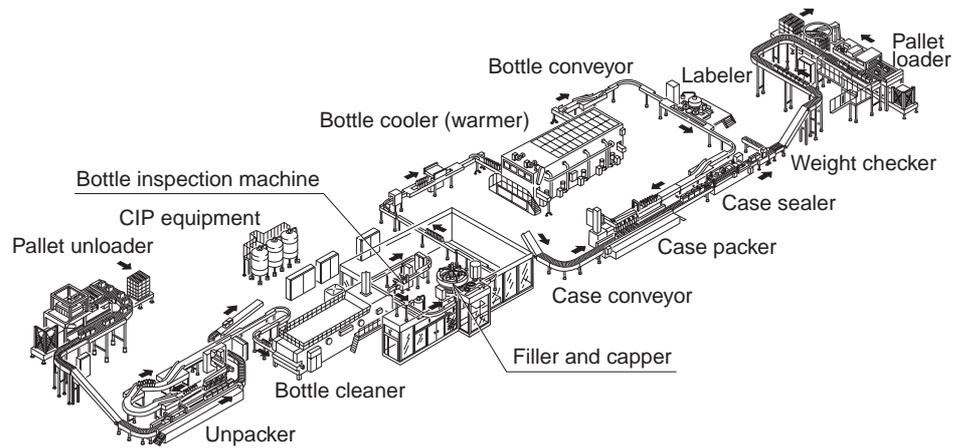


Fig. 9 Example of manufacturing line constructed by MHI (outline)

throughput of 800 bottles per minute in 1966. After two years, it increased the filling speed to 1 200 bottles/min. Since then, it has improved its technical capability to lead the industry and has created products that meet the market needs.

In the 1970's, bottles were replaced with cans. In 1970, MHI developed can filling machines. In 1987, it developed a high-capacity machine having a throughput of 1 500 cans per min. To meet the needs for high speed and high capacity keeping the high-accuracy filling rate, it developed a unique measuring system that measured the filling rate with a flow meter and put a filling machine having the world's highest throughput of 2 000 cans per min on the market in 1997. Thus, MHI has led in the filling and packaging technology.

It entered the toiletry field making the best use of its liquid filling and packaging technology in 1986 and the pharmaceutical field in 1992 to expand the market.

3. Food and packaging machinery of today

The PET bottles were introduced into the soft drink field for the first time in 1982. As the use of small PET bottles was permitted in 1996, containers were rapidly switched from cans to PET bottles, and it has been required to increase the kinds of applicable liquids and improve the productivity and quality of filling machines. In 1996, MHI developed a volumetric PET bottle aseptic filling line including an inline PET bottle molding for the first time in the industry to reduce the running cost. In 1997, it introduced a high-speed and high-accuracy PET bottle filling machine having the Japan's highest throughput of 1 000 bottles per min. to meet the needs of the industry (**Fig. 8**).

At present, mainly cans are used for beer, and mainly PET bottles are used for soft drinks. To more appropriately meet the needs for stable production and high quality of these products, MHI has improved filling machines and developed key devices in the production process, such as can seamers and cappers, that are used

together with the filling machines in cooperation with Mitsubishi Materials Corporation (named Shinryo Aluminum Can Sales Company Ltd. in 1993 when the joint development was done) that is a container and cap manufacturer and Alcoa Closure Systems Japan Ltd. (named Shibasaki-seisakusho in 2000 when the joint development was done), so that the reliability and quality of the whole plants can be improved (**Fig. 9**).

Due to the various needs in the market and environmental concerns, in different shapes of containers, such as bags, cups and bottle shaped cans are introduced. With 50 years of experience in the filling and packaging, our company has been leading the market by adopting these experience to always meet the requirements. The filling machine has been proven to be efficient and 1 000 units are delivered in the market in total.

4. Food and packaging machinery of tomorrow

Environmental problems top the list of our world's most pressing issues today. Also in the food industry, there is a rapid move toward 3R (reduce, reuse and recycle) and energy saving to reduce the influence on the global environment. MHI develops and supplies products for the recycling-oriented society as measures to realize the philosophy of the customers.

First, MHI develops methods of manufacturing containers for maintaining the product quality and reducing the weight. Second, it develops new methods of sterilizing and cleaning containers without using conventional cleaning water and chemicals. Third, it promotes chemical recycling of used PET bottles increasing in number. For these methods, MHI makes full use of the most advanced plastic technology, electronic technology and process technology. It has started the development of these methods to realize them in the near future.

