Bonding Fiberglass Laminate to Continuous Cast Acrylic - Choosing the Right Resin

It is essential to use the correct resin to ensure a strong bond between the fiberglass laminate and the acrylic shell part. Using the wrong methods with the right resin can still lead to a poor bond, but using the wrong resin, even with proper methods, will not produce a good result.

The proper resin is one designed and formulated to bond with continuous cast acrylic. There must be a chemical interaction between the resin and the acrylic surface to achieve good results. 'Interaction' is a softer term than 'attack' for this process (etching of the acrylic may be a better description), but it's important to emphasize that the resin must be specifically designed for use with continuous cast acrylic sheet.

Usually, a vinyl-ester resin is recommended for the primer coat on hot tub, spa, or swim spa acrylic shell parts. Not just any vinyl-ester resin will create a strong bond; it must be a vinyl-ester resin designed and tested to provide reliable results with continuous cast acrylic. These vinyl-ester resins are typically epoxy-based and contain higher styrene levels than most laminating resins. Care must be exercised to ensure the correct laminating techniques are used, even with the right resin. Proper laminating procedures will be covered later in this summary. It is also crucial to always follow the resin manufacturer's recommendations for laminating methods and procedures.

Resins other than vinyl-ester resins can be successfully used as a primer coat, but with these, it is even more important to strictly follow laminating procedures to achieve the best results. These other resins must again be designed specifically for use with continuous cast acrylic. Most major resin suppliers offer what they call "Acrylic Bonding Resins"; these are formulated and tested to ensure a good bond to acrylic surfaces. Once again, the laminating procedures are crucial for success. These alternative resins are typically used in the bath industry, but the hot tub or spa environment presents a more demanding challenge for maintaining a strong bond between the fiberglass and acrylic. This is why most spa manufacturers prefer to use vinyl-ester resin at least for their initial or "bond" coat. This layer is also generally not "filled" with calcium carbonate, calcium sulfate, or a combination of both. Remember that the vinyl-ester layer serves two key functions: first, as a tie layer between the acrylic and the laminate layers; and second, as an osmosis barrier that prevents water from migrating through the acrylic to the acrylic/laminate interface, which could cause blisters and delamination.

The "spa" environment is described as more challenging and includes many factors, but it is not limited to the following:

- Being filled with chemically treated hot water for extended periods
- Being left uncovered in intense sunlight for periods
- Being used outdoors where temperature ranges can vary between extreme heat and cold
- The acrylic is being stretched very thin in some areas, especially in the foot-well that bears the most weight when filled with water and occupants.

These factors and others make achieving a strong bond during hot tub/spa manufacturing crucial for producing a durable acrylic shell that won't suffer from delamination, the separation of the acrylic from the fiberglass matrix.

When selecting the right resin, samples of thermoformed acrylic sheet should be submitted to the resin supplier for testing and recommendations. All resin manufacturers have laboratories and staff dedicated to testing their products. You should also request information about the gel times used, the glass content of the laminate, the catalyst type and amount, and the testing methods employed to evaluate the bond.

Once you are confident that the proper methods are being followed at your facility, samples from your process should be submitted for follow-up testing every 2-3 months. The samples should be collected from all areas of the hot tub, including the deck areas where the acrylic is very thick and the footwell areas where it is thinner.

Proper Laminating Procedures

Using proper laminating procedures is nearly as important as selecting the right resin. Several factors will be discussed here, and you should always seek advice from your resin supplier for their recommendations. Key points include glass content, catalyst loading, gel times, roll-out of the laminate, total and per-layer laminate thickness, and shell acrylic part preparation.

The glass content of a laminate indicates the fiberglass-to-resin ratio, where the fiberglass provides strength. The higher the glass content, the stronger the laminate, provided the fiberglass is properly wetted out with resin and rolled to remove all air voids. When done correctly, this produces a very strong laminate without excess thickness or weight. Additionally, fiberglass does not shrink as resin does during curing, so a higher glass content means less shrinkage in the laminate layer and a lower risk of the laminate pulling away from the acrylic. Using fillers in the resin reduces the potential for higher glass content because more resin is used to wet out the fillers rather than the fiberglass. For this reason, it's recommended that at least the first or "bond" layer does not contain calcium carbonate or similar fillers. A glass content of at least 25% is desirable for this initial laminate, with 35% or higher being even better.

