YOKOGAWA GROUP'S LATEST SURFACE MOUNT LINES

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Yokogawa Electric Corporation manufactures a wide variety of surface-mount boards, from those for PLCs and other small controllers to large multilayer high-density boards for LSI testers. In addition, it promotes Group-wide global management and therefore has many laboratories, factories and sales offices both domestically and abroad. This paper introduces the latest surface mount technology (SMT) lines of Yokogawa Manufacturing Corporation (YMG)'s Komine factory (located in Akiruno City, Tokyo), one of the Yokogawa Group's main factories. The Komine factory operates round-the-clock, manned for the most part by dispatched employees. The three latest SMT lines utilize information technology and have the flexibility to respond to the limited production of a diversified number of products.

INTRODUCTION

Within a span of not quite one year from January to November, 2005, three surface mount lines (K1, K2 and K3) were newly established at the Komine factory of Yokogawa Manufacturing Corporation in Akiruno City, Tokyo. The Komine factory is one of the Yokogawa Group's mother factories in Japan. These new lines feature state-of-the-art performance specifications among the assembly lines of the Yokogawa Group. They support the Yokogawa Group's high-variety low-volume production of circuit boards, from small boards to large high-density multilayer boards. In recent years, companies have accelerated the shifting of production to locations overseas, as typified by the situation in China. Moreover, in Japan in-house machine operators are being increasingly replaced by personnel dedicated to machine operation (temporary employees). These highly advanced mounting lines have been realized by actively focusing on the introduction of IT to production lines with the theme of ultimately realizing non-skilled operation capability. Yokogawa plans to deploy mounting lines same as these to the Yokogawa Group's production sites in Japan and abroad. Figure 1 is a photograph of one of these lines.

*1 Sourcing and Manufacturing Business Headquarters

CONFIGURATION AND FEATURES OF SURFACE MOUNT LINES

The following describes the configuration of the Komine factory's K2 mounting line (Figure 2) and its features:

(1) Support of small boards to large high-density boards
The mounting line supports a wide range of circuit boards, from small boards sized 90 (L) × 80 (W) ×1.0 (T) mm, up to large boards sized 500 (L) × 390 (W) × 4.5 (T) mm and weighing up to 3.0 kg. Thus the line covers circuit board specifications for all of the Yokogawa Group's existing products.

(2) Four interlinked modular mounters with the latest specifications
Four modular mounters with the same specifications are interlinked to support the mounting of ultra-small 0603-size

Figure 1 Komine Factory's K2 Surface Mount Line

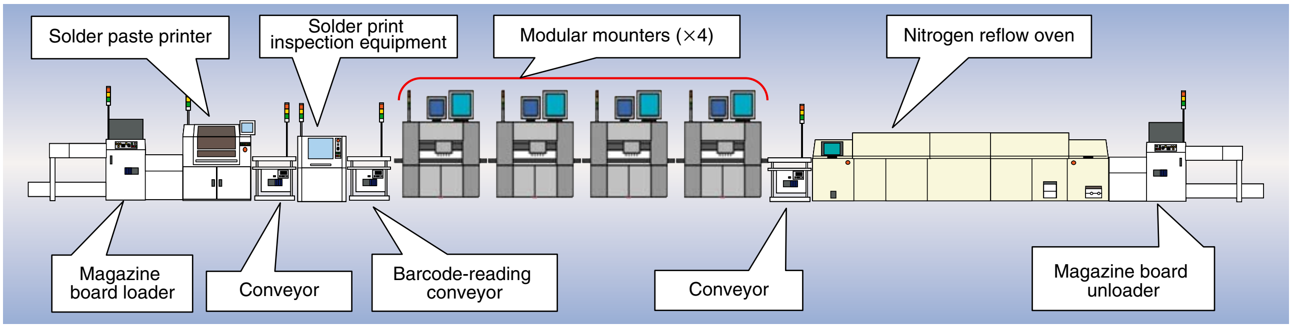

Figure 2 Komine Factory's Surface Mount Line Configuration

chip components and square 45-mm QFP, BGA and CSP devices, as well as atypical components such as connectors. Thus every mounter can deal with all types of components. This strategy has made it easy to optimize machine-to-machine tact balance, achieving high productivity with all machines in full operation. At the same time, this strategy has reduced the risk of production line shutdowns.

