Pressure print heads: an exercise in cost savings

The dawn of the 21st century has seen even greater pressure on the assembly industry to improve efficiency, reduce costs and gain a competitive edge through technology change. An area on where much research has been focussed is the printing process: pastes, stencils and printers all evolving to allow higher speeds at minimal defect rates… but still physical problems were likely to affect the process. Paste condition in air could deteriorate, regular cleaning slowed down the process, and paste wastage causing both disposal problems and cost penalties. Machine manufacturers addressed the problem by developing pressurised print heads, with varying success, but now Paste Puck Ltd has re engineered the captive paste print head concept, to introduce a precision – yet aggressively cost effective system, and what's more, the print head is disposable. The first production versions of the new head were unveiled at SMT Exhibition, Germany, in June, but the concept had been rigorously trialed prior, and an edited report of typical results obtained is now available.

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Throughout the 1990's, solder paste printing technology had grown steadily towards being the 'preferred process' for assemblers, as machine, stencil and paste manufacturers developed products which made the printing operation more 'user friendly'. But printing still tended to cause bottlenecks and reduce line throughput, as assemblers simply couldn't find a system that would give consistently fast, trouble free paste deposition. This article looks at the evolution of printing over the last decade and examines the cost saving benefits of what looks like a revolutionary new print head.

Innovations such as metal squeegees, laser cut stencils in frameless mounts, vision improvements and paste formulations with wide process windows made higher print speeds possible. Paste was applied manually in the early stages, then by automatic cartridge dispense – but the print operation was still the limiting factor to any operation, causing frequent stops for cleaning and paste recharging, whilst often being affected by environmental changes on the line. In the mid 1990s several equipment manufacturers launched pressurised print heads designed to clean up, speed up and generally simplify the printing operation by enclosing the paste in sealed systems. Aimed mainly at large volume operations, these expensive, complex arrangements promised to revolutionise printing, but in the event often proved less efficient and uneconomical. However the print head concept has evolved significantly, with the recent introduction of a simple, economical unit from British manufacturer Paste Puck Ltd.

Figure 1: paste Puck Pack

Puck Pack

The Puck Pack is a revolutionary retrofit print head, supplied in one size, designed for use on most popular printers, and available filled with most leading pastes. The simple, self fit system allows precision printing and gives process stability, yet is easily installed without the need for air, expensive software and regular maintenance. But there's one more important advantage. The paste head is disposable, eliminating all the difficult cleaning problems often associated with traditional pressurised systems, and giving additional benefits. It is fitted in seconds, keeps print media fully enclosed and in peak condition, and when empty it is disposed of like a normal empty paste pot or cartridge.

During its development the Puck Pack was put through rigorous field trials with a number of machine manufacturers (KIStech, EKRA etc); paste manufacturers (such as AIM, Interflux); and high profile assemblers and OEMs such as DaimlerChrysler. The results showed that an independent print head can give obvious significant process improvements over squeegies with advantages such as increased line throughput and ease of utilisation, with major process and cost improvements over conventional, dedicated pressurised systems. It also eliminated some of the problems found when using difficult print media, because being a sealed system which eliminated air, it acted to widen some paste print process windows.

Justification

A significant purchase justification exercise was undertaken at a British facility of a major subcontract assembler, which subjected the Puck Pack to a programme of rigorous trials to compare its cost and performance against standard squeegee printing. The following was taken from the final report covering the trials:

Ease of use

The print head and the interface are the same height as the standard squeegee blades, which meant no software modifications were necessary. Retrofitting simply meant replacing the squeegees with Puck Pack pushers, setting the print parameters and locating the print head under the pushers. The whole operation took minutes and had the added advantage of being easily reversed if required.

Results

By enclosing the paste inside the head, the effects of atmospheric contact are eliminated. A media print gasket makes the head to stencil seal, keeping paste within the head with none on the foil to degrade or crust. Puck Pack differs from other encapsulated systems in the way paste is delivered to the board. Instead of relying on an outside power source, the motive force is taken from the printing machine itself, which exerts downforce on the paste in the head sealing it to the stencil, and moving the paste onto the print window. The system works with a lower print pressure than other enclosed deposition units, eliminating paste concretion and separation.

The Assembler's Required Process Benefits:

- Improvement in print quality – higher yield
- Reduction in paste usage – cost savings
- Faster stencil changeovers – increased production
- Reduced operator intervention – increased production
- Cleaner stencils, reduced machine clean cycle - cost saving

The Assembler's Process Requirements

- The head must be capable of printing repeatedly <0.015"
- The entire system should run reliably between scheduled maintenance stops (2 weeks)
- It should be robust enough to withstand handling in a production environment
- It must not cause any damage to stencil or host printer
- The original machine squeegee head assembly should be easily reverse compatible following Puck Pack installation.

