THREE BOARDS IN A FOUNTAIN...

Retrofitting a robot to accommodate a new soldering process helps Rockwell engineers solve an assembly challenge.

NEW TECHNOLOGY IS like a coin. Heads—it brings benefits that create a better product. Tails—a unique product configuration brings daunting production challenges.

This was the situation at Rockwell Automation's plant in Sumner, IA. One of the key products built at this facility is a variable-speed AC drive. This high-volume product is manufactured in two drive sizes: a 3 HP model and a 5 HP model. The key to their reliability lies in their design, which incorporates an innovative technology, patented by Allen-Bradley, called "board in board."

This technology revolutionizes how printed circuit boards (PCBs) interact. Instead of standard male-female connectors, board-in-board PCBs have interconnecting tabs and slots for electrical contacts. There are no connectors or pins. The edge of one board has tabs, and the mother board has mating slots that go right up to the edge of the tabs. When the boards are inserted together, these tabs must be soldered to provide an electrical connection.

The primary benefit of this technology is that it saves board space by eliminating through-hole connectors. This provides more real estate for functions without enlarging the product's dimensions. It also enhances product reliability.

The challenge comes in soldering the tabs. The tabs are similar to the pads on surface mount devices. However, unlike leads for individual components, which have consistent process times, some board-in-board tabs require a 1-second dwell time while others require a 4-second dwell time. In addition, the tabs are all on the same side of the board edge, and only 0.024 inch separates the pads. This is the perfect setup for a formidable soldering process headache.

A new variable-speed AC drive presented an assembly challenge to manufacturing engineers at Rockwell Automation.

Reviewing the Soldering Options

Rockwell's Sumner plant is not a small facility. Production lines incorporate many automatic and semiautomatic processes, including variations on the soldering process. There were several soldering processes in-house to consider. Two robotic workstations provide automatic selective soldering for most products assembled at the plant. This was the most obvious method to try first, because of the programmability of the robots. However, for

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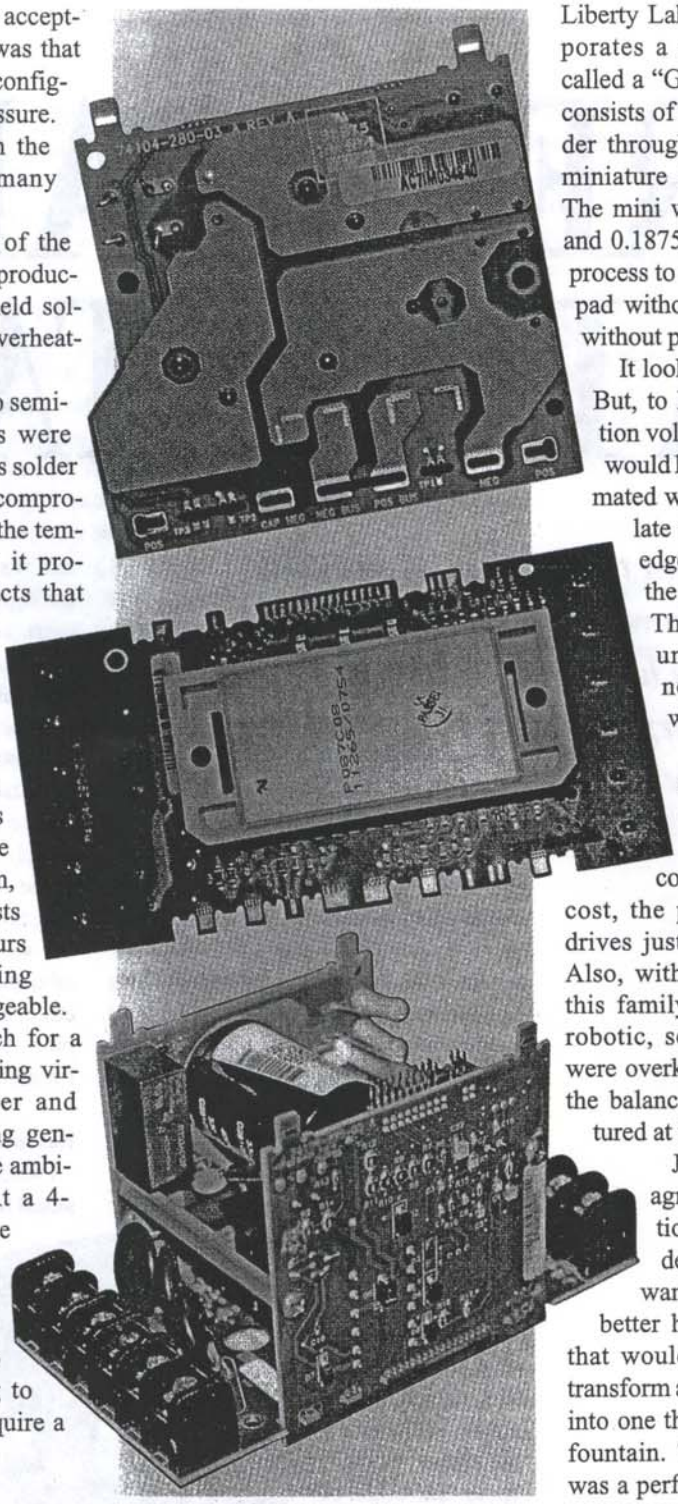
various reasons, it was not an acceptable solution. One key factor was that the tabs of the board-in-board configuration could not tolerate pressure. Even the slight pressure from the soldering iron delaminated many pads.

