Reflow Evolution Reduces Costs, Improves Reliability

New solder reflow technology is resulting in lower nitrogen consumption and significant cost reduction due to low-maintenance equipment.

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Advances in solder reflow, as in any other stage of the surface mount assembly process, often are the result of dramatic innovations that lead to the introduction of new technology or equipment. However, process advances also emerge in incremental, evolutionary stages, as the result of design and engineering innovations that make existing systems more efficient, more economical or more effective.

Enhanced reflow processing has reduced maintenance requirements, MTTR, MTBF and costs. Several innovations have had a dramatic impact on reducing nitrogen consumption and its related costs, while maintaining high-quality reflow results. Other designs, initially intended for advanced assembly technologies, have led to increased oven reliability for all reflow applications.

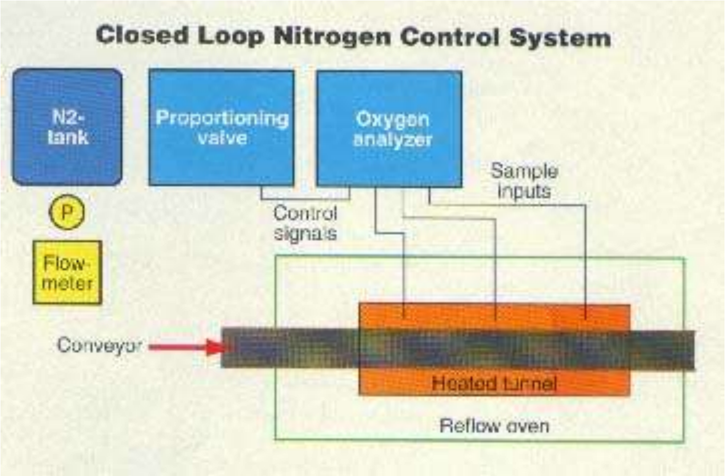

Figure1. A closed-loop nitrogen control system
minimizes the flow of nitorgen into the oven without operator intervention

Minimizing maintenance

As a result of industry-wide growth in the use of no-clean fluxes, there now is a maintenance issue concerning the removal of flux residues that tend to accumulate on cooler-surfaces within the oven. The costs involved in flux removal and cleaning procedures include time, lost production and the allocation of operators to the task.

Therefore, any innovation that reduces both the time and the personnel required for flux-related maintenance will have a positive impact on productivity. A recent advance in this area is a nextgeneration internal flux separation system that eliminates the need for flux filters, recirculated water, heat exchangers and the labor involved in maintaining these systems.

The flux-laden gas is diverted through a tube, passing from heated areas of the oven into an area where the flux can be extracted. It is then precipitated outside the oven to a collection point, from which it can easily be removed during scheduled preventive maintenance.

To design a system that prevents flux accumulation within the oven and then extracts it at the collection point, several engineering challenges had to be resolved. Extensive study led to the identification and characterization of factors that affect flux evaporation and condensation. Collaborative efforts with paste manufacturers, using their proprietary no-clean fluxes, enhanced the understanding of the process. Testing in some of the world's most demanding production environments determined the efficacy of flux separation.

Testing demonstrated that internal flux accumulation was reduced so significantly that flux filters, heat exchangers and pumps no longer were required. Without these elements, the overall oven design became simpler and inherently more reliable.

To remove the minimal amount of flux that may remain inside the oven, an automatic self-cleaning mode is used for periodic internal cleaning. This causes condensed flux to flow to the flux collection point. On programmable ovens, the self-cleaning mode can be activated automatically during planned downtimes.

Reducing nitrogen consumption and costs

Another aspect of reflow that assemblers have targeted for cost-cutting is nitrogen consumption. The goal is to reduce operating costs while maintaining a stable oxygen PPM level within the oven to achieve the process benefits of nitrogen reflow. Recent engineering innovations have contributed to this goal by reducing gas flow turbulence within the oven, reducing the size of the oven opening and adding a closed-loop nitrogen control system to the oven.

The closed-loop system significantly reduces nitrogen consumption

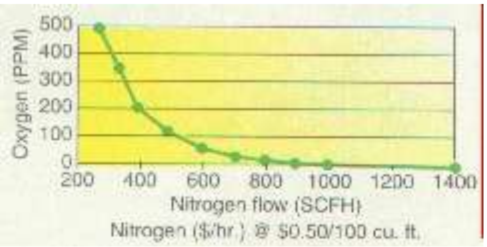

Figure 2. Considerable savings
in intorgen consumption is generated since proportionally greater quantiteis of nitogen are required to achieve lower PPM levels

The stability of the PPM level is most vulnerable at the oven entrance, where oxygen tends to be drawn into the reflow tunnel as boards are introduced. That oxygen is then distributed throughout the tunnel by the inherent mixing action of the forced convection heating process.

Lowering the agitation of the convection-heated gas to maintain a stable PPM level presents a significant engineering challenge. However, design adaptations to the internal configuration of many convection reflow ovens now enable the gas to flow in a more laminar fashion, without abrupt changes in velocity or direction, and without sacrificing heat efficiency.

