

Wave-soldering in a hermetically sealed full tunnel under nitrogen atmosphere

# The next dimension in sophisticated lead-free processing

Jürgen Friedrich, Erska, Germany

*The Powerflow N2 wave-soldering oven from Erska is regarded as the ultimate solution for lead-free processes. The full-tunnel concept assures low residual oxygen, and due to temperature compensation of the inherent warming ensures a very stable thermal condition for the board assemblies. The furnace helps to enlarge narrow process windows, and the modular concept enables customized solutions.*



Figure 1: The Powerflow model N2 features an inert gas-soldering system

Although the components development is enormous, there is still a segment of them that either cannot be provided as SMDs or do not have the required heat resistance for reflow soldering. Wave-soldering technology is still in demand to process these THT (thru-hole technology) parts. In spite of all prophecies of its demise, wave soldering represents a very economical process, even if, since the introduction of inert-gas technology in the 80s, basically nothing has changed.

Lead-free solder materials have a smaller process window. The cause for this is seen in the higher solder thermal demand and the higher soldering heat resistance of the components, which is not insignificant. If we want to enlarge the process window, either the component heat resistance must be increased by selecting suitable materials, or the heat transfer during soldering must be more

effective, in order to reduce the delta T. However, it should not be forgotten that in comparison to reflow soldering, the interaction between process parameters for wave soldering are more complex. Wave-soldering equipment offers potential for increasing the heat transfer, and can thus help to enlarge the process window. The process can be placed on a broad basis which makes its design easier, and extends the range of parameter determination.

From a technical perspective the inert gas, full-tunnel machine still represents the non-plus-ultra in soldering. Increasing sales figures of those ovens over the years underpin this view. However, many assemblies do not justify the use of nitrogen, due to their simplicity. These types of boards can safely be processed in open atmosphere machines. The Powerflow machine concept of Erska provides vi-

able solutions to these different requirements for the first time in a platform. Due to its modular design, it serves as the basis, from inert gas to the open-atmosphere soldering system.

## Full tunnel – why?

The basis of a new modular machine generation always represents the highest expansion stage, a point of departure from which systems with lower requirements can be derived. In the Powerflow family, this is the N2 full-tunnel inert gas soldering system (figure 1). This means that the machine configuration can be precisely optimized and matched to specific applications. At the center is the closed tunnel that contains the freely configurable preheater, the solder aggregate and the cooling zone. In order to keep contaminants away from the tunnel, the spray fluxer is not integrated here. The modular concept allows detaching the machine for transport purposes. The units thus produced are easy to lift, so a transport or relocation is very easy.

As the full-tunnel system operating under inert gas offers optimal prerequisites for the lead-free wave-solder process, the decisive level of residual oxygen content can be adjusted finely. Lower residual oxygen means less oxidation, less oxidation in turn means better wetting characteristics of the soldering partners. If oxygen is supposed to be almost completely forced out of the process zone, the furnace has to feature a hermetically sealed tunnel (figure 2). To ensure the stable low residual oxygen values that are required, the process tunnel must constantly be purged with pure nitrogen. The nitrogen supply of the oven delivers a constant flow rate. Optionally, a residual-oxygen measuring unit can be installed to regulate the residual oxygen in the tunnel. Another advantage of the full tunnel is the increase in thermal efficiency. Due to the closed tunnel, thermal losses are massively reduced, and the thermal energy given off for preheating the assemblies is less when compared to open systems.

## The preheater challenge

A great challenge in the oven design was to ensure the thermal stability over a long period, to securely maintain the narrow lead-free process window. The mass of the process tunnel absorbs the thermal energy of the preheaters, until ideally, a thermal balance is achieved. In practice, however, a thermal balance is not achieved in the tunnel, as the heaters are constantly switched on and off with different parameters and cycles, depending on throughput. Thus, the thermal energy introduced into the tunnel is not constant. This means that the limiting thermal conditions are not constant either, and in mixed operation, it is not easy to always preheat assemblies precisely to the required temperatures under these constantly changing conditions.