Catalyst loading measures the MEK-peroxide-to-resin ratio. Most resins require about 1.5% catalyst by resin weight. It is essential for the resin manufacturer to provide recommendations on the type of catalyst and the appropriate loading, including information on how conditions like hot, cold, humid, or dry weather can affect it. The catalyst loading determines a specific gel time under laboratory conditions, which significantly influences the bond quality to the acrylic part. Typically, the acrylic needs to have the resin in liquid form against its surface for a certain period before the resin begins to solidify, allowing styrene and other bonding agents to chemically etch the acrylic for a proper bond. A gel time in the range of seventeen to twenty-five minutes generally works well. Seventeen minutes provides sufficient chemical etch time, and a cycle up to twenty-five minutes usually does not cause over-attack on the acrylic shell due to extended solvent exposure. An uncontrolled exothermic reaction not only weakens the bond because of a too-short gel time but can also cause orange peel on the acrylic surface. In thinner draw areas, it may lead to "fiber print through," where the exothermically heated acrylic molds slightly to the underlying glass fiber, making the fiber texture visible on the surface. The manufacturer will have product-specific advice on peak exotherm temperature, but typically, the ideal exotherm temperature ranges from 60 to 70 degrees Celsius.

Properly rolling out the fiberglass laminate is essential throughout all areas of the acrylic part, especially in regions of the shell where the acrylic is thinned during the thermoforming process. These thin sections can develop small craters and bubbles or blisters over time and during use if the fiberglass roll-out is not done correctly. Air pockets left in the laminate layers trap styrene vapors, which can continue to damage the acrylic shell until the vapors escape through the acrylic material. This can cause crazing or cracking of the acrylic, depending on the area and how poorly the roll-out was performed. Even in the thicker deck areas of the part, voids can lead to crazing or cracking, depending on how severe the issue is.

The thickness of each laminate layer, as well as the total thickness of the laminate, also influences the quality of the bond. Applying too much material in any single coat or overall can make achieving a good bond difficult. Usually, a first layer of no more than 3 mm should be applied; it's also acceptable to use a thinner first layer, which should then be rolled properly to eliminate all air voids and allowed to chemically react and harden before applying the next layer. This initial layer should have reached its peak exotherm and cooled back to room temperature before adding the next laminate layer, typically after about two hours, depending on the resin formulation and equipment setup. The resin manufacturer should be consulted for their recommendations.

The second layer of laminate can be slightly thicker, but it should not exceed 5mm in thickness. This is usually enough to reach a total thickness of 7-8mm for any bath or hot tub application. If a specific application requires more thickness than recommended, additional layers should be spaced out with more time in between to minimize shrinkage or warping of the shell part.

The acrylic surface of the shell part to be laminated should be clean and free of oils, waxes, or other surface contaminants that could hinder the bond between the acrylic and fiberglass. A good way to ensure cleanliness is by wiping the surface with isopropyl alcohol. More aggressive cleaners may be used, if necessary, but their use should be limited and carefully monitored. For example, acetone can be used, but it should not pool on any part of the acrylic shell, nor should a cloth soaked in acetone be left on the surface. A damp rag with acetone can be used to wipe off dirt or debris completely without leaving the acrylic surface wet.

De-natured alcohol is harsher than isopropyl alcohol and doesn't appear to provide any extra advantages; that's why isopropyl alcohol is recommended.

We recommend not using waxes or release agents containing waxes or silicones on the thermoforming molds during the process. Applying these products on the molds can cause a residue on the surface of the thermoformed part and hinder the bonding between the laminate and the acrylic. If releasing the acrylic parts from the molds during thermoforming is a problem, it's better to use talcum powder.

Additionally, there are two common approaches to testing bond strength: traditional tensile testing and environmental testing to failure. In traditional tensile testing, a sample is "pulled apart," and the force needed to do so is measured. This assesses the bond strength under very specific and ideal conditions. In environmental testing, the bond is subjected to long-term challenges involving temperature changes. We have found that a cycle of scalding water bath and freezing can reveal weak bonding that traditional tensile methods might miss. Details of our internally developed test method are available upon request.