Manual soldering was out of the question. Aside from the sheer production volume required, a handheld soldering iron is highly prone to overheating due to human error.

As a temporary solution, two semiautomatic solder pot systems were drafted to solder the drives. This solder dipping process represented a compromise answer to the problem of the temperamental dwell times. But, it provided variable results. Products that came up with overprocessed leads or leads that were not well-wetted had to be reworked and functionally tested. Obviously, this entailed additional costs. Sometimes, quality defects were as high as 15 percent to 20 percent. The defect rate went up and down, and so did the production costs because of the extra man-hours spent repairing and retouching rejected drives that were salvageable.

In the meantime, the search for a compatible process was covering virtually all possibilities. Laser and microflame selective soldering generated too much uncontrollable ambient heat for this product. At a 4-second dwell time, these processes could potentially char the board. Because of the close proximity of the tabs, there was also a chance of too much ambient heat spreading to adjoining pads that did not require a 4-second dwell time.



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ATExpo Provides the Solution

While researching options, Rockwell engineers remembered seeing a new soldering process at a recent Assembly Technology Expo. Developed by Robotic Process Systems Inc. (RPS, Liberty Lake, WA), the process incorporates a miniature solder fountain called a "Gaussian" wave. The process consists of a solder pot that pumps solder through a tiny nozzle, creating a miniature fountain of molten solder. The mini wave is only 0.25 inch high and 0.1875 inch wide. This allows the process to wave-solder each individual pad without undue ambient heat and without putting pressure on the board.