(3) Advantages of pluralizing the same mounting line
Pluralizing the same mounting line has eliminated the production setup work involved when exchanging models to be produced between mounting lines.

(4) Consistent quality of lead-free soldering
The mounting line meets the requirements for lead-free manufacturing that is currently in high demand. In addition, in-line solder print inspection equipment has been introduced to prevent in-process defects from inadvertently advancing to the back-end process. The nitrogen reflow soldering ovens employ a combination of 12 zones and water-cooling units to assure consistent soldering quality.

(5) IT-driven fully-automated setup changes
By applying information technology to the entire mounting line, setup changes can automatically be made to mount data, backup pin positions, determine widths of conveyance, and set reflow temperature profiles. In addition, the mounting line has the most advanced functions, such as controlling the remaining quantity of parts, preventing part setup mistakes, tracing back production history and the capability to command the startup of planned work.

MOUNT DATA GENERATION PROCESS

To generate mount data, a data generation environment common to all of the companies in the Yokogawa Group is used. The mount data generation system obtains the necessary circuit board and component mounting information from CAD (computer-aided design) and PDM (product data management) information which is available from databases to automatically synthesize these blocks of information. For the optimized allocation of parts to the mounting machines, the system performs computations so that the mounting time of each machine is minimized and the machine-to-machine mounting time is the same. The system thereby minimizes throughput time in continuous production.

NETWORK CONFIGURATION OF MOUNTING LINES

Figure 3 shows the mounting line network. Major equipment components, such as the solder paster printers, and solder print inspection equipment and mounters, are interconnected by a dedicated network to achieve centralized data management. This strategy has made it easy to maintain and back up mount data. Moreover, it has also made it possible to instantaneously and collectively apply the results of additional data generation or make changes to all of the lines with just a single round of data processing.

The IT option server is responsible for controlling the IDs of mount data, parts, production information and circuit boards, and for managing the information necessary for production. The barcode-reading conveyor reads information about the models being produced contained in barcodes that are affixed to the circuit boards. The conveyor thereby transfers parts information and mount data required for each individual mounting machine.

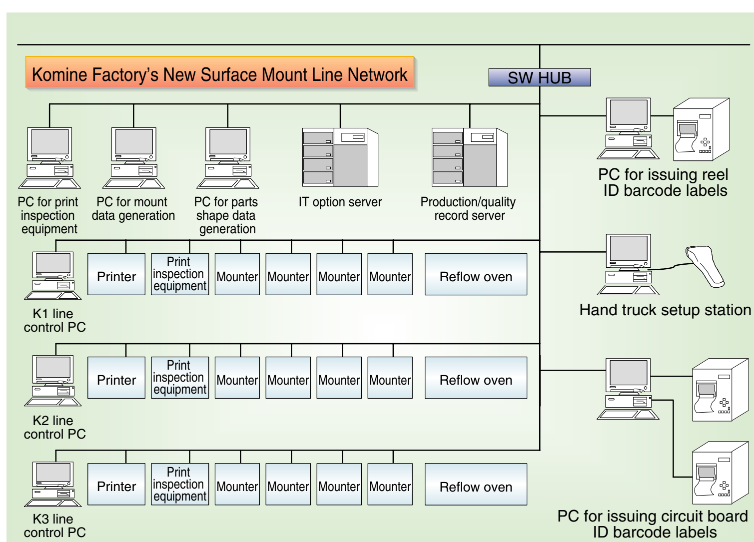

Figure 3 Komine Factory's New Surface Mount Line Network

Figure 4 Unloader and Coupled Hand Trucks

Figure 6 Hand Trucks for Setup Change

The production/quality record server is responsible for acquiring records of production and quality, such as information on mounted parts and availability factors. This server acquires quality information including production results and failure rates in real time.

OUTLINE OF SYSTEM COMPONENTS

The major components of the system are outlined below:

(1) Magazine loaders/unloaders for circuit boards

Two types of magazine racks are used with the magazine loaders/unloaders, i.e., those for M-size boards no wider than 250 mm and those for L-size boards wider than 250 mm and up to 390 mm wide. The use of two types of racks has improved operating efficiency and the use of space. When large-size heavy magazine racks are used, they can be transported safely by coupling hand trucks (Figure 4). Yokogawa Electric's FA-M3 programmable logic controller is used to control the magazine loaders/unloaders, and is capable of automatic board width adjustment and barcode reading based on the magazine rack size.

