Yamaha Motor Monthly Newsletter

November 15, 2016 (Issue No. 47)

2016

1987 Novem

The Z:TA-R YSM40R is Yamaha's latest surface mounter model and boasts a mounting speed of 200,000 chips per hour (left). Following the 1987 YM4600S model, the YM6000T (right) was the first "chip shooter" model marketed under the Yamaha brand name.

Yamaha Motor Technology Traditions

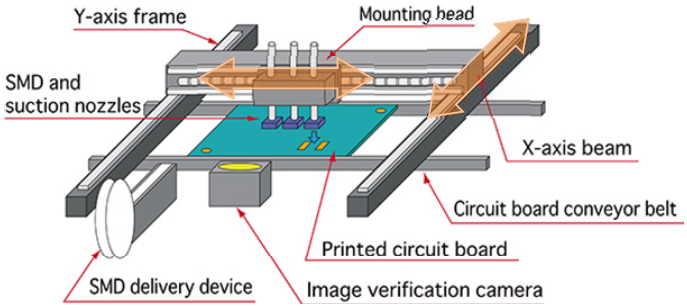
From the YM4600S to the YSM Series

Revolutionizing Circuit Board Manufacturing with Yamaha Surface Mounters

From televisions, air conditioners and refrigerators to lighting, personal computers and smartphones, our lives are filled with a menagerie of electric appliances and electronic devices. But, did you know that Yamaha Motor products are playing an important role in the manufacture of the electronic control units and circuit boards used in these products? Since Yamaha Motor first began making industrial machines known as surface mounters in 1984, the company has continued developing its surface mount technology (SMT) based on original ideas, and the business has grown to put us among the world's top four manufacturers in the field. In the spring of 2016, cumulative sales of Yamaha surface mounters surpassed the 40,000 unit mark. In this issue, we introduce the evolution of Yamaha's SMT products and technology over the course of more than 30 years.

What are Surface Mounters?

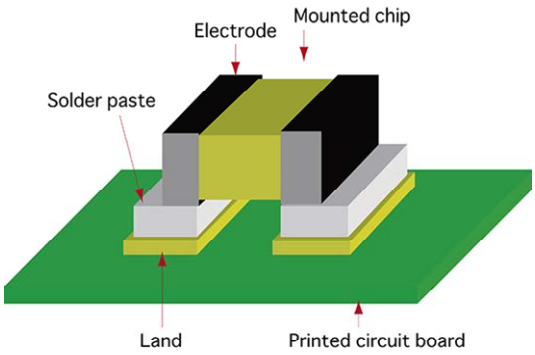
Today, most printed circuit boards (PCB) for electronics are produced with surface mount technology (SMT), which places specially made components for mounting like chips, transistors and diodes to the surface of the board. These are called surface mount devices (SMD). SMT helps create circuit boards that are lighter, more compact and have a higher concentration of SMDs on them.



A diagram of the internals of an XY-axis robot-type mounter. This basic format has not changed over the years.

On a production line for conducting these three processes, surface mounters perform the second role, the essential one of actually placing the SMDs on the circuit board.

The number of SMDs mounted on a typical circuit board is several dozen, but depending on the size, that number can be as much as several thousands. And, the assortment of SMDs is very diverse and can include rectangular/square chips ranging in size from less than 1 mm to several mm, rectangular/square "package" components up to several cm in size, and parts with irregular shapes and sizes.



The diagram shows a chip (SMD) mounted on a circuit board. After this, the solder is melted and then re-solidified to "weld" the chip to the land.

For this reason, many factories increase efficiency by using multiple types of surface mounters on a single production line, with special "chip shooter" mounters capable of mounting a large number of chips at high speed and multipurpose mounters that can handle a wide range of components, from package parts to odd-shaped parts of different shapes and sizes. Both of these types operate in the same way, with the pneumatic nozzle on the head sucking up the parts and placing them one at a time in the prescribed positions on the circuit board.

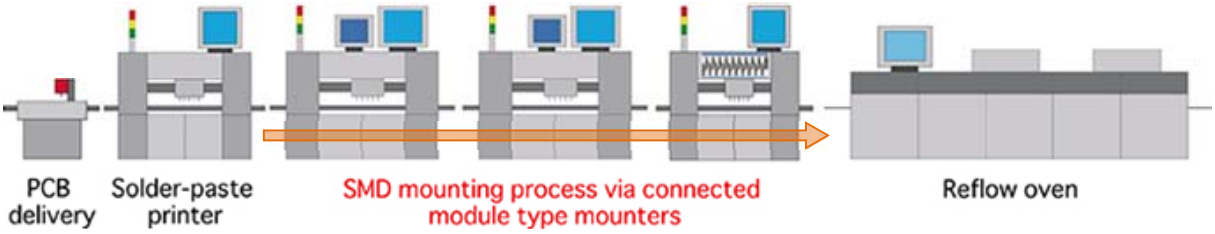
From the 1980s into the 1990s, high-speed rotary-type chip shooters were the mainstream. They were large (up to 5 meters in width and weighing over 4 tons) and used one large rotating head fitted with many nozzles, while the multipurpose mounters in use were XY-axis robot-types with a relatively compact width of about 2 meters.

