Evolution of Mitsubishi "EVOL" Corrugated Board Box Making Machine

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1. Introduction

Corrugated board boxes are the most familiar form of packaging and are a key part of the world's logistics and commodity distribution systems. They are also considered to be earth-friendly products because they can be recycled after use.

Mitsubishi Heavy Industries, Ltd. (MHI) has been manufacturing corrugating machinery since 1955. MHI has produced over 700 corrugated board box making machines for customers all over the world. In this paper, we will introduce the further evolution of the "EVOL" series based on the EVOL-84 cutting-edge corrugated board box making machine presented in this magazine in 2005.

2. Corrugated board box making machines

Figure 1 shows the basic configuration of a corrugated board box making machine. The flat corrugated board stacked in the feeding unit enters the machine one sheet at a time. The printing unit prints on the board while it is being transferred by the transfer conveyor. In the creaser slotter unit, the board is creased and slotted to enable folding; it is then glued, folded, and formed in the folding unit. When the sheets finally reach the counter ejector, they are counted and stacked.

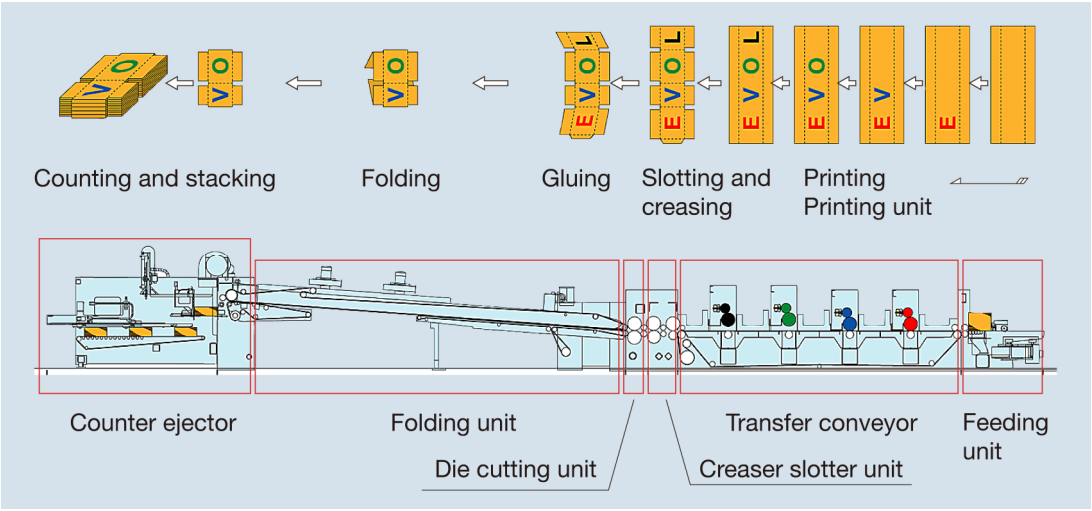

Figure 1 Basic configuration of a corrugated board box making machine
This shows the basic configuration and manufacturing processes of the corrugated board box making machine.

3. Development concept and machine features

The EVOL-84 developed in 2003 had a maximum board width of 2140 mm (84 in). The EVOL-100, with a maximum board width of 2,555 mm (100 in), was introduced to the market in 2006. The EVOL series of machines are highly regarded both in Japan and in the rest of the world, as they are high-performance devices that exceed the performance of conventional box making machines.

The development of EVOL was based on a thorough study of market needs using the theme "the machine that allows the customer to share the advantages." The four main development objectives along with the features and subsequent improvements are explained below.

3.1 High productivity

As a highly-productive box making machine, EVOL is capable of performing the work of two conventional corrugated board box making machines.

(1) Reduced setup time

Corrugated board box making machines can produce up to 100 different types of boxes per day and must be quickly reconfigured for each box type. EVOL is equipped with a fixed frame structure that eliminates frame chucking and releasing that used to create a setup bottleneck. EVOL has an automatic setup structure that requires no operator intervention to set up the next job, achieving a "two-minute set up time by two operators" level of operation. This reduces the setup time by 60% compared to conventional machines.

(2) High-speed

With a production speed of 350 sheets per minute, EVOL is the world's fastest machine for a maximum board length of 870–950 mm. We achieved this by implementing measures such as increasing the strength and rigidity of various parts of the machine, improving the shock absorbing performance to avoid damaging the leading edges of sheets in the counter ejector and redesigning the control system for the main drive motor.

3.2 Production flexibility

(1) Production of small boxes

The need for small boxes is on the rise due to the increase of on-demand logistics approaches. The EVOL-84 has the world's shortest minimum board length, 220 mm, which is unusual for a machine of this size. We accomplished this by redesigning the diameter and configuration of the roll.

