



Paper and Printing Machinery Supporting the Information-Based Society

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1. Introduction

The Paper & Printing Machinery Division started the manufacture of pulp and paper machinery in 1951, and of printing machinery in 1961 at the Mihara Machinery Works. In 2000, now renamed as the Mihara Machinery & Transportation Systems Works, this manufacture and sales-integrated organization began to supply products to customers while responding quickly to changes in the industrial environment. Also manufacturing paper converting machinery, Mitsubishi Heavy Industries, Ltd. (MHI) is the only company in the world to handle the three major pillars of paper and printing machinery. It is now developing new and attractive products to meet the needs of customers.

MHI is also developing next-generation high-speed paper machines that are easy to operate and service, and printing machines of high productivity and high flexibility to cope with the trend toward small production and short delivery to support the information-oriented printing industry.

This paper introduces the past, present and future of the pulp and paper machinery and printing machinery, especially sheet-fed offset presses.

2. Past of paper and printing machinery supporting information-based society

2.1 Old days technology for pulp and paper making machinery

(1) Start and progress of paper making machinery business

In the days when big paper making machines were mostly imported, Mihara Machinery Works started development of high-speed paper machines, and delivered the first paper machine for newsprint paper of wire width 1930 mm and design speed 260 m/min, at Harada Mill of Fuji Paper Industry Co., Ltd. in October 1952 (Fig. 1). In 1957, MHI concluded a technical license agreement with Beloit Corporation of the United States to acquire the technology for bigger size and higher speed machine promptly. And

thereafter, in 1971, the newsprint machine of 8 690 mm wire width and of 915 m/min in speed installed at Tomakomai Mill of Oji Paper Co., Ltd. marked the 100th machine for us. Until now, more than 200 sets of big and high-speed machines were manufactured in every detail using specific equipments for the customers not only in Japan but also Korea, China, Southeast Asian countries and so forth.

(2) Challenge to technology progress

Since the early stage of this business, great efforts have been exerted on research and development. In 1982, No.2 pilot coater was newly installed, and in 1985 the first pilot paper machine was constructed. Leading engineers in the design and research section were sent to Beloit R & D Center to study the latest technology. In 1989, elemental technology test facilities were established in the Paper & Printing Research Center of Hiroshima Research & Development Center, and the technology of elemental study and structural analysis of various paper layer which are closely related to paper making process were upgraded. In 1992, the second pilot paper machine was constructed, and in 1997 dryer section of the highest drying capacity in the world was added, so that the paper quality could be evaluated by the sample sheets taken from the reel. Through such original technical developments, Acdeflo headbox, MH winder, Sortrex,

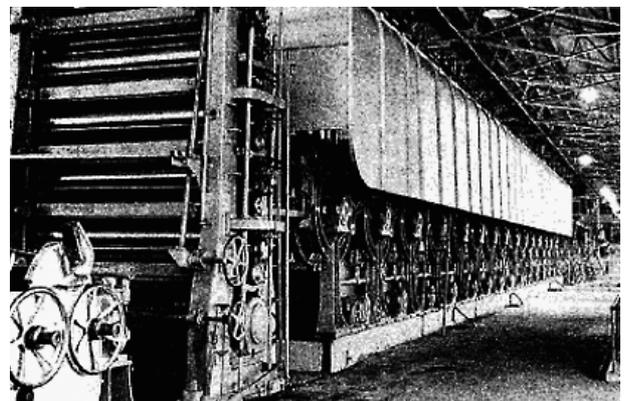


Fig. 1 Installation process of the first set of paper machine (1952)

MH former, Controlled Crown Roll with multi-shoe, and many other new products were put on the market one after the other.

In 2000, MHI abandoned the technical license agreement with Beloit, acquired their patents, know-how, and other intellectual properties, and opened business operations to the global market, through the acceleration of the development of new paper machine with its own technology.

2.2 Past of sheet-fed offset press

(1) Beginning and progress

Manufacture of printing machines was started in 1961 with technical assistance from Societe Marinoni of France.

Initially, this Division was a steam locomotive manufacturing plant. The printing machinery was of an utterly different category, demanding high precision to a micron scale in every part.

Later, with the company's original technology, various printing machines were manufactured including the initial sheet-fed offset press, to be followed by the commercial web offset press and newspaper offset press. The three major pillars of the printing machinery were thus established.

