1. Introduction

Mitsubishi Heavy Industries, Ltd. (MHI) developed the MJ Series Paper Machine to achieve the world’s highest speed, highest operating efficiency, and highest quality. Marketing of the MJ Series Paper Machine began in October 2001. During the development, the performance of each Paper Machine section was studied in element tests and simulation analysis, and verified by pilot paper machine trials. The pilot machine produced commercial newsprint at a reel speed of 2 000 m/min at a customer demonstration in May 2002. This was a world record performance. Today, sections of the MJ Series Paper Machine are successfully installed on many paper.

2. Status of Each MJ Section

2.1 MJ Headbox

The MJ Headbox is an upgraded, high-speed version of the Concept IV-MH dilution control headbox which was installed in Japan in 1996. A new lightweight and high-strength carbon graphite reinforced composite flow-sheet has been developed to increase operating life and improve maintenance. Fig. 1 shows a picture of a 7 m wide MJ headbox with dilution control for a paperboard machine.

2.2 MJ former

The MJ former was developed to produce newsprint and fine paper at a speed of 2 000 m/min. It uses a suction forming roll in the initial dewatering section to assure high dewatering capacity for high-speed, stable operation. Following the suction forming roll, MHI’s original wedge-shaped dewatering blades apply pulses of high dewatering pressure on the fiber mat. This promotes improved fiber dispersion and produces excellent formation. The former has the strongest effect on paper quality, and the MJ Former has been developed according to the specific needs of each paper grade (see chapter 3).

2.3 MJ press

The MJ Press is a modular dual shoe press with a transfer belt. In the pilot machine, threading is no problem at 2 000 m/min and sheet dryness over 50% is assured. Fig. 2 shows the front view of a pre-assembled MJ press modules. This new modular design allows a very smooth installation, and contributes to shortening of the installation time.

2.4 MJ dryer and MJ attractor

At operating speeds exceeding 1 600 m/min, threading becomes extremely difficult in the initial dryer sections. The MJ Attractor is a device to create vacuum at the sheet release point of a drying cylinder. This technology effectively enhances web stability in the initial drying section of the MJ Dryer. The MJ attractor is also used in existing machines to improve the operational stability of the dryer sections.

2.5 MJ sizer

The MJ Sizer is a rod metering film coater successfully running in starch and pigment applications. The MJ Turn Bar improves the out-going web stability and provides mist-free operation at high machine speeds.

3. Expansion of application of the MJ technology

3.1 MJ Former Plus for fine paper

For further evolution of the MJ Former, MHI is developing the next-generation former that satisfies the needs of paper mills and features easy and high control performance. In particular, fine paper used in wide applications is required to have both excellent formation and low tensile ratio in various specifications of the paper. Accordingly, new dewatering technology has been established for improving the formation and tensile ratio at the same time, by applying pulses of high dewatering pressure to the initial constant pressure dewatering zone at the roll surface.
Applying stable pulses of dewatering pressure in the material layer on the roll with no space for escape is technically difficult. The blade shape and optimum application condition established by element study were applied in the pilot paper machine, and a continuous trial was conducted at speeds of 1,400 to 1,600 m/min. For the first time in the industry, as shown in Fig. 3, it has been demonstrated that both formation and tensile ratio can be improved at the same time.

**3.2 MJ former for paperboard**

In developing the MJ former for paperboard, the high dewatering concept of the MJ former has been inherited. Specifications and configuration of dewatering devices have been radically reviewed in order to achieve stable dewatering and high paper strength while using materials of heavy basis weight and freeness. This former has an extended initial dewatering section to increase the mat dewatering resistance for heavy basis weights, highly flexible control shoes at the forming roll exit, and a unique layout of the forming shoe box that does not create paper defects even with increased basis weight. This former is capable of manufacturing paperboard up to 150 g/m² in the twin wire section of the base layer. The first MJ former for paperboard is expected to start up in 2005.

**3.3 VentaShoe technology**

The VentaShoe has been developed to introduce the MJ technology as a retrofit to an existing blade-type gap former with a small capital investment. The VentaShoe is composed of ceramic blades with special grooves over a circular surface located in the initial dewatering section of the former. By evacuation through the grooves, a dense paper layer is formed between the top and bottom surfaces by initial constant-pressure dewatering from the two sides. This technology has been installed in existing machines and increased speed and greatly improved paper quality have been obtained. For example, the speed was increased by 200 m/min at Mill "A", the former dewatering capacity was increased by 10% (the formation was improved) in Mill "B", and brightness two-sidedness was improved from 1.9% to 0.4% in Mill "C".

**3.4 MJ Calender**

The MJ Calender utilizes the MHI Multi-CCR, for controlling caliper, and shoe calender technology for producing bulky paper. The Multi-CCR has the capability of controlling edge caliper and is quick in convergence of caliper control. The time for achieving caliper control is typically reduced by about 10 minutes. The shoe calender features long nip residence time and calenders with low surface pressure. Heat from the hot roll acts mainly on the surface layer and is minimally transmitted to the inside layer. In this way, the fibers and coat layers can be softened by the heat at low surface pressure, and a bulkier sheet is expected.

**3.5 Pilot trial at MHI**

MHI has a test plant for evaluating the MJ Series Paper Machine with customers. The former of the pilot paper machine is a roll blade former, the press is a closed-draw dual press, and the all top tier dryer section has air caps in the last half. Shoe calender trials can be performed independently. The reel has center winding assist. Hand sheet trials for pressing can be used to evaluate dewatering capacity in cases for modification to extended nip press or like. A pilot coater with a design speed of 3,000 m/min has various blade and film coater heads that can be operated to test any coating solution. Testing of the curtain flow coater is also possible.

**4. Conclusions**

MHI has already delivered and installed more than 200 complete paper machines in Japan and many other countries. The design speed has been dramatically increased from 260 m/min for the first machine installed in 1952 to 2,000 m/min for the MJ series. The MJ paper machine has been developed to achieve high speed as demanded in the global market and advanced paper quality, which is particularly demanding in Japan. In paper making mills in Japan, operation efficiency is about 10% higher than in other countries, and higher quality paper is being produced. MHI continues to concentrate its research and development efforts on further innovation to further advance the excellent manufacturing technology and high paper quality in Japan's paper making mills.