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Profiled Squeegee Blade: Rewrites the Rules for Angle of Attack

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Abstract

For centuries, the squeegee blade has been used throughout many applications for depositing viscous materials through screens and stencils to transfer images on to substrates, from cloth material to electronic circuit boards. One area of blade printing mechanics that have been reviewed many times is the angle of attack of the blade. Typically it has been tested from 45 degrees to 60 degrees to optimize the printing quality and efficiency. However, this typically ends up as a compromise, from fill characteristics (45 degrees) to print definition (60 degrees). This paper will present the revolutionary performance of the profiled squeegee blade, which has recently been developed to create a virtual multi angle of attack for unsurpassed process control for all types of stencil printing processes.

Introduction

Squeegee

The Squeegee is a key element to the print deposition. Its purpose is to contain a volume of print medium in front of it when moving along a stencil as well as applying a downward force on the material to fill a predefined image on the stencil. The other property of the squeegee blade is to wipe the surface of the stencil so as to create a uniform topography of the printed image.

Key properties to a squeegee blade are:

Angle of Attack – The squeegee blade can have various degrees of angle relative to the stencil. Typical angles are 45 degrees and 60 degrees. 45 degree squeegees typically apply an enhanced downward force on the print medium and therefore fill the images more efficiently however, lack an effective wiping action leaving a thicker deposit caused by a smear. 60 degrees, reduces the downward force on the material and therefore has a tendency to fill apertures less efficient but shears the deposition leaving a cleaner print definition.

Blade hardness – Shore hardness of material if a polyurethane material is used or thickness if Stainless Steel material used gives rise to the blade flexing under pressure. This in turn causes the blade to change angle of attack. Poly material is typically used with mesh screens, which require more compliancy, and metal blades are typically used with steel foils with 100% open apertures.

Squeegee Speed Carriage

This system transports the squeegee mechanism forward and backwards across the stencil. The speed of the carriage is set to accommodate various print medium properties to give a consistent and uniform deposition.

Variation in speed of the carriage may have profound effect on fine and ultra fine pitch devices. For example:

0.5mm pitch QFP has apertures running parallel and perpendicular to the squeegee blade, see figure 1.

Apertures are typically 1.5mm x 0.25mm, Print speed 25mm/S

Time taken to fill aperture:

Parallel = 10mS

Perpendicular = 60mS

A ratio of 6:1

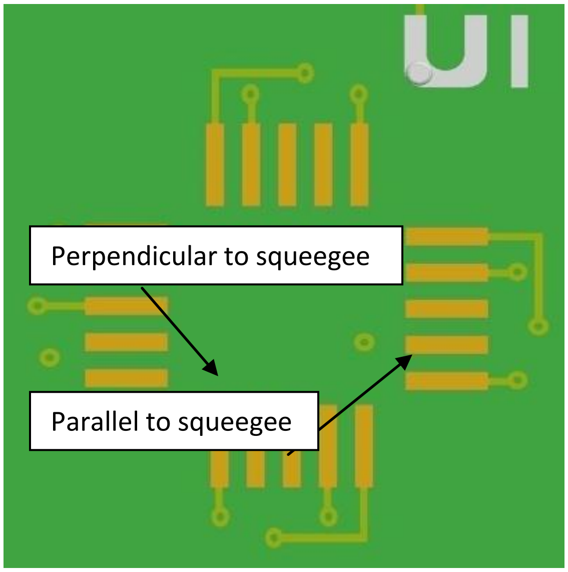

Figure 1 – QFP Aperture orientation

Another phenomenon that takes place is the ramp up and ramp down velocity of the print carriage. Short print strokes and higher speeds may have a dramatic effect on devices closer towards each end of the print stroke. This is all due to moving a mass to terminal velocity in a short distance. With narrower boards, higher print speeds and aforementioned QFP concerns there is a need for quicker dynamic paste roll to compensate for the inaccurate printing speed.

Aperture Filling

The Area Ratio formula (IPC7525B) assumes a 100% aperture fill. Aperture fill is achieved by a combination of Squeegee type (angle of attack, blade flex etc.), Print Speeds and the make-up of the solder paste being printed. There has been many experiments published on effective aperture filling, however, verifying that the aperture is 100% filled prior to being released from the stencil has not been typically established. Studies such as squeegee angle of attack, squeegee material type, edge treatments and ultrasonic/vibrating squeegees have been tested, claiming to enhance the paste deposition/transfer efficiency.

A new design

Realizing the advantages of the two most common blade angles, a new squeegee has been designed that encompasses the wiping action of the 60 degree blade, and the downward force of the 45 degree blade. A patent pending "profiled" blade is the result. The profiled blade has a primary 60 degree angle of attack with the enhanced design molded into the face of the blade that behaves like a 45 degree blade. This combination enhances the rolling motion of the paste while maintaining the wiping characteristic of the 60 degree.

