

SURFACE PROFILE AND SURFACING VEIL: REDUCING PRINTOUT WITH A RESIN-RICH SURFACE

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ABSTRACT

Printout on the surface of an FRP laminate has one primary source: resin shrinkage. The very property that makes polyester resin with glass reinforcement so durable is its own enemy when surface appearance is an issue. During the curing stage of a laminate, resin shrinks and glass does not shrink.

A surfacing veil added to a lamination schedule will dramatically reduce the resin shrinkage at the surface, giving it a smooth and consistent resin-rich surface. A consistent resin-rich surface in the composites industry includes a corrosion barrier, UV barrier, a smooth finish and lower porosity.

Surfacing veil added to a process can also increase efficiency, including quicker resin flow in closed-mold situations, earlier demold time, protecting pultrusion dies, strengthening the gel coat, and bonding the gel coat to the reinforcement.

INTRODUCTION

In the composites industry, resin shrinkage is that lowest common denominator that we have simply come to accept. By the time all the benefits of a fiber-reinforced-polymer process are added together, resin shrinkage becomes a back-burner issue. We work around it.

Understanding how the shrinkage occurs helps us adjust to this issue.

Combined chemical elements produce a monomer. Embodied monomers produce a chain called polymers. Polyester is a polymer. The liquid form of resin commonly used in the thermo-set composites industry possesses viscosity with limited translation. Each chain, or polymer, is independent of one another. The resin curing is simultaneous to the polymers crosslinking. Polymerization. No translation. No viscosity. The resin hardens. The resin shrinks.

Resin shrinks and glass does not shrink. Once a laminate is cured, the glass fibers appear to poke

through the surface. This is actually the resin retreating from the surface. Printout.

During polymerization, styrene evaporates. This too is the reason resin shrinks. The amount of styrene that evaporates has more to do with surface area, and not volume of resin or gel coat. For example, let us set two laminates side by side, each a square foot in surface area. Laminate A has twice as much resin as laminate B. Three and a half grams of styrene evaporates from each laminate. Proportionately, laminate B has greater styrene evaporation. A larger percentage.

Styrene evaporation is relevant as it pertains to the path of least resistance. In an open mold situation, the styrene evaporates from the backside of the laminate. The surface of the laminate, against the mold, has considerably less shrinkage. If all elements of the lamination process are correct (mold condition, demolding time, ambient conditions, lamination schedule), the surface of an open-mold laminate will look good. Appearances can be deceiving and will be briefly addressed in this paper.

On the other hand, closed molding has no path of least resistance. Styrene does not escape the confines of a closed mold like it would in an open mold. The metamorphosis during polymerization still occurs, and resin still shrinks. Unlike an open-mold laminate, a closed-mold laminate shrinks evenly. The surface profile of a closed-mold laminate shows more obvious degradation than that of an open-mold laminate.

There are many ways to improve on a surface as it pertains to resin shrinkage. Low profile additives (LPAs) in the resin and a barrier coat are viable options. Thicker gel coat and increased resin are simply not options. The reasons are not going to be discussed in this paper. LPAs and barrier coats alone are viable improvements, but not enough.

This paper and associated presentation will address the need of a surfacing veil in the lamination process.

A surfacing veil included in a lamination process will obviously greatly improve a surface profile. This

occurs because of the consistent resin-rich surface the veil promotes. The consistent resin-rich surface in turn creates a corrosion barrier, a UV barrier, lower porosity, and a smooth or class-A finish.

There are additional advantages to using a surfacing veil. Resin flows more quickly in closed molds. Demolding time can be reduced in both open and closed mold situations. Pultrusion dies are better protected with a surfacing veil. Veil equalizes the temperature of an SMC mold. Gel coat reacts well to continuous-strand glass surfacing veil, by strengthening the gel coat and by bonding the gel coat to the reinforcement.

HOW DOES A SURFACING VEIL PROMOTE A RESIN RICH SURFACE?

Surfacing veil creates a condition where resin is more evenly dispersed at the surface. Instead of resin-rich pockets, the resin is more evenly distributed at the surface.

What is a surfacing veil?

A surfacing veil is a mat that is manufactured in such a way that allows for quick and easy resin absorption. The very properties promoting this quick wet-out also limit the resin shrinkage.