(2) Solder paste printers

Since these printers meet lead-free soldering requirements, it is easy to replace the printing squeegee. They also support closed squeegee installation. The printing cycle time per L-size circuit board is as short as approximately 20 seconds. These printers output circuit board information to the back-end process and the back-end conveyor automatically adjusts the board width.

(3) Cream solder print inspection equipment

To prevent solder print failures, which are said to account for more than 50% of mounting failures, from inadvertently advancing to the back-end process, the system performs 100% post-printing tests. The shared use of the inspection database ensures the same inspection quality among the mounting lines. Inspection data can be generated in a short period of time by downloading CAD Gerber data and part coordinate data. Inspection quality can be totalized automatically and monitored online.

(4) Modular mounters

The modular mounters read the barcode labels that are affixed to the circuit boards to automatically change the board width and model. Barcode readers (BCRs) are placed on both the part side and the solder side to automatically detect the parts-mounted side (i.e., topside or backside). Mount information read by the first mounter is transferred to the subsequent mounters. The last mounter feeds temperature profile, board width and other information to the reflow ovens (Figure 5). Four mounters of the same type capable of placing various parts, from 0603-size chip components to square 45-mm GFP and BGA devices, are interlinked to achieve the shortest throughput time with the optimum equipment layout, meeting the requirements for non-skilled operation. Collective setup changes can be made to feeder-fed parts using hand trucks (Figure 6), to tray-fed parts using parts tray carriers and to stick-fed parts using multi-stick feeders. An external setup station is available in order to set parts without work stoppage the mounting lines.

To prevent faulty parts settings, intelligent feeders and pallet barcodes have been adopted. Reel-fed parts and tray-fed parts

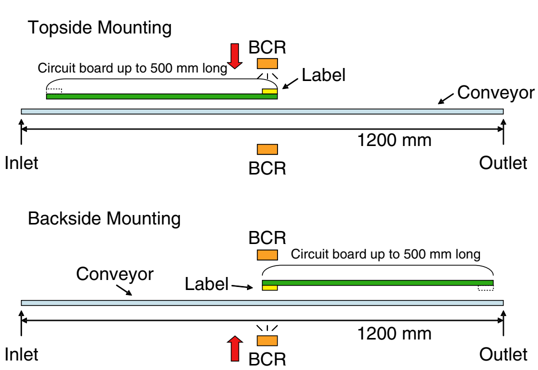

Figure 5 Detection of Parts-mounted Sides (i.e., Topside or Backside)

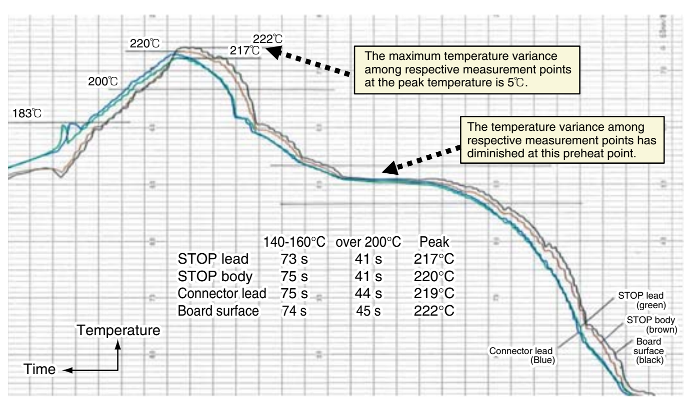

Figure 7 Temperature Profile of Large Circuit Board (390 [W] × 500 [L] ×3.2 [T] mm)