(2) Technical advances

As printing has changed from monochromatic to full color in order to attract the attention of consumers, four-color machines are now needed. In Europe and America, multi-color printing has also been developed by adding features of several colors to the four colors. In the carton and packaging field, an inline coating device for adding extra value by coating is required.

Handling of such multi-color machine requires a considerable amount of labor and skill. Furthermore, a printing press is a high-precision machine and therefore an expensive asset, and an urgent demand from printing firms is to increase the actual operating time. To meet this current trend, sheet-fed offset presses have been developed according to the basic concept of Q&Q (Quick and Quality).

The forerunner of this concept was the DAIYA-X exhibited at the first fair of International Graphic Arts Show (IGAS) in 1974. Since in those days there were no sensors or computers of high performance, a machine for controlling the dampening solution and ink volume and automatically controlling the register during the printing operation was presented at the exhibition. This machine was highly evaluated as a printing press that pointed the future direction for printing firms.

A representative practical machine is the Auto Pre-set Inking (API) system developed jointly with Dai Nippon Printing Co., Ltd. in 1981. Combining a device for reading the plate ratio and ink keys remote

control, this is a practical machine for presetting the ink key opening degrees to be optimum for the print image and controlling colors promptly. Today, this system is employed by makers around the world, and the full digital work flow is an online version from the prepress.

There was a further requirement to develop a series of models by the same design concept, if the machine size differs, in order to enhance service and maintenance by customers, and development of the future-oriented F series began in 1985. This machine had a remote control device for setting the plate change operation and printing pressure, which occupies most of the preparation time, for the first time in the world, and 500 sets were ordered within two years from the release in 1989, against the background of the strong economic boom. On the occasion of this model, the export business began to expand widely.

3. Present technology of paper making machinery and printing press which support the transmission of information in the society

3.1 Present technology of pulp and paper machinery

(1) Start of development project

The new machine development project was started in 1998 to establish original technology on pulp and paper machinery. After the market survey, technical trend analysis, and investigation of customers' evaluation on MHI machinery, the target period of putting the new machine on the market was set in October 2001.

The project is named MJ (Mitsubishi, Japan 2000) to express enthusiasm for presenting a brand new technology from Japan and to make 2 000 m/min operation feasible. It also implies the next generation of the current best-selling products of the MH series.

The basic strategy for technical originality can be summarized as follows.

- To be a reliable supplier who achieves customer satisfaction.
- To emerge from supplemental development of Beloit technology to original technology development.
- To develop a high-speed paper machine using domestic technology (hardware + paper making technology).

Thus, the challenging activities toward technical independence were started.

(2) Features of new machine

To develop the MJ2000 paper machine, the following targets were set to realize well-balanced performance.

- Global acceptance
- Stable operation at high speed over 2 000 m/min and high productivity
- Operator-friendly manipulable machine

- Integrated central operation and remote-controlled maintenance
- Realization of excellent paper quality

In the process of research and development, much time has been spent on the elemental studies from the viewpoint of front loading. Extraction and analysis of parameters ruling the performance, development of simulation technology, and fabrication of simulation models were thoroughly worked out and developed, and results were technically reviewed by the specialists in each field at the MHI Research & Development Center. On the basis of results of these elemental studies, each part of the pilot machine were modified and evaluated in the individual operations of each section, and integrated paper making trials were carried out. The latest layout of the second pilot paper machine is shown in **Fig. 2**.

The outline configuration of the second pilot paper machine is as follows: The former is of roll blade type, which is notably enhanced in dewatering capability, the press is a non-open draw dual shoe press with advanced water squeezing performance, and the dryer is an all-top felt arrangement with the air caps disposed in the latter section. The calender is a shoe calender capable of getting bulky paper (independent operation also possible), and the reel has a center winding function also. The wet web is supported by machine clothings all the way from the former to the terminal end of the dryer, so threading the machine is very easy and steady. From the dryer to the reel, the web is transferred by a vacuum conveyor type threading device. By the advantages of this stable threading and many other devices, high-speed operation of 2 000 m/min (120 km/h) is realized.

Machine configuration and scaffold layout of MJ2000 paper machine are presented to major customers by 3D-CAD, and maintenance facilities, devices for clothing change and other points are improved in detail based on the users' opinions. **Fig. 3** shows the appearance of the MJ2000 paper machine.

