Multilayer Lamination - Vacuum Frames

Darrell Parsons
Applications Engineer
Isola – USA
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While the PCB Industry as a Whole has long recognized the value of performing Multilayer Lamination operations under Vacuum the specific method of achieving that Vacuum varies.

A common method of introducing Vacuum Lamination to a facility that has a well functioning Hydraulic Lamination Press is to use “Vacuum Frames”. These Frames allow the user to create an individual “Vacuum” Environment in any single press opening without any changes to the existing equipment.

When a user changes from a Standard Hydraulic Lamination System to one utilizing Vacuum Frames the pre conceived expectation is often that the change will result in Fewer Voids, Better Fill and Bond, Less Image Transfer and all at Lower Lamination Pressure. The reality is that if you understand and work with the limitations of the system you will get fewer voids; you will get Better Fill and Bond but probably not with significantly Lower Pressure and probably not with less Image Transfer.

The Vacuum Frame System consists of a Frame (usually Aluminum) that is Rectangular in Shape and about 1 inch thick. Both sides of this Frame have “Gaskets” in place. An outlet port for drawing a Vacuum and usually a single (less often a multiple) double sided plug port for Thermocouple wiring. The concept is to place the “Booked” Multilayer package inside the Frame opening with solid Plates in contact with the Gaskets on Both sides, pull a Vacuum and apply Heat and Pressure in the normal Lamination Cycle. With a well maintained Frame system the Vacuum can be pulled “Offline” from the Lamination Press and product maintained in a very low pressure Vacuum environment, a potential advantage with Heavy Copper innerlayers or other designs that might be harder to fill. Not all Resin Systems will benefit from a Long Vacuum Soak prior to Lamination but some Systems will benefit from the “Drying” action that Vacuum can provide.

The real Key to getting the Benefit of a Vacuum Frame System is to understand that the Dynamics of Thermal and Pressure Transfer normally associated with a Standard Hydraulic Lamination Press is going to change when using Vacuum Fames.

Because Frame is solid and the Gaskets are limited in the ability to compress a Narrow range of total stack height must be calculated and maintained without regard to the actual stack height of the Product being Laminated. The material used and how they are placed to achieve that "Standard" stack height inside the Frame will change the Thermal Transfer Characteristics as well as how that stack height is calculated.

THE SINGLE MOST IMPORTANT FACTOR TO UNDERSTAND WHEN USING VACUUM FRAMES IS THE STACK HEIGHT CALCULATION, FOLLOWED BY UNDERSTANDING THE IMPACT THAT OTHER MATERIALS AND WHERE THEYARE PLACED IN THE BOOK HAVE ON THERMAL TRANSFER.

Essentially the stack height must be calculated on the "Compressed" value of all materials including the Multilayer Board being laminated. Shops that lay up product and add Filler to achieve a stack height that looks to be appropriate for any individual Frame will often find that as pressure and heat are applied in the Lamination Process the combination of Thickness reductions caused by evacuation of Air, Resin Melt – Flow and Fill and compression of Pressure distribution Pads will result in a final stack height low enough that the "Hard Stop" provide by the Metal Frame and Gaskets will prevent Pressure Transfer to the Product inside the Frame. As the "Effective Pressure" is reduced Thermal Transfer Efficiency falls dramatically creating a situation where the product may not see adequate pressure or thermal transfer.

ISOLA can provide a Spreadsheet "Stack Height Calculator" based on input regarding specific Vacuum Frame dimensions and Gasket Thickness, Multilayer Board Thickness and other Materials but it should be noted that Gaskets when new will provide significant resistance to pressure at Lamination but after a few cycles can become soft enough that the Stack Height may need to be recalculated. The problem most shops have to deal with is that a correctly Calculated Stack Height in an "Un-Compressed" state is high enough that getting the outside plates to seal against "soft" Gaskets can be very difficult. The solution is usually to provide some Mechanical

Aid to help compress the package while drawing a Vacuum, once the Vacuum is in place it is no longer a problem. Hydraulic or Mechanical Compression devices (basically Clamps) are recommended to avoid situations where Lay-Up Technicians are forced to reduce the correct stack height to allow a Vacuum seal to be achieved.

You can expect the Thermal Transfer Rate to be reduced even when using the same pressure as normally used in a Non-Vacuum Hydraulic Lamination System, part of that reduction in Transfer rate is going to be a function of Materials used to build the appropriate Stack Height and how they are placed inside the Vacuum Frame.

Most often a Book is put together outside the Vacuum Frame and will consist of Several Multilayer Boards with separator plates of either Stainless or Aluminum with a Stainless Plate Top and Bottom then a Pressure Distribution Pad (often Compressible paper) then the Outside Rigid plate with Bushings, all held in place with tooling pins of a length appropriate for any given stack height. The remainder of the Calculated Stack Height can be anything but using Paper, Pads or Laminate will significantly slow Thermal Transfer and should be avoided if possible. Metal Plates are very effective for Thermal and Pressure Transfer but most are not absolutely flat and parallel creating small air gaps where transfer efficiency can be compromised, that can usually be overcome by alternating metal plates with one ply of Kraft paper between plates, more than one ply will slow Thermal transfer and should be avoided. You may have to use a combination of Thickness to achieve the desired Stack Height as the total variation from Minimum to Maximum is usually no more than a ¼ inch.

Vacuum Frames can be effective but are not something you can set and forget. It will take some work to get set up correctly and will require a commitment for regular monitoring and maintaince but is certainly a valid alternative to a Full Vacuum Lamination Press.