Complex equipment and technical control procedures are required to ensure constant preheater temperatures. Consequently, in order to guarantee reproducibility and stability of the process, warming of the system tunnel is detected, and the temperatures of the preheater modules are compensated accordingly. A pyrometer is available at the end of the preheater zone for monitoring and documentation of the assembly temperatures. For

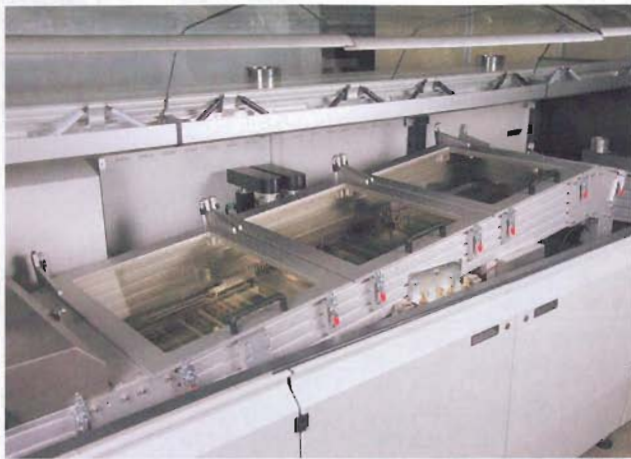


Figure 2: The furnace features a hermetically sealed tunnel, to ensure stable low residual oxygen values

traceability, with this option the preheating temperature can be allocated to each assembly. The length of the preheating zone can be configured from 1.8 to 2.4m. Figure 3 shows the structure of the tunnel and the pre-heating zone.

For the heater modules, there is a choice between medium and short-wave radiation elements and convection modules. The number and sequence of the heater modules can be freely selected within the preheater section. The dynamic preheating modules equipped with short-wave IR elements offer the advantage that they can transfer different amounts of energy from 0 to 100% virtually inertia-free. This is particularly advantageous in mixed operation with a wide variety of assemblies, as the speed of the conveyor does not need to be changed.

The convection modules in the tunnel can be installed from below and from above. In general, they offer the same advantages as a reflow process, where convection has represented the state-of-the-art for years, and offers the possibility of gently and uniformly heating high-mass assemblies. The regulated fans of the modules enable different heat-transfer rates at constant temperature, which in turn is advantageous for soldering of mixed assemblies.

## Process-gas cleaning

An ongoing issue of closed system concepts is contamination of the process zones due to flux vapors, outgassing of PCB material, dust, etc. If these contaminations precipitate onto the assemblies, this could result in serious defects. A modern soldering system such as Powerflow reliable excludes these types of effects, a multi-phase cleaning system handles the process gas atmosphere. In the two preheating zones upstream from the solder aggregate, and in the soldering module, a portion of the atmosphere is constantly extracted, cleaned in a central module and then returned to the same modules. The unique feature is that the three gas flows are not mixed in the process, and the residual oxygen in the soldering modules remains very low. Contaminants are successfully removed from the process atmosphere.

One positive side effect of the process-gas cleaning is its contribution to the temperature compensation of the assembly temperatures, with due consideration of the temperature in the process tun-

nel. The permanent exchange of the atmosphere prevents the process gas from overheating, and thus it helps stabilize thermal conditions in the tunnel. This way the temperature compensation of the preheater works under more constant conditions.

## The spray fluxer

For years, spray fluxers have been regarded as state-of-the-art. However, if these systems are considered in detail, it becomes evident that there are good options for improvements. In the Ersä oven, this is being realized in the mechanical structure. Unnecessary corners and edges were carefully avoided to make cleaning as simple as possible. Flux dust is extracted underneath the board, in front of and behind the spray head, as well as above the board. The filter elements are made of metal fabric and can be washed and reused. Accessibility to the spray heads and to their drive unit is simple as the entire unit can be conveniently

pulled out on telescoping rails. The system is equipped with a maximum of two spray heads and separate flux supply (figure 4).

The flux can be loaded directly with its original containers ranging to up to 10l. The container level is monitored. The flux is conveyed to the spray heads via pumps, and the displacement quantity can be freely defined in the solder program. The displacement quantity itself is measured via flow-rate sensors, displayed and logged.

Movement of the spray heads underneath the board is executed via a linear drive with a precise positioning system. The surface to be sprayed can be programmed in several ways. In the solder program, the surface value can be entered either via a graphical user interface, or more elegantly by scanning the soldering frame on the conveyor via a light barrier. Assembly position and size are captured automatically for fluxing without any programming intervention required from the operator.