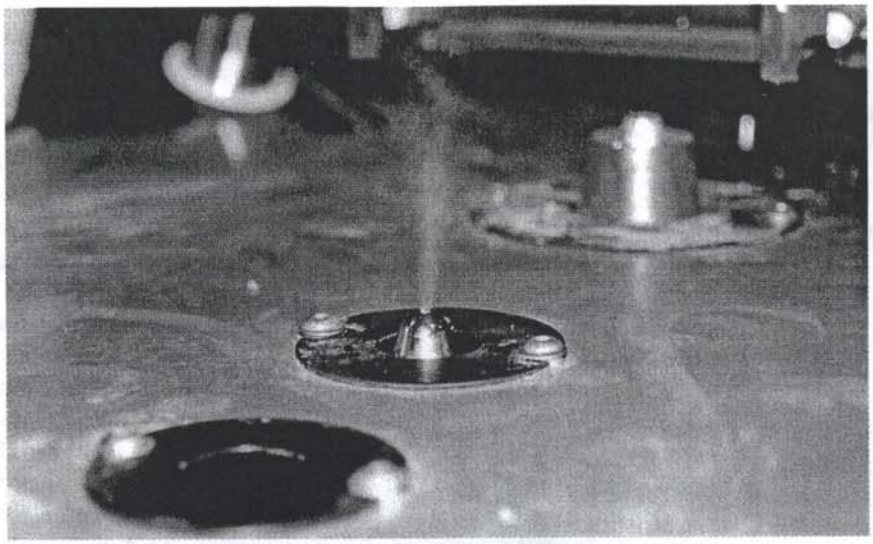
It looked like the perfect solution. But, to handle the required production volume effectively, this process would have to be part of a fully automated workstation that could articulate the drives so the two board edges could precisely approach the solder fountain for each pad. This could be a very costly undertaking, and Rockwell needed to contain the cost without sacrificing efficiency.

If one of the existing robotic workcells could be retrofitted with the solder fountain technology, and it could be done at a reasonable cost, the production volume of the drives justified the changeover cost. Also, with the new configuration of this family of drive controllers, two robotic, selective-soldering stations were overkill. One could easily handle the balance of product mix manufactured at the facility.

Jess Baker, president of RPS, agreed that the drive configuration was well-suited to the solder fountain process. But, he wanted to test samples to get a better handle on the modifications that would be needed to effectively transform a single-point soldering robot into one that could work with a solder fountain. The solder fountain, itself, was a perfect match for processing the unusual tabs.

Understanding Solder Fountain Technology

The dynamic wave technology uses a pump assembly to create the solder



A nozzle sprays flux onto tabs before they pass through the solder fountain.

waveform. This waveform is created using a closed-loop servomotor and impeller. The solder is directed horizontally down a 5-inch long channel to a position where it is directed upward 4 inches through a 0.5-inch diameter nozzle. Attached to the top of this nozzle is a solder nozzle that generates the proprietary Gaussian wave. The characteristics of the Gaussian wave are adjusted by controlling the speed of the motor, as well as the configuration of the second nozzle, which is typically site-specific.

A shroud surrounds the solder nozzle. This is used to direct nitrogen around the nozzle and its working area. The nozzle assembly is 16 inches long from the motor end to the mounting space, 7 inches tall from motor bottom to nozzle top, and 3.75 inches wide at the motor mounting plate.

There were some design challenges, particularly in the solder nozzle area, to automate the process for consistent repeatability. In the end, the single-point soldering process was successfully swapped out for solder fountain technology.

