Can today's depanelers cut it?(depaneling printed circuit boards)

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Depanelization is the post-assembly process that separates individual PCBs from multiple board arrays called panels. Separation is done by cutting away the tabs that hold the PCBs in the panel from either bottom or topside.

Manufacturers panelize their boards to optimize their in-line production equipment. This occurs in surface mount and mixed technology production lines from initial screen printing through test. "Depaneling is necessary at the end of the production cycle so the final circuit board can be made a part of the finished product assembly," says Ron Corey, president of Fancort Industries in West Caldwell, N.J. "A clean, consistent cut is necessary so that the board 'fits' into the assembly for which it is intended. The depanelized board should also have clean edges without any damage to components near the points of separation, or there may be mechanical or electrical problems after final assembly."

Six ways to singulate

There are six principle ways to efficiently singulate and depanel PCBs after assembly. "Two of the most common methods for depaneling low-volume PCBs are to bend pre-scored boards by hand or place the edge into a jig to hold while pressure is applied by hand," says Klaus Heimann, president of FKN Systek in Framingham, Mass. "The second method is to break tab routed boards with mouse bites by hand or with a hand-cutting tool. This method can make sense for very low-volume production with PCBs that have no surface mount components on them. Because bending PCBs causes deformation of circuit traces and components, as panels get thinner and smaller, and are populated with more SMT components, it becomes necessary to find better methods to separate the individual panels from the main array."

Heimann believes four better methods are:

* The use of sharp circular/linear blades to crush the remainder material on a pre-scored board.

* Punch system to cut tabs on a tab-routed board.

* Diamond blade or carbide saws for cutting boards with overhanging components or boards with no score-line.

* Routers for tab-routed panels.

Making the best choice

All depanelers and depaneling methods are not the same; neither in cost nor final result.

Each method has distinct advantages and disadvantages. The selection of a depaneling method is dependent on a variety of factors, including capital cost, labor cost, speed and quality.

"The top-of-line depaneling solutions include either stand-alone or inline punches, NC routers, and NC saws," says Chip Gill, product manager of depaneling systems at IPTE LLC in Alpharetta, Ga. "These top-of-the-line depaneling machines are more frequently used on high-volume, high-value assemblies, where quality and throughput are primary concerns. Top-of-the-line systems are robustly constructed to provide longer tool-life, higher throughput, lower maintenance and longer equipment life."

Often, the finished board determines which depaneling method to be used. "We currently have an application for an aerospace electronics assembler with a very expensive, tab-routed board that has gold plating along the edges of the board," says Corey. "A requirement for this finished board is to remove the tabs with a tolerance of +.005 in./-.000 in. They currently do this by hand and are incurring significant labor costs. The finished product is not up to the customer's quality expectations. A router with CAD software programmed to cut with these tolerances, minimal stress and a clean board edge is the only answer."

Stand-alone (batch) machines and in-line depanelers are available depending on customers' needs. Many considerations must be weighed when choosing. "The cost of manpower will play a major role in this decision," says J.B. Byers, senior applications engineer at PMJ automec Corp. in Longmont, Colo. "Normally the cost of tooling will be less with stand-alone machines, so short run or R&D products may not be cost justified to run on in-line machines. Where as high-volume products may be better suited for in-line depanelers. Most stand-alone machines are more tolerant of large, tall or odd-shaped components.

Emerging technologies

Today's complex board shapes and smaller sizes are driving emerging technologies in the depaneling industry. "Issues of stress to solder joints on surface mount components along score lines is a prescription for board rework," says Corey. "The need to drive costs down has manufacturers using as little scrap on the panel as possible, and this means increased component density, and more stress risks. Product life cycles are also shrinking, which means manufacturers need equipment with considerable flexibility for depaneling the boards that make up the heart of the equipment. At Fancort, we've seen small boards measuring 1" x 1" in an array of 100 boards that require depaneling, and each board has parts near the edges."

Innovative depaneling developments can increase assembly capacity while decreasing scrap by gently removing unwanted board and panel materials. "Today's depanelers can be fully automated machines integrated within the test or final assembly process," says Byers. "This will remove the human error factor from the process. Depaneling manufacturers are using the newest software for easier, quicker programming and simplified user interface. Change over from one product to another is much faster and less labor intensive."