In May 2002, more than a hundred customers were invited to an open operation trial of the second pilot machine, and newsprint paper reel take-up was demonstrated in sensational success at 2 000 m/min, that exceeds the maximum commercial speed of 1 700

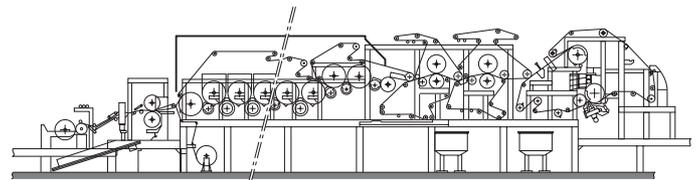


Fig. 2 Layout of No.2 pilot paper machine

m/min in Japan.

This pilot paper machine can be utilized to analyse and evaluate the quality of the paper which is made out of various paper stock, fillers, and chemicals following to the customers' choice.

3.2 Present situation of sheet-fed offset press

(1) Inauguration of project

Existing sheet-fed offset presses are often called by the name "DIAMOND series" in order to publicize the corporate identity. However, the "mechatronics" philosophy proposed by MHI is no longer unique these days as the technical level has been averaged owing to advances in computer technology and intensified competition among manufacturers. In Japan, meanwhile, the decline of the bubble economy was followed by a low-growth era, and customers are much more demanding about the degree of finishing of machines, printing quality and performance, while needs and preferences of printing are more diversified, and uniform massive lot production is being replaced by small lot production in a wide variety.

Against this background, for survival of sheet-fed offset press along with retention of customers, improvement of production efficiency is urgently required. For this purpose, the keenest needs are concentrated on the perfect printing press capable of printing two faces by one path and enhancing productivity substantially, and MHI's efforts are being accelerated. The present situation of development of the perfect printing press is here introduced.

(2) Features and merits of major products

For paper travel of recent sheet-fed offset presses, the ideas of fluid dynamics based on MHI's accumulated aircraft technology are utilized in various parts. The technology of installing air chambers under the paper guide of the delivery unit of DIAMOND and skeleton transfer cylinder and conveying thin sheets by air cushion has been introduced in wider stock



Fig. 3 MJ2000 paper machine

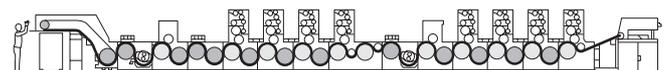


Fig. 4 DIAMOND 3000R for DYNA GRAF



Fig. 5 DIAMOND 3000TP

range press. This technology has been further enhanced so that it can be applied in the perfect printing press. Ink for sheet-fed press is cured by oxidative polymerization, and is not dried for several hours after printing. In the perfect printing press, therefore, a higher technology of flawless transfer of sheets to the delivery unit without making contact is required.

Combining these technologies, a convertible press capable of changing sides applicable to double-face coating has been developed for the first time in the world and delivered to a customer in the United States (Fig.4).

With regard to the exclusive perfect printing press without reversing mechanism, in the type of printing one color alternately on the face and reverse side, since the sheet is elongated during printing, the precision of register is lowered, and high printing quality is hard to obtain. This problem was radically solved by developing the Tandem Perfector applicable to stretchable thick sheets and UV (Ultra Violet) printing field. This printing machine is an original MHI perfect printing press having a unique cylinder configuration capable of finishing printing of the reverse side in the first half of the process, and transferring the sheet to the front side printing unit by an even number of transfer cylinders to conclude perfect printing. Great expectations are held of it in the printing industry (Fig.5).

From now on, efforts will be accelerated in the development of one path both side coating.

4. Future of paper and printing machinery

4.1 Future technology of pulp and paper machinery

(1) Outlook and vision

Reviewing the consumption trends of paper and paper board in the world, an annual growth rate of about 2.8% is continued, and a steady increase is predicted also in the years to come. On the other hand, the Kyoto Protocol requires that Japan, the European Union, and other industrialized nations must reduce emissions of greenhouse effect gases at a specific rate as compared with 1990 level, and Japan must realize 6% reduction. To protect the environment on a global scale, various action programs are being promoted intensively, including recycling of paper, saving of energy, and planting of forests.

Japan's pulp and paper companies have the technology to operate machines at the highest production efficiency in the world. MHI has developed MJ series paper machines on the basis of high paper quality cul-



Fig. 6 Central control room of next-generation paper machine

tivated in the market in Japan and high-speed paper machines of high production efficiency. It is MHI's objective to upgrade this series machines in the global market, and by developing a new technology vigorously, to realize the still higher productivity machine with less sheet break and to realize energy-saving machine to conserve environment, thus contribute to the whole world.