Reducing the size of the oven openings also limits the amount of oxygen that can enter the tunnel. While a flexible barrier may be used at the tunnel exit, such a device may brush components off the board at the entrance. Instead, oven suppliers have worked with users to customize the opening to their production requirements, making it as small as possible while allowing sufficient clearance for components.

Perhaps the most significant contribution to reduced nitrogen consumption has been the introduction of a closed-loop nitrogen control system. When such a system is mounted inside a reflow oven, it combines continuos monitoring the oxygen PPM level with rapid-response control over the flow of nitrogen into the oven.

If no boards are being produced, the closed-loop system automatically reduces nitrogen consumption. As soon as the system senses the change in PPM caused by product entering the oven, it releases sufficient nitrogen to maintain the preset PPM level. Closed-loop nitrogen control has proved to be effective on a variety of board types, including those with heavy component loads (Fig. 1).

The most significant benefit of such a system is that it allows users to determine, establish and maintain an optimal PPM level for each specific application. Since field experience has demonstrated that levels from 100PPM to as high as 1500 PPM or more provide excellent reflow results in many instances, it is not always necessary to reduce PPM levels as low as 25. This generates considerable savings in nitrogen consumption, since proportionally greater quantities of nitrogen are required to achieve lower PPM levels (Fig. 2). Users can therefore optimize both the process benefits of inert reflow and the cost benefits of reduced nitrogen usage to achieve high-quality reflow yields (Table 1).

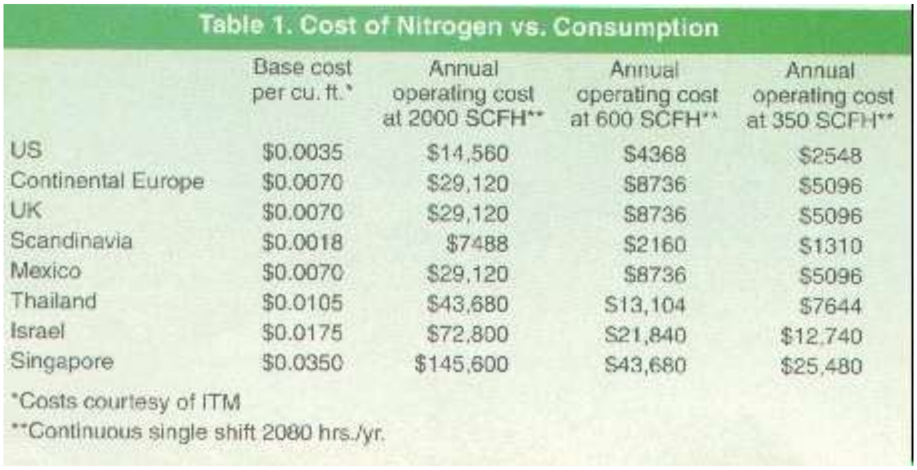

Table 1. Cost of Nitrogen vs. Consumption

	Base cost per cu. ft.*	Annual operating cost at 2000 SCFH**	Annual operating cost at 600 SCFH**	Annual operating cost at 350 SCFH**
US	$0.0035	$14,560	$4368	$2548
Continental Europe	$0.0070	$29,120	$8736	$5096
UK	$0.0070	$29,120	$8736	$5096
Scandinavia	$0.0018	$7488	$2160	$1310
Mexico	$0.0070	$29,120	$8736	$5096
Thailand	$0.0105	$43,680	$13,104	$7644
Israel	$0.0175	$72,800	$21,840	$12,740
Singapore	$0.0350	$145,600	$43,680	$25,480

*Costs courtesy of ITM

**Continuous single shift 2080 hrs./yr.

Manufacturers stand to gain both immediate and long-term benefits from partnering with innovative suppliers

Improving reliability

When oven suppliers work in partnership with users to develop custom solutions for advanced applications, the resulting engineering innovations often can provide added benefits to all reflow applications.

As an example, component manufacturers required high-temperature processing for ball or column attach. However, existing fan-based heating systems were not capable of maintaining higher temperatures. Joint engineering initiatives undertaken by oven and motor suppliers led to the development of new blower motor technology capable of sustaining temperatures as high as 400oC.

The outcome of this effort was the creation of more powerful heating systems that benefited all reflow applications, at all temperature levels. Incorporating more rugged blower motors, with lifetime warranties, into new reflow ovens resulted in heating systems that provided even greater reliability for assembly operations.

Conclusion

The impact of such evolutionary innovations in reflow processing becomes most apparent as they are transmitted throughout the industry. Usually, they are developed in an engineering partnership, as a supplier responds to an individual users' specific reflow application. For this reason, manufacturers stand to gain both immediate and long-tern benefits from partnering with innovative suppliers. Once an innovation is developed, it is extended to all users by being incorporated into new equipment or retrofitted to the installed base. When several incremental advances operate in combination on multiple systems in multiple locations, the resulting synergies can generate dramatic overall improvements in reflow yield and quality.