One of the newest emerging technologies is the release of sawing technology. This allows material removal to occur three to five times faster than was previously possible with routing. The thickness of the blade used for sawing is much thinner than average router bits, thus allowing smaller street widths, which will mean much better use of PCB material.

"This can also allow boards that had been designed as a V-score to be depaneled using

a saw," adds Byers. "This will eliminate the damage that can be done to boards when they are broken along the V-scores. Some of these problems include delaminating and breaking off small surface mount components. Depaneling machines have also made great strides in reducing the cost of tooling and making that tooling much more robust and flexible for the electronic assemblers of today."

Depaneling's accuracy has improved too. Smaller sizes, denser designs, and ever-tightening locational and dimensional tolerances have driven the need for more accurate machines and higher quality tooling. "Some depaneling systems now include cutting-program adjustment based on fiducial locations, optical inspection and measurement of singulated product, and cutting tool wear detection," says Gill. "An additional concern caused by small PCBs is the necessity to hold the separated piece during and after the cutting process."

Speeds and feed rates

To meet the accelerated production rates of today's modern assembly lines, depaneling must meet line cycle times or multiple stations may be required, along with the associated handling equipment. Cutting speeds and feed rates have a direct reflection on unit-per-hour capabilities, finished edge quality and cutting tool life.

"The most commonly used feed rate for NC routers is 120 in./minute through FR4," claims Gill of IPTE LLC. "Typical sawing feed rates are considerably faster at 480 in./minute. Another advantage to sawing is that it requires less board 'real estate', resulting in overall lower cost. All speeds are directly related to the cutting tool, material thickness and composition. Different tools can work at different feed rates and different rotational speeds. Cutting tool manufacturers' recommendations are normally starting points from which the user can further optimize the process."

Separation anxiety

High-tech, panelized PCBs require a precise, stress-free separation process to prevent damage to PCBs and line operators' nerves. Quantitative data exists which can offer a comparison of stresses induced by the various depaneling methods. "Epoxy/fiberglass laminate is a very tough material," says Gill. "The processes which tear, shear, or punch through FR4 impart higher stresses than those which actively cut the material, such as routing or sawing. Higher stresses are more likely to cause damage to components and solder joints." A fractured solder joint or capacitor can not always be detected in the test process, and can lead to latent field failures and associated warranty costs.

Assemblers can help prevent depaneling from damaging boards by working with their design department during board design and layout. "Keep components at least 0.5mm from the score line," cautions Corey. "Put tabs into in-line positions if possible. Put the tabs in some type of symmetrical matrix that allows for increased speed when routing."

In addition to the stresses present during depaneling, there are also dust removal and ESD protection issues. Static charge, generated by router-bit's cutting material and vacuum airflow, is a localized phenomenon. However, "This is usually managed by the use of conductive materials, ionized air and by adding a braided copper ground cable to the inside of the vacuum hose," says Petri Kosonen, material processing engineer at JOT Automation Inc. in Irving, Texas. "But even more troublesome, is the attraction of dust particles when static charge is present. This will cause malfunctions of final products or additional cleaning process will be needed in the production line. It is obvious that this cannot be a solution in today's manufacturing line so integrated ESD control is vital in the whole production line."

Dust removal and dust control must be implemented at depaneling stations. Kosonen believes that on most routers the router-bit is surrounded by a vacuum foot, which usually holds a bit-concentric router brush. An up- or down-cutting, chip-breaker routing-bit is most commonly used to draw the cuttings into the vacuum airflow. This design can generally remove most dust and is also one part of the whole dust evacuation system.

The worst and most expensive type of failure is product failure. "Depaneling is not a glamorous process and often is not given the consideration of other machine types," says Byers. "However, when carried out correctly it results in increased productivity, quality and ultimately profitability. Circuits are not getting simpler or less intense -- depaneling systems represent a small investment in product protection and productivity."

Board depaneling will continue to be a critical element of electronics assembly. New and improved depaneling machines are emerging, bringing with them a reduction in rework, operator fatigue and lowered assembly costs.