Statistical analysis of solder joints

Due to the inherent design of the Puck Pack it produces a far more accurately defined paste brick with excellent release characteristics and much greater repeatability. Combined with the lack of atmospheric contact with the paste, this produces impressive post reflow results.

An exercise was performed to gain data in order to compare the number of defects obtained across the boards produced before and after implementation of the print head. The same code of board was employed throughout the trial. The following is the analysis performed on the data collected:

H_o = no difference between the fraction of non-conforming or fallout from the process.

H_1 = difference between fraction of non-conforming or fallout from the process.

Initial analysis of the data indicated that it was not normally distributed. Therefore the comparison between the data set has been carried out using a binomial test. Our data set is very large therefore we can use the normal approximation to the binomial.

where

$$\hat{p}_1 = x_1/n_1$$

$$\hat{p}_2 = x_2/n_2$$

x_1 number of non conforming for sample taken prior to implementation

n_1 total number of opportunities for the sample taken prior to implementation

x_2 number of non conforming for the sample taken post implementation

n_2 total of number of opportunities for the sample taken post implementation.

Under the null hypothesis $\hat{p}_1 = \hat{p}_2 = \hat{p}$

Therefore using:

$$\hat{p} = \frac{n_1\hat{p}_1 + n_2\hat{p}_2}{n_1 + n_2}$$

The total number of opportunities on the specific board being used for this exercise is 2800.

we obtain

n_1 = 198 x 2800 = 554400

x_1 = 121

n_2 = 191 x 2800 = 554400

x_2 = 51

$\hat{p}_1$ = 0.000218253

$\hat{p}_2$ = 0.000095362

$\hat{p}$ = 0.00015785578

Using the normal approximation to the binomial we have:

$$Z = \frac{(\hat{p}_1 - \hat{p}_2)}{\sqrt{\hat{p}(1-\hat{p})\left(1/n_1 + 1/n_2\right)}}$$

Therefore we obtain:

Z = 5.1568132

Conclusion

H_o is rejected when the absolute Z value obtained > $Z^{\alpha/2}$

Using Neaves statistical tables with a 5% level of confidence we obtain

$Z^{\alpha/2}$ = 1.645

Therefore we reject H_o

Concluding that there is sufficient evidence to suggest a difference between the fraction non conformances between both sets of data. The set of data from after implementation had a smaller number of non conformances therefore we can conclude that there has been an improvement in the quality of joints.

The percentage reduction in the defect rate is given by:

$$1 - \frac{9.53 \times 10^{-5}}{2.18 \times 10^{-4}} = 0.5633$$

Therefore approximately a 56% decrease in defective opportunities with the new print head.

Solder paste waste analysis

The test involved a standard batch of 110 boards. Trials showed that paste wastage (scrapped paste left on stencil, blades etc) was decreased from 57% with conventional printing, to 5% using the Puck Pack.

The customer estimated that it could save in the region of £6,750 per year per line on paste wastage alone – a significant £54,000 if all lines at the facility were running Puck Pack. Further savings would be returned by the improvements in the print quality (less requirement for rework) and speed of changeover, whilst line throughput would be more efficient as the cleaning requirement would be minimal, together enabling more accurate delivery targets to be met.

The recommendation of the engineers was that Puck Pack was highly cost effective and could be easily integrated in all assembly lines with subsequent substantial savings.

Furthermore as there is no requirement for capital equipment the Puck Pack could be utilised simply as a consumable product so limiting stringent financial needs to a minimum.

Conclusions 'conclusion' summarised

Puck Pack has brought a new dimension to the pressure print head concept. The self fit cartridges give consistent, c risp paste deposits with each new head and are clean - in fact the environmental aspects of the new system are significant: As well as a reduction in cleaning and so a reduced use of solvents, the PuckPack is a sealed system with no paste leakage, so there is minimal risk of operator contact with lead or other toxic materials.

Also, more paste is effectively used for printing compared to standard squeegee performance, because it produces little paste wastage i n use it reduces scrap disposal problems. When empty, the head is simply removed and a new one fitted in seconds making any other maintenance unnecessary.

The Puck Pack can be used with lead-free, low viscosity pastes, adhesives and many leading paste manufacturers have already committed to offering it with their products filled.

The system is overall very economical – low initial outlay, the heads add around £10 to the cost – but this is soon made up in the efficiencies it brings, and so proves to be a low cost of ownership – quick payback, best value system.

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