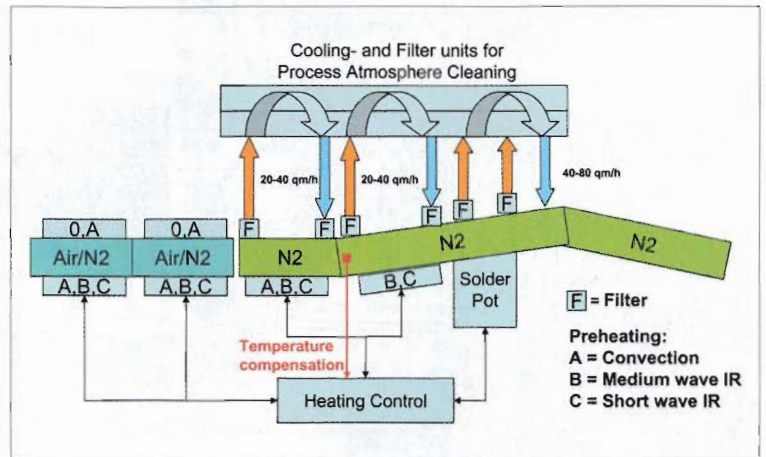


Figure 3: The principle of the tunnel and the preheating zone

## ZUSAMMENFASSUNG

Im Zusammenhang mit dem jetzigen Übergang auf die Verwendung bleifreier Materialien in der Baugruppenfertigung sind natürlich auch auf das Wellenlöten andere Anforderungen zugekommen. Zum einen muss, weil die Bleifrei-Pasten mit höheren Temperaturen verarbeitet werden (circa 30 bis 40K höher), die Temperaturkontrolle des Lotguts, um Schäden auszuschließen, sehr genau durchgeführt werden. Wesentliche Themen sind auch Stickstoffflöten sowie Lot-tiegel, Lotpumpen und andere Aggregate aus Materialien, die nicht vom flüssigen Lot angegriffen werden.

## RÉSUMÉ

A l'heure du passage à la production de composants sans plomb, le brasage à la vague est lui aussi confronté à de nouvelles exigences. En effet, les pâtes sans plomb nécessitant des températures plus élevées (environ 30 à 40K de plus), le contrôle de la tempé-

ture pendant le brasage doit être effectué avec une grande précision afin d'éviter tout dommage. Autres thèmes importants : le brasage sous azote et les creusets, les pompes de brasage et autres organes fabriqués en un matériau résistant aux flux de brasage.

## SOMMARIO

Nel contesto dell'attuale passaggio all'utilizzo di materiali privi di piombo nella produzione di aggregati, sono emerse delle nuove esigenze anche nel campo della saldatura a onda. Poiché le paste di saldatura vengono lavorate a temperature più elevate (circa dai 30 ai 40K in più), per evitare danni è necessario soprattutto controllare in modo molto preciso il materiale di saldatura. Altri temi fondamentali sono le saldature all'azoto, i crogioli e le pompe di saldatura e altri aggregati in materiali che non vengono danneggiati dalla saldatura liquida.

Powerflow features double-wave soldering technology. The soldering aggregate has been completely redesigned and adapted to the requirements. Thus the distance between soldering nozzles and board can be adjusted from outside, without opening the tunnel. Mechanical adjustment on the solder-wave height is a matter of a few minutes, with no down time and no service time. For service, the aggregate will be lowered and moved out of the machine. Accessibility for service and repair is excellent. Parts that meet molten solder are protected against the dissolving lead-free materials.

## Conveyor system

For the board conveyor the options are frame and finger transport. The system can be separated after the preheater. In this case, the conveyor system of the soldering module has its own drive. Different speeds can be set in the flux-preheating area and in the soldering module. The transfer of assemblies or soldering frames to the separating stage of the conveyor is monitored. A switch-on/switch-off delay can be programmed for each sensor individually, to adapt the monitoring behavior to the actual conditions prevailing in the machine.

The finger transport system is limited to the soldering module. The short design offers advantages for mixed operation throughput, as the speed can be switched on earlier, in contrast to longer finger transports. It is easier to remove for service work and fewer fingers are used. The other conveyor system is based on bushing chain conveyors in different variants that are service-friendly and work reliably. Belt conveyors are not used due to the high temperature stress associated with lead-free soldering.

The machine is controlled by a PLC unit that regulates and monitors all functions of the soldering system. Visualization as well as data input and output is executed on a PC, communicating with the PLC via network. Optionally, a PC is offered that is specially adapted to the requirements in production environments. Touch-screen operation, uninterruptible power supply and a network interface are included.

The system software provides features like soldering program management, fault logging, process recording, user management, solder log, timer with individual switch-on-times for each individual heater, as well as monitoring of all motors connected to the CAN bus. At the touch of a button, motor current, speed, and temperature of any drive in the machine can be displayed. This is a good example of how a modern controller concept contributes to profitability of a plant.

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**Figure 4: The oven can be equipped with a maximum of two spray heads and separate flux supply**