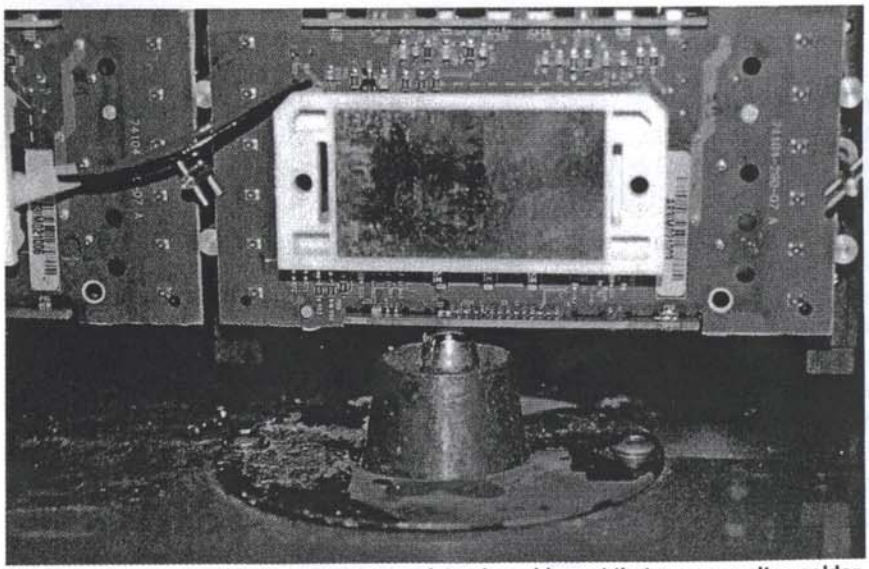
Retrofitting the Workcell

In reconfiguring the workcell, the positioning system remained the same. The soldering head was removed and the solder pot with the pump, the nozzle and the associated equipment was added. A nitrogen generator was also built in. This device extracts nitrogen from the surrounding air and supplies a high-quality stream of the gas around the solder nozzle. This saves the added cost of installing an external nitrogen tank and all the environmental concerns that go along with it. Flow rates of the nitrogen are crucial to the characteristics of the Gaussian wave, the diameter of which can be adjusted from 0.0625 to 0.375 inch.

The system is equipped with two, easily exchanged fixtures. One fixture holds three of the small frame size, and the other fixture holds two of the large frame size. It takes approximately 30 seconds to change the fixtures and 5 seconds to change the program, so changeovers from one drive type to another are very quick.

An operator loads the drives into the fixtures and pushes the start button. Then, rotating the drives within the fixture, the robot passes the drives over a nozzle that sprays flux onto the areas to be soldered. After they're fluxed, the drives are carried to the solder nozzle. The robot passes them through the soldering process, rotating the boards so each pad gets passed through the solder wave. Because both sides of the drives must be soldered, the robot rotates the boards 180 degrees, passes them over the flux nozzle again, and returns to the solder nozzle to complete the soldering. The boards then move to an area for unloading.

Programming is handled through Windows-based software. The operator selects a program, hits the enter key, and then uses the arrow keys to tell the solder robot to execute that program. The overall system is versatile. With



The Gaussian wave soldering process consists of a solder pot that pumps molten solder through a tiny nozzle, creating a miniature fountain. A robot passes PCBs through the miniature wave.

some new tooling and a little programming, the station can adapt to virtually any product that can be processed using solder fountain technology.

The system is only a few months old and is still going through the qualification process, as required for all new production equipment at Rockwell. Approximately 100 drives have been processed, and all have been perfect. To date, we have not seen bridging, gaps or other soldering problems with the new system. The average product cycle time is 1 minute per drive—more than 20 seconds faster than the solder dipping process. It also appears that the added costs of repair and rework will be virtually eliminated as soon as full production can be turned over to the newly retrofitted workcell.

Even the slight pressure from the soldering iron caused many pads to delaminate.

The robotically soldered drives have passed highly accelerated life testing. The boards were cycled through temperatures of -40 to 110 C and vibrated from 8 to 15 G. In addition, 50 drive assemblies successfully completed 500 hours of burn-in testing at 50 C. This is part of Rockwell's rigorous qualification testing for new processes.

Retrofitting Brings Savings

By retrofitting an existing automated system, Rockwell saw a 65 percent savings over the cost of building new equipment. In actual configuration, selective soldering is very different from solder fountain technology. The only thing they have in common is the result—something is soldered. How they work and the apparatus parts involved are totally different. Yet, changeover was accomplished successfully and cost effectively.

With a little analysis of production needs and comparison of applicable technologies, it pays to look at in-house equipment when defining a new process. Depending on the type and configuration, most existing automated process stations can see equal or higher savings through a relatively straightforward exchange process. This can save manufacturers substantial money, while upgrading to the latest in production technology for any automated area on the assembly line.

For more information on variable speed drives or retrofitting equipment, call Rockwell at 319-578-2215. For more information on solder fountain technology, call Robotic Process Systems Inc. at 509-891-1680. □