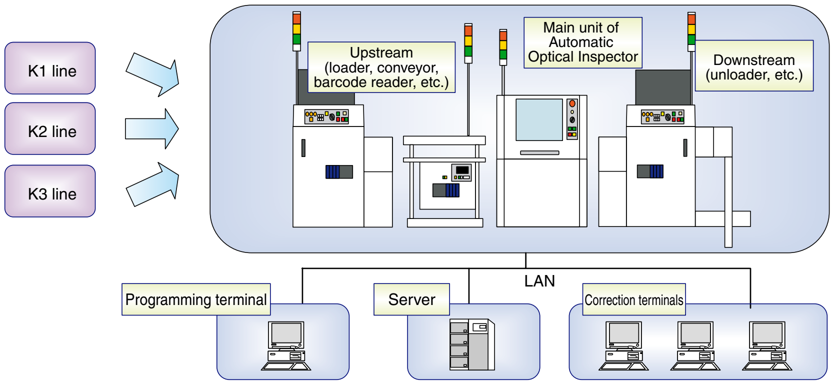

Figure 8 Solder Joint Inspection Equipment

are respectively associated with the feeders and pallets in the database. The mounters automatically check parts with their placements when hand trucks and/or tray carriers are set up. If any disagreement is found, the feeders issue a warning accordingly to prevent faulty parts setting. In addition, the mounters constantly check the remaining quantity of parts (reacting when there is only approximately 5% of the full quantity), and before the lines stop due to the exhaustion of parts, the mounters give prior notice of the necessary information such as part numbers and stocking racks, enabling the advance preparation of parts. As a traceability function, the system logs the mounters' full mounting information in real time (e.g., what error has occurred in which part, at which board, and with which nozzle). The log data can be accessed at any time from a personal computer on the network by typing a date or board ID as the search key. As a result, it is possible to make quality improvements on the same day or to search board-by-board production records (e.g., which board was loaded with parts at what time and when the part in question was replaced).

(5) Nitrogen reflow ovens
Each reflow oven is equipped with a combination of 12 zones and water-cooling units to deal with small circuit boards with low heat capacity, and up to large 4.5 mm thick circuit boards with high heat capacity. For large circuit boards, the ovens are equipped with bar units for automatic warpage prevention. For reference purposes, an example of the temperature profile used for large circuit boards is shown in Figure 7. The reflow oven receives model information from the upstream mounters to automatically set temperature profiles. In order to eliminate time loss when changing the temperature profiles, the board transport speed is varied and a hot-air heater method is applied, thereby maintaining the temperature. This strategy enables temperature profiles to be changed in a very short time.

(6) Automatic Optical Inspector
The solder joint inspection equipment can check 1005-size chip components for "floating" and test 5,000 parts in a matter of 3 minutes (Figure 8). It is thus possible to inspect the K1 through K3 lines with just one unit of equipment. Figure 9 shows examples of nonconforming components that were detected using this equipment. Like the mounters, the system employs a method of creating testing programs based on parts shape libraries rather than on board-by-board testing programs. This method makes it easy to switch from one board model to another as well as to cope promptly with sudden board revisions. Solder joint inspections unavoidably involve false reports (excessive decisions). By making a dedicated correction terminal (rework station) available, it is possible to quickly recheck the falsely-reported circuit boards. In addition, retaining judgment records created by both equipment and humans has increased inspection accuracy.

CONCLUSION

Modern mounting lines are not merely a procession of interconnected machines, but are instead a system of machines including an information network, all of which are organically interlinked. Thanks to the evolution of hardware and software for control technologies as typified by personal computers, surface mount lines have evolved into completely different production systems from those seen in 1987 when the Yokogawa Group first became involved in surface mounting. While the introduction of information technologies has enabled non-skilled operation, managers responsible for mounting lines are required to have extensive knowledge and a grasp of technologies encompassing both hardware and software. At production sites, there is therefore a growing need to cultivate system engineers.

In addition, there is a pressing need to address system risk management and preventive maintenance, including preparedness against control system failures such as application errors and server failures. ◆

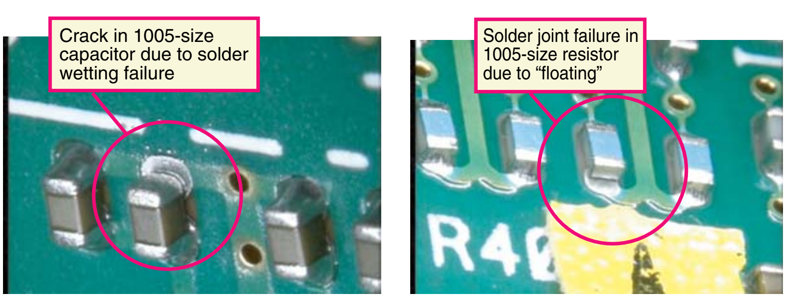

Figure 9 Examples of Nonconforming Parts

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