Historical force diagrams for squeegees display the blade pushing the paste forward and downward into the aperture. see figure 2. Closer to reality, the paste roll is also being forced up the squeegee blade. This action can facilitate the paste sticking to the squeegee during the print stroke and remaining when the stroke has completed and lifted from the stencil. Lead free pastes typically have more issues associated with the paste rolling effectively, and sticking to the face of the squeegee. This phenomenon may lead to starving of the paste bead which in turn reduces the paste roll which can lead to insufficient paste deposition. See figure 3. The profiled blade redirects the force of the paste roll back down where it enhances the paste roll and facilitates filling of the aperture. The result is the potential to increase print speeds, and an improvement to the transfer efficiency. See Figure 4.

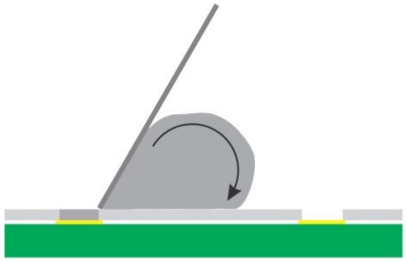
Figure 2 - Historical Diagram

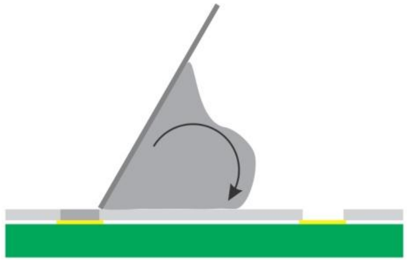
Figure 3 - Actual Diagram


Figure 4 - Profile Diagram

Field Testing

Recently the profile designed blade was put to the test. Using lead free paste that has been known to cause issues, especially with the first boards printed, after down time, and as the paste roll diminishes. A preliminary test was done using a production process and directly replacing the standard blades with the profiled blade. Five boards were printed with the standard blade, then five boards printed with the profile blade. The boards were weighed prior to printing and after printing to determine the weight of the paste printed. The stencil was cleaned and fresh solder paste was dispensed from the cartridge before each blade was tested.

Table 1 Paste Mass results

Standard Squeegee

Print #	Pre Weight g	Post Weight g	Paste Weight g
1	72.02	72.93	0.91
2	70.28	71.11	0.83
3	71.56	72.42	0.86
4	70.91	71.78	0.87
5	71.74	72.62	0.88

Profiled Squeegee

Print #	Pre Weight g	Post Weight g	Paste Weight g
1	70.88	71.7	0.82
2	70.95	71.77	0.82
3	71.7	72.56	0.86
4	70.68	71.52	0.84
5	70.13	70.99	0.86

As can be seen by the paste weight shown in this table, the first and fifth print with traditional squeegees, displayed a higher than expected result. As described later, this anomaly can be attributed to the paste trails, dropping additional paste on to the larger apertures.

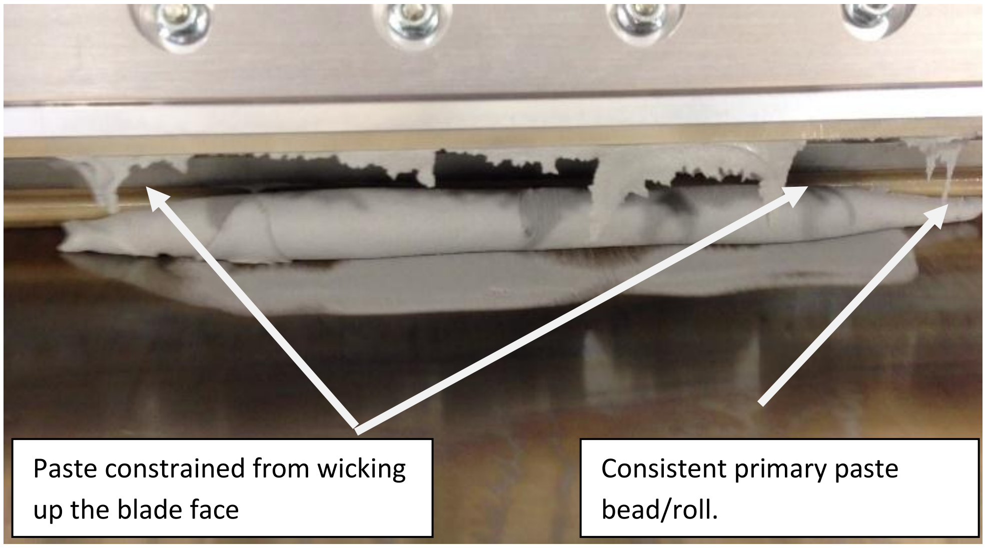

Figure 5 – Paste Bead Control

As can be seen in Fig 5, the paste roll is kept ahead of the blade face by the unique patent pending profile. While the mass of the paste is kept ahead of the face of the blade, the profile is feeding in to a smaller area and maintains a constant bead size and roll characteristic.

