Improving Screen Print Efficiency, Speed and Accuracy

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Most SMT Process engineers can easily describe two major elements controlling the success of the surface mount process, but often overlook a third critical factor. Typically, they name solder paste and stencils, but the lowly squeegee blade is almost never considered to be of importance in the surface mount process. In fact, squeegee blades are often the items of least concern when considering a multimillion-dollar SMT assembly line, however, this often overlooked item can significantly effect the total process, productivity, and production line efficiency.

Historically, plastic or polymer squeegee blades were the only tools available for printing applications until metal squeegee blades were introduced in the late 1980s for SMT solder paste printing. The polymers tend to be softer and more flexible, leading to scooping and scavenging solder paste from the aperture — resulting in insufficient solder joints. In addition, there is always concern about squeegee blade sharpness with polymer (polyurethane) squeegees, a problem that is not typically associated with metal squeegees.

Basically, the duller the squeegee, the more pressure will be required to thoroughly wipe the stencil, and the longer it will take a solder paste to print at an acceptable squeegee pressure. In addition to edge sharpness, the thickness of the blade and its resulting stiffness will directly influence the print quality, print angle, and print speed.

Blade Edge Sharpness

Blade edge sharpness impacts overall print performance. Competitive blades with pronounced radiused edges are prone to a “hydroplane” effect and require more pressure to obtain a clean wipe. The radiused edge decreases the print angle at the tip of the blade and reduces the process window for printing with high-viscosity solder paste and epoxy formulations. A good analogy is the question: “Which will clean your car's windshield better, the old dull windshield wipers or the new sharp wipers?”

It has been shown through independent testing that stiffer and sharper squeegee blades result in lower wiping pressure, faster printing speeds, finer pitch print resolution, and improved solder paste deposition. The increased print speed naturally improves throughput and production line efficiency, while the finer print resolution allows smaller print geometries. The better paste deposition reduces the solder bridges and rework. The reduced wiping pressure increases stencil life and reduces stencil damage.

High-Tack Printing

High-tack solder paste printing is often desirable for the SMT process since it tenaciously sticks to the pad of the PC board to form a well-defined and consistent solder brick. High-viscosity solder pastes are desirable, but printing efficiency may suffer due to decreased print speed and defects experienced in the SMT printing process. The high tack solder paste readily sticks to most metals and coated blades. This stickiness is termed "curtaining." To prevent the tacky paste from sticking to the squeegee, it is typically constructed with a low surface energy material, and many appropriate materials and coatings are available. These include Teflon particles entrapped in nickel plating, titanium nitride coating over spring steel, and electroplated nickel. All squeegee coatings are susceptible to chipping and flaking. The squeegee coatings which flake or chip off might become entrapped in the solder joint and create a low reliability solder joint or solder void.

In all cases, the surface of the squeegee blade is rough, thus increasing the effective surface energy. The increased surface energy results in increased curtaining and solder paste sticking to the squeegee's surface and collecting on the blade and holder. This solder paste fouling of the print edge prevents a clean print stroke and requires application of additional solder paste to compensate for solder paste stuck to the blade holder and printer hardware. As a result, the operator must take additional time to clean the equipment in an effort to maintain consistent solder paste volume on the stencil for acceptable print quality.

The operator's cleaning effort is laudable in attempting to maintain consistent solder printing, but it is misplaced. But there is stuck solder paste which is allowed to dry out and form a crusty oxide which may clog stencil openings, create open solder joints due to inadequate solder, or even create solder voids in the solder joint due to increased oxides in the solder paste.

Independent testing has confirmed that the best combination of parameters a squeegee should have are described as a solid, electroformed, bright, hard nickel, which has been chemically-mechanically-polished (CMP) on both the edge and the surface. This testing confirmed that electroformed nickel which has been polished to an ultra-smooth surface exhibits the lowest surface energy, resulting in less curtaining, faster printing speed, lower printing pressure, improved print resolution, and increased squeegee and stencil life.

Fine Line Stencil's unique Slic-Blade® process creates a very smooth and slick blade surface, virtually eliminating the problem of solder paste sticking to the blade. The smooth surface reduces solder paste shear thinning against the blade surface, eliminating viscosity breakdown and rheology changes in the solder paste. The solid nickel blade will not chip or flake like coated blades, thereby eliminating solder joint contamination.

The Slic-Blade needs less than 0.5 pound per inch of blade width (0.5 lbf/inch) instead of the industry accepted standard of 1.0 to 2.0 lbf/inch. Being solid nickel, the squeegee will not rust like the Teflon-coated, steel blade does. Since there is no rust, there is no possibility of rust flakes being entrapped in the solder and causing solder voids. A simple microscopic examination of the various squeegee blade edges reveals that edge sharpness does not appear to be a consideration by present blade manufacturers. This design deficiency is tolerated because the processes never allow for proper blade design, even though these blades are sold at premium prices.

Independent evaluation results from test sites using the all-nickel reported a very low blade pressure of 2 to 4 lbf total blade force for a 10-in. wide blade, with superior print quality since the flux rheology was not distorted under excessive paste-shear breakdown effects. No flux squeeze-out at the edge of the solder brick and the absence of “paste-tails” resulting in less solder bridging and rework. The evaluation tests included 120 micron (ultra fine pitch) line and space apertures and 300 micron (fine pitch) line and space apertures at horizontal, vertical, and both 45° orientations. Higher print speeds were reported by all test sites, which increased productivity and lower process costs.

Using this new blade results in an ideal printing environment by using a smooth, low surface energy electroformed nickel with a precision ground, sharp blade edge, which makes higher print speeds possible. Longer blade life and stencil life have also been observed because there is less stress on both blade and stencil. Combining all of these features into one blade and the ultimate blade results in improved productivity as well as substantial cost savings.

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