(2) Production of bottom lock box

The bottoms of the conventional corrugated board boxes are sealed with metal staples. Recently, however, the demand has been for boxes with bottoms that are closed by interlocking the board flaps to simplify later recycling. This requires complicated shapes of cuts for each box, that catch on each other during manufacturing using the conventional type of counter ejector that stacks boxes up by inserting them on the bottom of the stack, preventing high-speed production. To solve this issue, the original EVOL was equipped with the CE7 counter ejector, which uses MHI's unique stacking system so that boxes can be stacked from the top without problem.

The maximum ejection capacity of the CE7 is 25 bundles/min. However, to meet the needs for more efficient production capacity, a new servo control system was introduced for each part, the structure was simplified, and the operational cycle was reduced. These improvements led to the development of the CE8 counter ejector in 2008 that gives the world's highest processing performance of 35 bundles/min. This is 40% better than the conventional type of ejector.

3.3 Improvement of box quality and reduction of losses

(1) Improvement of printing register accuracy

For the first time in Japan, a one-piece belt type transfer mechanism has been used for the transfer conveyor. Transfer using the conventional roll type transfer mechanism caused some problems, such as the interference of the sheet end with the roll when delivering the sheet to the subsequent printing unit. However, the new mechanism has solved this problem, and with the help of a suction belt that holds the sheets throughout the entire printing process, high printing register accuracy has been achieved.

Figure 2 shows the one-piece belt type transfer conveyor and **Figure 3** shows one example of printing register accuracy.

(2) Reduction of ink loss

MHI's unique chamber type ink doctoring device in the printing unit, which is equipped with some systems including the forced ink collection system in the chamber, reduces the amount of ink lost during color changes by 70% compared to the conventional device.

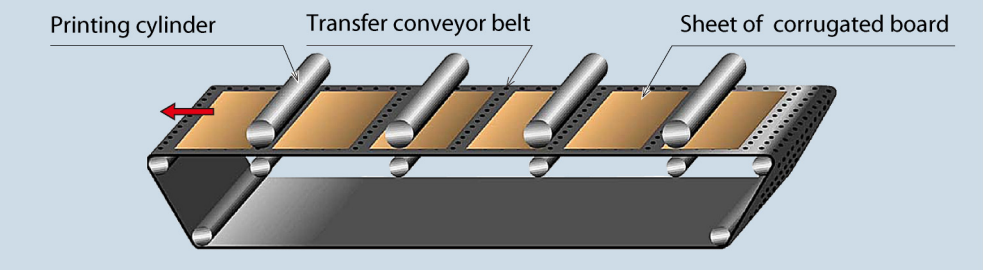

Figure 2 One-piece belt-type transfer conveyor
This patented one-piece belt type suction transfer conveyor has high sheet-transfer accuracy.

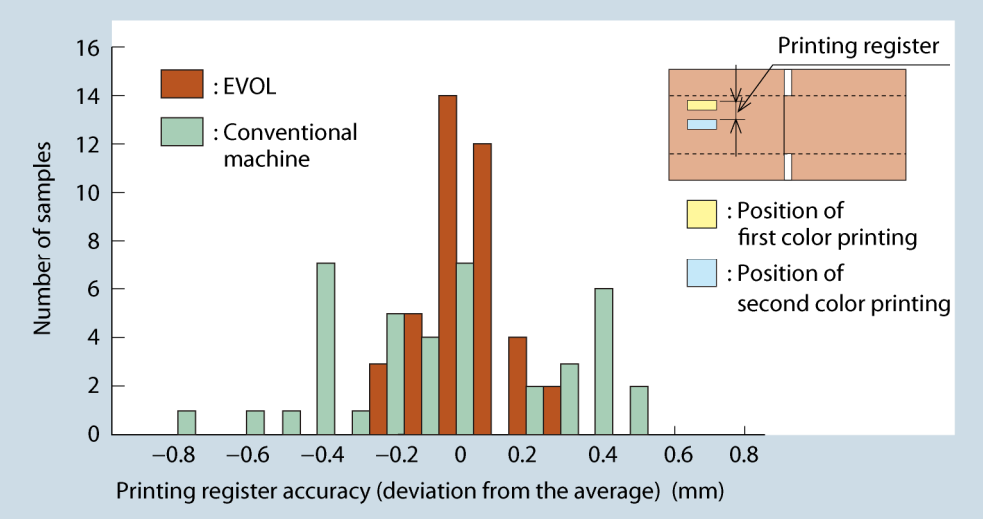

Figure 3 Example of printing register accuracy (comparison with data of conventional type)
Comparison of printing register accuracy for EVOL running at 350 sheets/min. with that of a conventional machine running at 300 sheets/min.