(2) Productivity improvement of new machine

Productivity improvement by prevention of mist in the former and press, prevention of paper dust generation in trimming and tail cutting devices, and development of a stable running device in the dryer, make the target frequency of sheet break into half of the conventional level. Sheet break suddenly increases the working load of the operators, and automation is required for broke removed and machine cleaning. There is a requirement to develop automatic starting and stopping of the machine and to develop technology to keep machine clean for the extension of continuous operation period. In the operation of next-generation paper machines, remote monitoring is realized in the less-man power central control room by using a monitoring device, (Fig. 6), and all the paper machine including the winder is operated only by three operators.

(3) For conservation of the environment and energy saving

Construction of new paper machines is necessary to cope with the growth in global demand for paper, and at the same time it is essential to lower the energy consumption rate. MHI is now concentrating its efforts on drastic energy saving in the screen and pulper, reducing sliding resistance in the former, and squeezing the required power in the shoe press. Equally important is the design concept for minimizing the mechanical parts that require periodical

maintenance. The roll cover material of wear-resistant ceramics make the roll change frequency to less than half of now. The clothing life will be extended substantially by joint development with clothing suppliers. With these environment-conscious machines and through continuous development of energy-saving technology, MHI will contribute to conservation of the environment.

4.2 Future of sheet-fed offset presses

(1) Outlook and vision

Human beings cannot exist without culture, and no culture can exist without printing. In every country around the world, printing offices are concentrated in the capitals and major cities from which information is transmitted. The printing industry is the business of converting information into media and transmitting it to the people. A few years ago, electronic media began to grow rapidly as new media, and printing was predicted to fade away. However, together with the advancement and popularity of personal computers, mobile phones, information-related appliances and the Internet, the environment of information-sharing by the public grew larger, and the total volume of information has increased explosively. Data of commercial printing is digitized, and the data can be directly uploaded to the Internet. In the printing business alone, as lifestyles become diversified, large-scale jobs are decreasing, but small-scale jobs are increasing steadily. Including the design business, the entire printing industry is clearly becoming transformed into an information transmitting industry. In this situation, the speed of transmission of information in the world is becoming faster and faster, as compared with the manufacture of electronic media, and the manufacturing speed of printing equipment needs further improvement.

(2) Enhancement of production efficiency of new machines

In order for a machine to exhibit high productivity, changes in the operating environment and the people using it must be taken into account.

What must be kept in mind is development of "printing machines used by people, friendly to people, and friendly to the environment."

A printing machine is basically a machine for mass production of duplicates of the designer's image, and it is required to print at a specified repeatability. For this purpose, (1) elements and components composing the machine must work reliably, (2) maintenance must be easy or not required, and (3) response to mechanical operation is always constant, are needed. Especially, when the digital image data created by the designer is distributed through the communication

network and printed at shops, the printing machine is a printer at the terminal of the network, and it is even more important to exhibit a specific repeatability all the time. On the other hand, the printing machine is an expensive asset in production, and it is required to enhance production efficiency, that is, to maximize the actual operating time.

(3) For the environment and energy saving

Only part of printed matter is reserved in book form, and the majority is consumed. That is, once read, printing matter is destined to be discarded. Paper is made from forest resources, and images are formed on the sheet of paper by using ink and dampening solution by operating the printing press while consuming electric energy. After the operation, the ink is washed away from the machine by using solution. Indeed, this is an industry that imposes a heavy environmental load. Accordingly, recycled paper and soy oil ink are used, and water less printing not requiring the use of dampening water is being evaluated anew.

From the printing machine side, attempts have been made to decrease waste paper occurring in the process of color adjustment at the start of printing, reduce the operating power, and recycle the cleaning solution, and this campaign must be further intensified so as to reduce the environmental load.

5. Conclusion

The Paper & Printing Machinery Division is the only company in the world capable of researching and developing both paper and printing, and it is henceforth determined to make its merits known widely to customers in the pulp and paper field, paper converting field, and printing field, to expand its operation while making best use of its advantages, and to develop further technology and products. Your kind suggestions and advice to MHI will be greatly appreciated.

(Home page address: <http://www.mhi.co.jp/mihara/>)

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