Entering the industrial robot business in 1984, Yamaha Motor used its technological expertise to develop an XY-axis robot-type multipurpose surface mounter, and began selling it to other manufacturers on an OEM basis (sold under their respective brand names). Then in 1987, Yamaha made a full-fledged entry into the SMT industry by releasing the YM4600S, the first Yamaha-brand XY-axis robot-type chip shooter model. Although not as fast as the rotary-head types, it had the advantages of a simple construction, and was only 350 kg in weight, 1.2 meters wide and 1 meter long at the sides. And, it was mounted on caster wheels so it could be easily pushed to move it from one position to another. This offered manufacturers a lot more flexibility to use several units in-line or to create lines to fit the factory floor space available.

Unexpected Simplicity of the Revolutionary "Module Concept"

When changing a production line according to the type and number of circuit boards to be produced, large and heavy rotary-head type chip shooters required heavy equipment just to move them into place. This incurred additional costs and days of

production stopped, so rotary-head type mounters were unsuited for frequent line changes. Furthermore, each unit was very expensive so it was difficult for many manufacturers to purchase them over time as staged investments.
In contrast, XY-axis robot-type mounters like the YM4600S were easy to move around on lines and cost only about one-third to one-fifth the price of a rotary type. Also, putting three or four of them on a line brought mounting speeds on par with a line with a rotary type chip shooter, so the YM4600S provided greater flexibility to accommodate a wide range of production formats and scales—from high-mix low-volume type production to single-model type mass production—and thus enabled more efficient capability.
Yamaha Motor continued its SMT product development to achieve higher levels of mounting speed and accuracy, and it was always with an additional consciousness of these advantages. This led to the 1996 development of two mid-size models: the YV100 chip shooter and the YVL88 multipurpose mounter. In addition to boasting the industry's fastest mounting speed at the time, they featured the latest "full-vision" image recognition system for part placement accuracy verification (also developed that year), and were built on a platform strategy so they had the same structural layout and external dimensions (approx. 1.6 m x 1.3 m). This enabled Yamaha to follow up with a diverse series of models based on this basic platform.
These models were widely promoted as Yamaha's "module concept" that treated each different mounter as a "module" in a production line. By altering the number of connected systems or the combination of mounters, manufacturers could quickly set up ideal part-mounting processes to create highly efficient production lines.



Depiction of an SMT production line. The true value of the module concept lies in the ease of mobility and compatibility of the mounters when re-positioning them on the production line depending on the circuit boards to be manufactured.

The success of this concept led to solid sales growth for Yamaha surface mounters and prompted other manufacturers to switch to XY-axis robot-type mounters. Eventually, these mounters became synonymous with "module type" mounters in the industry, and entering the 2000s, the rotary-head type chip shooter that had been predominant on production lines had soon disappeared completely.
"We didn't develop the 'module concept' as a means to counter the rotary-head mounter," says a Yamaha employee in charge of planning and development at the time. "It was purely aimed at helping our clients achieve greater productivity in their operations by making it easier and more efficient to form and change production lines. After that, we introduced unified software for our products to further boost efficiency and speed when optimizing the line to best fit the needs of production," he adds.

Leading the SMT Industry with Core Technologies Developed In-House

The first task Yamaha tackled in developing the performance of its individual surface mounters was reworking the mounter head. To increase the mounting speed that was considered the weakness of an XY-axis robot-type mounter and to also deal with the increasing diversity of SMDs, Yamaha developed new types of heads one after another with multiple suction nozzles. They included types that increased the number of nozzles up to 16 in a line, a system that automatically switched between a number of different nozzles, a head with a nozzle with a rotating end piece that could alternate

between six different types of tips, and a system that made use of two heads on the front and back of a single X-axis beam on the robot.

The head assembly has been the object of continuous development and improvement. The photo shows the inline eight-head layout of the 2004 YG100B, with alternating high-precision nozzles for chip placement and nozzles for large or odd-shaped SMDs.

At the same time, Yamaha was quick to employ image processing technology to enable “full-vision” real-time verification of the type, shape and attitude of all the SMDs picked up by the suction nozzles and their positioning accuracy after placement on the circuit board. Furthermore, by employing innovative measures for the image verification system, the number and positioning of cameras, and also making continued improvements, Yamaha was able to achieve high-speed performance without interfering with the movements of the head assembly and increase the accuracy of part placement on circuit boards with higher degrees of part concentration.