(3) Improved folding accuracy

As automatic boxing becomes more common, high folding accuracy for corrugated board boxes is becoming increasingly important. The EVOL-84, developed in 2003, had excellent folding accuracy, as it was equipped with a special creasing device that adjusts to various different paper types, a gauging roller device, and an automatically adjusted folding guide.

The taper adjusted arrangement for gauging roller was developed in 2006 to meet the requirement for even greater folding accuracy. This gauging roller provides the appropriate corrective force according to the outer dimensions of the box, which change as the folding angle advances. This system has dramatically increased folding accuracy.

Figure 4 shows taper adjusted arrangement for gauging roller.

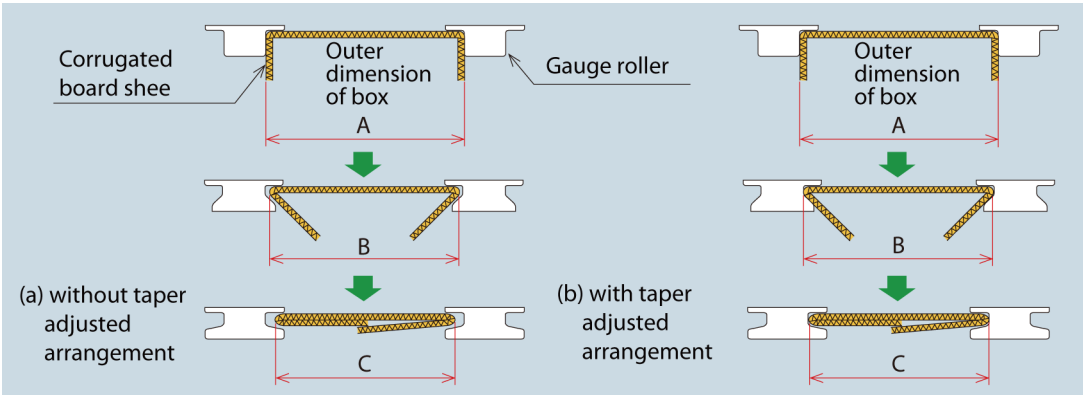

Figure 4 Schematic of taper adjusted arrangement for gauging roller (cross section showing the traveling direction of the sheet)
As the bending progresses, the outer dimensions A, B, and C of the box decrease. Because of this, parallel gauge rollers create clearances, as they cannot exert sufficient force to maintain the sheets in a conventional system. In contrast, the taper adjusted arrangement for gauging roller maintains the appropriate force, as the clearances next to the gauge rollers can be reduced in a tapered fashion.
Example (a) shows the case without the taper adjusted arrangement and the (b) shows the case with the taper adjusted arrangement (patent applied for).

(4) Reduction of sheet loss resulting from ink density

The ink density tends to be higher when printing the first several sheets using a conventional printing unit, and waste thus occurs until the ink density stabilizes. To solve this issue, the ink roll loading device and its control system were improved in 2007. This has resulted in perfect ink density from the very first sheet.

3.4 Improvement of operability and maintainability

(1) Fault diagnostic function

A machine fault diagnostic function has been added to show the location of faults, and indicate corrective action and inspection procedures on a screen.

(2) Preventive maintenance function

A preventive maintenance function has been added to automatically provide a notification for maintenance timings depending on the machine workload.

(3) Remote maintenance system

A remote maintenance system has been added to allow monitoring of the machine's operation over the Internet.

4. Modular design

In addition to the improvements described above, MHI has achieved a reduction in machine installation time using modular design. This was in response to the demands of customers who wanted to reduce down time when installing new machines. We describe the modular design of the folding unit in this section.

4.1 Modular design of the folding unit

Modular design is a methodology for reducing installation time by breaking the entire unit down into units of maximum possible size that require no disassembly, reassembly, or readjustment for transportation, loading, and installation.

The conventional EVOL folding unit was composed of nine modules. It required a long installation period, as the each of the nine modules required reassembly and readjustment at the customer's plant before production could begin. The folding unit we have used since 2008 is made up of only four modules, and this has reduced the time from unloading to production startup from nine to seven days. This reduces the down time when installing new machines.

5. Conclusion

The EVOL series of corrugated board box making machines has been well received by customers. We have delivered 95 EVOL units to customers in Japan and in many other parts of the world. This includes 27 orders from North America in the past three years. We will continue our efforts in the "Evolution" of the EVOL series to meet the current and future needs of our customers and support their production activities.

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