The Development of MJ Series
High Speed Paper Machine

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A new high-speed paper machine development project has started in 1999 and concluded with a product offering to the market in October 2001. This new product is known as the MJ series and is designed to complement the current MH series paper machines. The goal of the project is to produce quality paper at 2,000 m/min operation speed while providing an operator friendly product. The project has been developed in the course of an intensive elementary study, program simulation, model test, and final verification on our pilot paper machine at the Mitsubishi Heavy Industries, Ltd. (MHI) R&D center of Mihara, Japan. This paper presents the concept and results of the new style of paper machine.

1. Introduction

MHI has delivered the first paper machine in 1952, and joined the paper machine business. MHI has made a technical cooperation with Beloit Corporation in 1957. Since then MHI provided Beloit technology mainly in the Asian market place. To satisfy the Japanese customer's advanced needs, MHI started the development in 1979. Our current products "MH Series" offered to the market in 1995 which has been developed in the course of an intensive elementary study, program simulation, model test, and final verification on our pilot paper machine at the MHI R&D center of Mihara, Japan. MH-Series in the field are running successfully and holds a high speed record (1,530 m/min) at Fine paper grade in 2002.

The new generation high speed paper machine MJ series has been developed to achieve the following goal with keeping MH series advanced paper quality.
- High speed operation
- Easy operation
- Less maintenance

The new paper machine project started in 1999. Together a market survey was conducted and customer opinions were gathered relative to the needs for the performance characteristics of a high-speed paper machine. Through this study and development a new product was introduced in October 2001. This name MJ series implies the new technology from J pan and follows the line of the successful MH series, our previous group of product lines.

The basic goals of MJ project are
- Customer satisfaction,
- New technology development, and
- Worldwide market oriented with combined Japanese paper making technology.

2. Paper machine concept

The requirements of the paper machine are as follows.
- High productivity
  2,000 m/min in operation
  Few sheet breaks/higher efficiency
- Operator friendly product
- Preventive maintenance and rapid trouble shooting
- Excellent paper quality

The concept of each section is determined by customer needs and analysis of high speed operation problem.
- Head box: Short free jet + Surface treatment of head box inside
- Former: Roll forming + Serrated shoe + Counter blade
- Press: No open draw + Shoe pressing
- Dryer: All top dryer + Air cap
- Film coater: RMSP + Mist elimination
- Calender: Shoe calender
- Reel: Drum supported center wind + Control of air entrainment
- Winder: Single drum winder
- Control: Remote maintenance + Help system

Intensive elementary research and development work by experts of MHI R & D center and a series of rebuilds to the pilot machine allowed us to compare many different configurations.

Fig. 1 shows the concept layout for full scale paper machine as a result of the laboratory analysis.

3. Detail of each section

Each section has achieved a reliable design while providing easy, clean, and safe operation with less maintenance, and improved machine appearance and operation panel design (Fig. 2).
3.1 Headbox

The headbox (Fig. 3) is developed to meet the requirement of high-speed forming unit based on Concept IV-MH headbox that have references of over 120 units in the field, so that customer get uniform basis weight profile and fiber distribution at 2000 m/min operation. And the carbon flow sheet can reduce maintenance period.

The basic function of headbox are uniform distribution, fiber orientation control, fiber dispersion and basis weight profile. Uniform jet thickness and velocity from headbox are required for the optimization of the above parameters. Rigid structure against high internal pressure and cleanliness are also key issues.

(1) Smooth jet

We have evaluated the co-relation between jet smoothness and free jet length and/or nozzle geometry including the flow sheet length by the model test. The optimized nozzle geometry and short free jet length will give very smooth and stable jet as shown in Fig. 4. The headbox has been designed with a slim nozzle so that free jet length can be shorter.

(2) Round header

The internal pressure increases exponentially with speed increases. The headbox applies a parabolic round header against those high pressure. The parabolic curve has been determined by the CFD analysis to achieve uniform distribution. The CFD analysis result (Fig. 5) shows a round header having uniform distribution without any unstable flow as occurred in a rectangular header. A round header eliminates the need for a transition piece providing an advantage of space limitation for rebuilds.
(3) Maintenance
The headbox incorporates following equipment to reduce maintenance loads.
- Light and stiff carbon flow sheet
- Jig to remove flow sheets
- Full width and pond side cover
- Easy access to lip area by roll swing out design
Carbon graphite sheet allow alkaline cleaning without removing the flow sheet. The new material or long life surface treatment to prevent fiber deposit is now in the development process.

(4) Profile/quality
The integrated mounting high resolution CP system and edge flow valve are incorporated. These features combined with the thermal stability will achieve superior BW and fiber orientation profile.