Yamaha also applied its industrial robot servomotor control technology to achieve fast, smooth and accurate head motion along the X and Y axes, and for the up-down motion of the nozzles. The robust monocoque frame that withstands the high levels of drive force generated by the mounters was developed with the structural analysis technology and computer mainframes used for designing motorcycle chassis, core technologies mostly developed in-house. Furthermore, the ability to produce most of the main parts and components in-house gave Yamaha engineers greater freedom in the design and development of SMT products, which turned out to be a big advantage that industry competitors could not match.

The latest fruits of all this Yamaha technology and expertise are the Z:LEX YSM20 released in 2014 and the Z:TA-R YSM40R released in 2016. Both of these are module type surface mounters capable of handling chips, package parts and most odd-shaped parts. Thanks to Yamaha’s “1-Head Solution” concept, the YSM20 is a do-it-all model that combines the functions and performance capabilities from the previous four models of the series to enable a single head with the versatility to handle SMDs ranging from 0.3 mm × 0.15 mm chips to odd-shaped parts with a maximum length of 100 mm and height of 28 mm, plus the speed to mount 90,000 chips per hour (CPH).

As for the YSM40R, it is a high-end chip shooter model that can handle extremely small chips down to 0.2 mm × 0.1 mm in size and achieves the world’s fastest speed of 200,000 CPH (as of April 2016, Yamaha survey). Also, by using the three different job-specific heads, it can also mount odd-shaped parts with a maximum length of 100 mm and height of 25.5 mm.

Compared to the YV100 from 20 years ago, the YSM40R has almost the same size and dimensions but a mounting speed about 14 times faster. In other words, one YSM40R—and the factory floor space it occupies—has the performance/productivity equivalent to 14 YV100s lined up to form a production line. What’s more, as a high-performance, high-density module type model with the capacity to handle odd-shaped SMDs, it is a symbol of the evolution of Yamaha SMT based on ease of line formation and increasing productivity. With *Monozukuri* empowered by unshakable concepts, innovative ideas and the comprehensive resources of the Yamaha Motor group, we will surely continue revolutionizing SMT and leading the industry globally.

Yamaha SMT Product Progression

OCM8500 (1984)
Compact XY-axis robot-type multipurpose mounter developed for OEM sales.

Mounting speed: 0.9 sec./chip
Mounting accuracy: ±0.08 mm (QFP)*

*Quad Flat Package: A type of large SMD

YM6000T (1987)
An early Yamaha-brand mounter. Parts picked up by a suction nozzle were mounted on the printed circuit board after positioning by a mechanical centering device.

Mounting speed: 0.6 sec./chip
Mounting accuracy: ±0.2 mm (chip)

YV112 (1992)
Fitted with an inline 16-nozzle multi-head. This was the first model to utilize "full-vision" image processing verification for all SMDs mounted.

Mounting speed: 0.2 sec./chip
Mounting accuracy: ±0.1 mm (chip) ±0.08 mm (QFP)

YV100 (1996)
This model shared parts with the YVL88 multipurpose mounter, like a high-rigidity monocoque construction and exterior dimensions (approx. 1.6 x 1.3 m), and later developed into a wide-ranging series.

Mounting speed: 0.25 sec./chip
Mounting accuracy: ±0.1 mm (chip) ±0.08 mm (QFP)

YG200 (2003)
Despite its compactness and low cost, this model achieved mounting speed and accuracy comparable to large high-speed models.

Mounting speed: 0.08 sec./chip
Mounting accuracy: ±0.05 mm (chip)

YSM20 (2014)
This do-it-all multipurpose mounter brought together the functions and performance of four previous series models under the "1-Head Solution" concept.

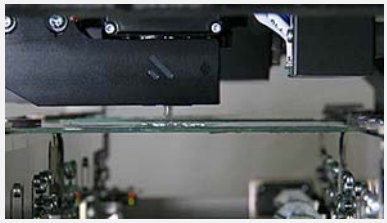
Mounting speed: 0.04 sec./chip
Mounting accuracy: ±0.035 mm (chip)

YSM40R (2016)
This model is capable of handling extremely small chips (0.25 × 0.125 mm) and boasts the world's fastest mounting speed* of 200,000 CPH.

Mounting speed: 0.018 sec./chip
Mounting accuracy: ±0.035 mm (chip)

*Source: Apr. 2016 Yamaha survey

Message from the Editor



Although these are machines you rarely have a chance to see, our surface mounters are truly a product line with indelible Yamaha qualities. Born from in-house needs for compactness and high-mix, low-volume production, they were eventually sold outside the company, where they evolved continually guided by unique perspectives to offer solutions for ever-changing client needs. In the IoT (Internet of Things) age we now find ourselves in, our mounters' speed, precision and versatility to handle ever-diversifying needs will surely be necessary more than ever in the coming future. You can see the amazing speed and accuracy of these surface mounters in action here.

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