Avoiding Surface Blisters in High-Temperature Epoxy Laminated Tools

One common problem we see concerning wet lay-up high-temperature epoxy laminates for tooling is surface blisters on the working face of the tool. The only cause of blisters in a laminate is trapped air. When the tool is heated, the trapped air expands and will take the path of least resistance to increase its volume. If this air is anywhere near the working surface of the tool, it will manifest itself as a blister.

Trapped air can come from many sources. We will try to explain causes and show the best solution to eliminate them. Inducing air into a laminate is unavoidable during the hand-laminating process. Problems occur when the air is not removed before the resin system gels. Laminating in more air than normal by poor techniques, such as not vacuum-bagging or improper vacuum-bagging, using a faster-setting hardener than required, and not using proper "bleeding" materials, can all be the source of trapped air.

Poor Laminating Techniques

There are as many ways to make a wet lay-up lami nate as there are people doing it. The most common cause of air inclusion is wetting-out fabric on a table and then applying each wet ply on top of the other. When the wet ply is put down, the air underneath it has to work its way up through the fabric and resin in the fabric. The air can be forced through by squeegee or stippling with a stiff brush, but it is often difficult to do. You often end up chasing a bubble around under the wet fabric. A better technique is to apply wet resin to the back of a tacky surface coat and work dry fabric into the resin using a squeegee or stippling with a short-bristle brush. This allows any air to move freely through the fabric, resulting in less trapped air. A good visual of this is to imagine smoothing out a dry sheet on a bed versus a wet sheet; a wet sheet will trap air under it and make it harder to smooth out.

Another recommendation is to spend proportionally 2-3 times as much time compressing the first 3-4 plies of the laminate, by squeegee or brush, than you would on the rest of the laminate. Most problems coming from a laminated tool occur in the first few layers. Trapped air in this area will always take the path of least resistance and cause a blister on the face. Laminators get in a hurry and rush through the entire laminating process without taking special care of the first few plies. Extra time invested there will pay dividends later by not having to grind-out and patch blisters or having to remake the tool.

Vacuum-Bagging

The vast majority of epoxy laminated tools meant for high-temp service (250° F. or above) should be vacuum-bagged. Vacuum-bagging does two things: lowers the resin content of the laminate, resulting in less shrinkage and more dimensional stability; and removes trapped air as excess resin is bled out of the laminate. Even the best laminator will induce air during the tool- making process. If that tool is allowed to gel without vacuum-bagging, that air will remain in the laminate. At elevated temperatures, that air will expand and result in blisters or possible de-laminations. The benefits of vacuum-bagging will far outweigh the time and cost of doing so.

Using a Proper-Speed Hardener

A common mistake people make is using a hardener with a gel time too fast for the size of the tool being laminated. The benefits of vacuum-bagging is lost if the resin system gels before vacuum is applied and excess resin is bled out. When choosing the proper hardener speed, factors such as area and thickness of the laminate, ambient shop temperature, and the number and skill level of the laminators need to be considered. If the gel time for the hardener is listed as 3 hours, for example, you should have the laminate bagged and under vacuum by 2 ½ hours, minimum. This extra time allows the resin to still be mobile enough to move under the vacuum pressure and be

bled out of the laminate. Most gel times are measured at 75° F. If the shop temperature is higher than that, the gel time will be lessened. If the gel time does not allow the full thickness of the tool to be laminated, the tool should be de-bulked before the resin sets. On larger and/or thicker tools, we recommend de-bulking after the first 3-4 plies. The more freely the resin is allowed to move and be bled out of the laminate, the less air will be trapped. The more toolmakers, and the better skilled they are, allows the tool to be laid-up and bagged within the gel time of the hardener. If in doubt, use a slower hardener rather than faster when vacuum-bagging.

Proper "Bleeding" Materials

Wet lay-up laminates are typically high in resin content; bleeding out this excess resin is one of the benefits of vacuum-bagging. During the bagging process, a perforated release film is used to separate the laminate from the "bleeder material," which soaks up the excess resin. These release films contain holes punched with various hole diameters and spacing, and are identified with different perforation schedules, designated by a letter or letter/number combination. Some schedules have minimum hole diameters and maximum spacing, like "P8," which has 0.015-inch diameter holes spaced 10 inches apart. Another schedule, "P," has large holes spaced close together; 0.045-inch diameter spaced ¼-inch apart. Perforation schedules like "P8" are used for making prepreg laminates, where you want the very minimum bleed-out. For wet lay-up laminate, we prefer the "P" schedule (or something similar) to allow maximum bleed-out.

Trouble occurs when toolmakers use perforated release film from the prepreg production area of the shop and use it on wet lay-up vacuum bag laminates. Prepreg-style perforations do not allow enough resin to bleed out and results in resin-rich laminates containing a lot of entrapped air. This is one of the most common errors and defeats the purpose of vacuum-bagging. Note: You cannot bleed-out too much resin using the "P" schedule under atmospheric vacuum bag conditions. You can, if you use pressure assist in an autoclave.

It is important to provide enough "bleeder material" to soak up the extra resin when using "P" perforation schedule. Once you fill up the bleeder material, resin stops flowing out of the laminate. Allow enough extra material so when the resin has gelled, there is some dry bleeder left.

If these suggestions are followed, you will find a dramatic reduction of surface blisters on your high-temperature laminated tool.

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