For the sake of this paper and associated presentation, all examples will refer to a continuous-strand glass veil. The variety of surfacing veil offers choices for varying applications. That variety includes polyester-fiber synthetic veil, paper veil, chop-strand glass veil, and continuous-strand glass veil. To discuss these varieties would mean further discussing barrier coat and LPAs. All choices have their respective pluses, minuses and overall effectiveness. In this discussion, the continuous-strand glass surfacing veil offers the widest variety of applications and offers the best surface.

In this case, a continuous-strand glass surfacing veil is a mat with evenly dispersed independent glass fibers.

A typical glass surfacing veil is comprised of 25-micron filaments. Each filament is independent of one another, held with a light resin binder. The dispersion of these filaments is consistent enough to give a paradoxical balance of loft and density.

By comparison, a standard chop-strand reinforcement mat or woven roving uses 25-micron filaments that are densely bunched together. This density promotes the reinforcement but prohibits easy resin flow.

In a typical lamination schedule, the surfacing veil is placed between the gel coat and the reinforcement mat.

How does the surfacing veil work?

In the case of the surfacing veil, the evenly dispersed fibers has two exclusive and independent objectives.

The first objective is resin flow. The veil, with its independent fibers, creates a conduit at the surface of a laminate. This is the loft property at work. The density of a woven-roving mat or chop-strand mat hinders the flow of resin. Because the veil offers rapid wet-out, the resin flows to and at the surface with ease.

On an even and level surface, pour an equal amount of polyester resin in two small pools. Drop a piece of 96 ounce woven roving on the resin, work the woven roving in the resin, and the wet-out time will be about a minute. Drop a piece of 15-mil glass surfacing veil on the resin, and the wet-out is less than a second.

The obvious rebut to this comparison is that there is considerably more glass and density in the woven roving. However, this is also the point of this comparison. The resin flows easily through the surfacing veil. The high amount of glass and density in the reinforcement is prohibitive to the resin wet-out.

The second objection is limiting resin shrinkage. We observed earlier that the evenly dispersed fibers are consistent enough to give a paradoxical balance of loft and density. It is this even and consistent density at the surface that also limits the resin shrinkage. This is the density property.

Visualize the resin-rich pockets that occur in a woven roving. The three-dimensional weave leaves the unavoidable condition of resin-rich pockets. This occurring at the surface is the perfect recipe for printout. Resin shrinks, and glass does not. The printout is obviously discernable because of the extremity created by significant resin-rich pockets.

The same phenomenon occurs with the surfacing veil, but to a much lesser extreme. The resin-rich pockets are defined by the gaps between filaments in the veil. However, unlike the woven roving, where the resin-rich pockets can measure an eighth of an inch between bunched filaments, the resin-rich pockets in the surfacing veil, for all practical purposes of measurement comparisons, are nonexistent. That is to say, the comparison is not going to be made by using a tape measure. Alleging these are true resin-rich pockets is a stretch.

Why a resin-rich surface?

A consistent resin-rich surface is key to the life of a laminate. Outside sources attacking a laminate will shorten its life span. Whether the attack is to the surface or beyond the surface, the laminate will not stand the test of time if it is not properly protected. A resin-rich surface is that protector.

The lack of a resin-rich surface spells porosity. There are no two ways around this issue. Porosity is doom for a laminate.

A paved highway is porous. This is doom to I-75 in Detroit every spring thaw. Water seeps into the pours and cracks of the pavement. When the water freezes, potholes occur. While technology continues to improve in the paving of our highways, potholes are still inevitable every spring thaw.

The composites industry does have the technology to improve the porosity of laminates. A surfacing veil, allowing an even resin flow at the surface, and allowing limited resin shrinkage at the surface, is that technology.

Even after all variables have been taken into account; ambient conditions, mold condition, glass to resin ratio, gel coat thickness, proper catalyst ratio; porosity from resin shrinkage is still inevitable, including open molds.

In a recent test by the National Composites Center, two identical specimens were compared for porosity. Specimen A had no surfacing veil; Specimen B had surfacing veil.

Other than surfacing veil, these specimens were identical. Because of that, the exact details are not necessary, beyond noting that the laminate contained 20 mil gel coat, vinyl ester resin, 54 ounce woven roving, and prepared with a 14-psi vacuum assist. These specimens were made with an intentional matte finish for photographic reasons. These tests were conducted to provide visual evidence of the behavior of gel coat with and without veil.