3.2 Former
The former (Fig.6) is a high speed unit where roll forming and blade forming technology has been harmoniously combined. This gives
(1) Stable high-speed operation,
(2) Simple and easy operation, and
(3) Uniform sheet structure.
Excellent runnability & maintainability is also achieved through comprehensive engineering work.

Fig. 5 Flow distribution in rounder header of MJ Flow head box
Rounder header optimized by CFD has a high capability of uniform distribution at high speed operation.

(1) Forming zone
Fig. 7 shows the forming zone and typical drainage profile. The initial drainage is performed by roll
and gives symmetrical initial mat on both sides.
The suction roll diameter has been determined by balancing CMD pressure uniformity and to achieve short free jet length. The drainage length over the suction roll has been determined through the test, which optimized stable high-speed operation and formation. The blade section consists of serrated forming shoe with counter blade as shown in Fig.7 and location has been determined from sheet structure uniformity and is positioned to make fabric/roll changing simple.
The serrated shoe blade with counter blade can generate higher drainage pressure than the conventional blade, therefore it will improve the formation in the middle layer of the sheet (Fig. 7).

The vacuum equipments will dry up the sheet to ensure the stable operation. Fig. 8 shows the former has sufficient drainage capacity at 2 000 m/min.

(2) Paper quality

Formation is the key property among various paper qualities. Fig. 9 shows the formation vs. speed. It can be seen that the former gives good formation level in the wide range of speed. Fig. 10 shows the former Z direction fines distribution to be uniform sheet structure.

Good formation and uniform sheet structure will be beneficial to coating, printing process and improve ply bonding.

(3) Operation

It becomes more critical to keep machine clean for efficient operation in high-speed. The former will provide the following equipment to reduce dripping and cause of sheet breaks.

- Return roll center mounting
- Air jet cleaner to remove water in the fabrics
- Ultra high pressure fabric cleaner
- Optimized mist ventilation

(4) Maintenance has been reduced with

- Easy roll/fabric changing design,
- Long life roll cover material, and
- Non contact guide sensor.

(5) The former will provide process monitoring system.

- Water thickness between fabrics (or solids %)
- On line dewatering amount measurement
- On line formation sensor

Together these systems provide optimum, clean operating conditions at very high speed.

3.3 Press

The press (Fig. 11) applies closed transfer dual shoe press arrangement, so that MJ press has following features.

- High de-watereing capacity
- Bulky sheet with less two sidedness
- No vibration, reduced sheet breaks at 2 000 m/min

The press is a very simple design consisting of two identical shoe units, which has advantages in reducing maintenance/spare parts inventory.

Sheet threading from the press center roll has been a bottleneck for high-speed operation, but the press eliminates threading work and can realize automatic sheet threading to the dryer section. Our pilot machine has run up to 2 000 m/min without any difficulties.

(1) 1st press

It is very important to enhance bottom side de-watering to uniform sheet structure at 1st press.
position. In case that roll press is applied, it requires over 200 kN/m to obtain equivalent dryness to the shoe press. This high nip loading results in reduced felt and roll covers life and increases the chance for vibration issue. One of the solution is the applying a bare roll (no rubber covered roll). But in this case a felt compaction become serious rapidly, and makes a machine to be unstable condition. On the other hand shoe press does not have such concerns and can maintain high dryness level in entire felt life and have an advantage from bulk point of view. Consequently we have applied shoe press on 1st press position.

(2) Dewatering capacity

The press can be operated with either four conventional felts or the combination of one anti-rewetting clothing and three felts depend on grade requirement. Fig.12 shows the comparison to conventional press configuration (Tri-Ex) and higher dryness by around 5% points with anti-rewetting clothing at 2nd press bottom position. In case of using four felts, very symmetrical sheet structure will be obtained but lose dryness due to rewetting phenomena. Further studies are on going to reduce rewetting.

(3) Quality

High quality printing needs a uniformity of surface and thickness direction. Paper grade and pulp characteristic have an effect on a compaction of each surface in pressing process. But the uniform fine-filler distribution by MJ former make MJ press being able to obtain superior less two-sidedness. The press also gives less two-sidedness in smoothness comparing to conventional press with shoe press at 3rd press.

(4) Operation/maintenance

It has been confirmed that stable sheet pickup is more critical in high-speed operation. The press assures stable pickup with trim vacuum box and trim jet, which is linked with pick up roll deckle adjustment. Mist will be dominant in the press section in high-speed operation. Mist hood and evacuation system will be installed for clean operation. The press will achieve easy and safe operation with good accessibility, well-designed felt and roll changing. On line dewatering measurement system with diagnostic program is incorporated as process monitoring to optimize operating conditions easily.

5. Conclusion

The concept and features of the MJ paper machine has been presented. MHI now opens up the door to world with the development of this new paper machine. The products and idea offered in the course of the development can be applied to rebuild project. We will supply new products/technology continuously to all market regions.