Consumers pursue safety, convenience and high quality. To meet these demands, it is required to take measures to increase the productivity and reduce the quality cost. Under these circumstances of the market,

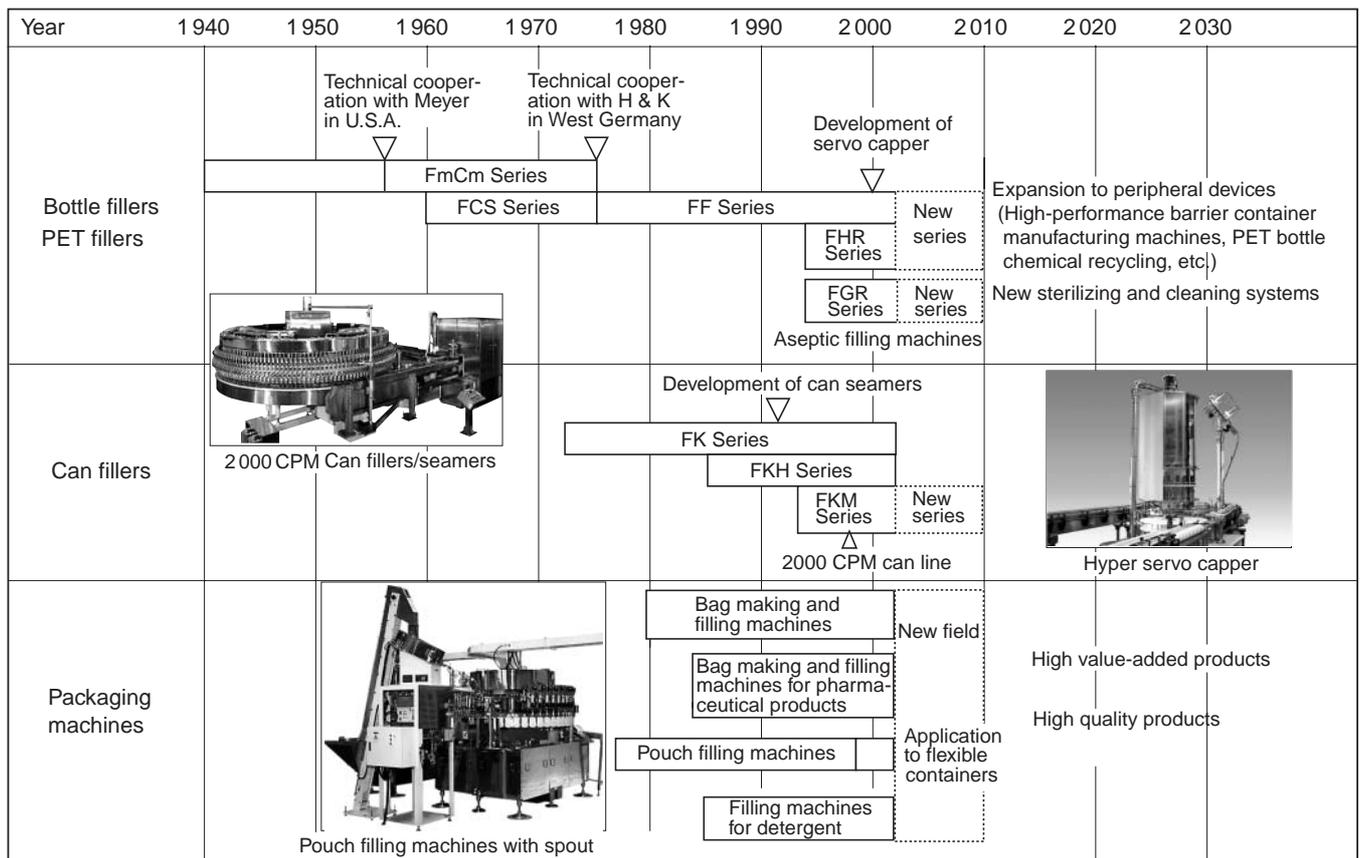


Fig. 10 History of major products



Fig. 11 Examples of products produced by MHI's food and packing machinery

machine manufacturers must examine how to fill various containers with various kinds of products and how to improve the maintenance efficiency. To solve these issues, it is necessary to introduce an operation knowledge system and establish a 24-hour service system to reconstruct the quick service system. (Fig. 10)

5. Conclusion

It is said that the world's food packaging industry has a 50-year history. The food packaging market is developing with changes in consumers' needs and social

environment.

MHI is expanding the product line of food and packaging machinery mainly based on the liquid filling and packaging technology. It intends to improve and develop these products and develop filling and packaging systems that enable to supply safe and high-quality foods, anticipating what the aging society will demand for (safety, convenience and high quality). It is marking a first step toward a total plant supplier.

MHI intends to further improve the food and packaging machinery which have the limitless possibilities, and support the customers under the slogan of "exciting products" and "active service" (Fig. 11).

Industrial Machinery Division



Deputy General Manager,
Industrial Machinery Division

Haruo Hagiwara



Yuji Kamimura



Toshikazu Horiuchi



Hirofumi Takahashi