The results of the test were encouraging so the profiled blades were left on the printer to print production boards. Observing the paste roll during the print stroke showed the roll sliding across the stencil with the standard blade, while with the profile blade, the paste rolls with the print stroke. The paste roll is contained on the stencil when the squeegee moves to dwell height.

Observing the printed boards through a microscope showed similar print definition. One anomaly noticed on a board printed with standard blades is a larger pad exhibiting an extra large deposit on the pad. This may be caused by paste trails. Paste that trails behind the blade leaving a line of paste. If the trail is over an aperture, it can add extra paste to the deposit.

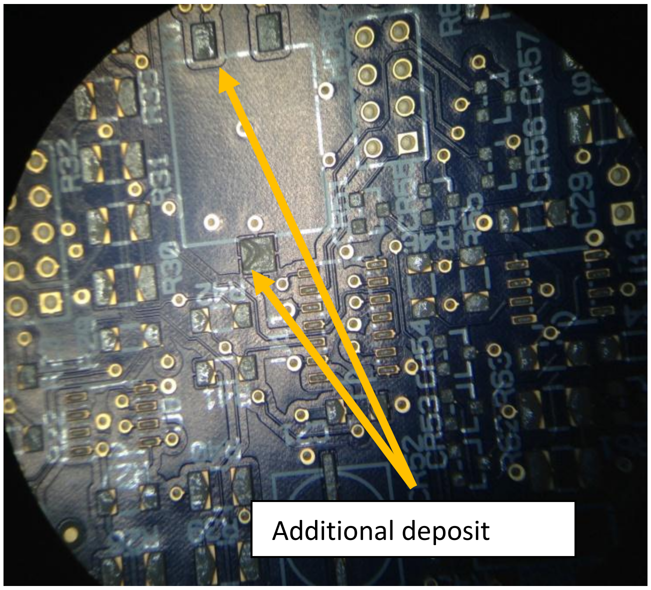

Figure 6 - 5th Board Printed with Standard Blade

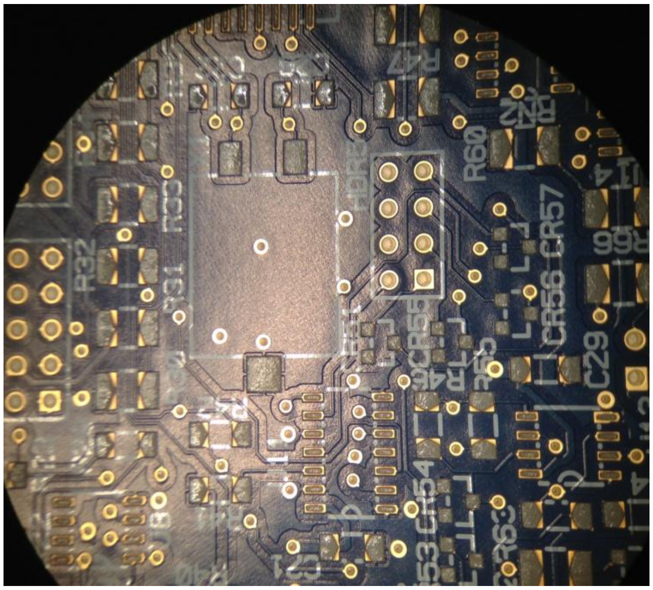

Figure 7 - 5th Board Printed with Profiled Blade

Summary
With today's production challenges with finer pitch devices and lead free processes, there is a strong desire for innovative solutions towards the improvement in paste roll control. Various attempts with coating of blades have not yielded the desired effect of minimizing the paste starving concern with lead free processes. In conjunction with paste roll control, enhanced paste deposition for lower area ratio apertures is not a desire but a requirement. The profiled squeegee blade fulfills the dynamics of paste roll control and aperture fill by its unique shape by controlling the mass of paste from wicking up the blade face. In conjunction to the paste mass control, the unique profile design channels the paste in to a smaller bead under the profile and thereby creating a localized controlled paste flow.

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2. Rita Mohanty, Bill Claiborne, Frank Andres, " Effect Of Squeegee Blade On Solder Paste Print Quality", www.speedlinetech.com