The cured specimens noted no difference in surface profile by the naked eye or by the touch.

Yet when the specimens were measured on a stylus profilometer, a dramatic difference was noted. Specimen A, the sample with no veil, measured a roughness average of 4500. Specimen B, the sample with veil, measured a roughness average of 28.

The stylus profilometer measures roughness average, or RA, of the vertical profile. It does not

measure a class "A" finish. The RA value is equal to 1/10,000 of an inch. The difference of specimen A, with no veil, 45/10,000 of an inch, and specimen B, 28/1,000,000 of an inch, is a staggering 160 times. This is not to read 160%. This is to read that the specimen with no veil is 160 times more rough than that with the veil.

Or for an easier visualization, sit in a chair next to the Renaissance Center in downtown Detroit. Look down at the ground. That is with surfacing veil. Look up. That is with no surfacing veil. This visualization compares 4.6' feet to the 747' height of the Renaissance Center. $4.6/747=160$.

This extreme yet simple example shows the porosity difference of a laminate with and without veil.

It should also be noted that this profilometer test was on a laminate with 20 mil of gel coat. If a laminate is to be produced with no gel coat, and painted at a later time, we need to keep in mind that the porosity will be greater with no gel coat and no veil. When this porous surface has paint applied to it, porosity will still be an issue.

A resin-rich surface also acts as a barrier preventing attacks to the laminate. The most common of these attacks is corrosion and ultra violet rays.

Perhaps the first thought that comes to mind as corrosion relates to an automotive part is road salt. The early Corvette leveraged this point. No body rust.

Today, advances in paint systems and metal fabrication, plus the use of thermal plastics and SMC has widened the playing field. The Corvette's rust-free bragging point can also be used by Saturn.

Beyond the outer body, other unseen components of the automobile are moving toward composites. A pultruded drive shaft for instance is a good example. While cosmetics are not at issue, the protection of this drive shaft is at issue. Introducing a surfacing veil to the pultrusion process will decrease porosity, and add a corrosion barrier. The corrosion barrier will protect the drive shaft from such attacks as road salt and transmission fluid.

Under the hood, items such as heat shields, battery trays and valve covers come in contact with a myriad of chemicals.

Every day, new ideas for composite parts become reality in research and development laboratories. Any and all of these components will come in contact with corrosive materials. A corrosion barrier becomes a necessity.

Ultra-Violet rays also attack a composite component. A surfacing veil with a UV inhibitor further protects a composite laminate.

The effects of UV attack are color degradation through oxidization, and ultimately a chalky and delaminated surface.

The class "A" finish is ideally the most recognized role of a surfacing veil. And in the automotive industry, class "A" finish is King.

Surfacing veil is the ingredient that best reduces printout. A class "A" finish cannot be attained when printout is present. The weatherability and durability of a composite laminate is improved with a surfacing veil. Weatherability and durability are part of the class "A" finish requirements. A surfacing veil applied to a laminate improves smoothness and eliminates paint pops.

Where else can I improve surface?

In the discussion of corrosion, the pultrusion process was mentioned. The example given was a pultruded drive shaft. While cosmetics are not important in this component, an improved surface with veil is important to protect against corrosion attacks.

The SMC process traditionally does not require surfacing veil. There are times however, a surfacing veil will improve the surface. If color degradation is present in a cured SMC part, mold temperature is most likely the culprit. A glass surfacing veil will equalize the mold temperature, and give the cured SMC part its desired consistent appearance.

HOW DOES SURFACING VEIL INCREASE EFFICIENCY?

Surfacing veil's claim to fame is cosmetics. Thus far, we have observed how surfacing veil can improve the surface and protect the surface. A surfacing veil added to a process can also improve efficiency. The resource savings may be time or effort. It may also be a hidden benefit.

Quicker resin flow in a closed mold

In a process that injects resin into a mold, particularly a vacuum assisted RTM process, resin flow is hindered by the densely packed fiberglass. Because resin shrinkage at the surface is already an issue, veil is most likely a component of the final laminate.

A hidden benefit is when the veil acts as a conduit in the mold. Resin pulled from one end of the mold to

the other moves quickly along the surface with this conduit. The resin at the surface can then soak into the glass, and ultimately decrease the time in the mold.

Earlier demold time for closed and open mold

Like in the above example, the time a laminate sits in a mold is dependent of process. That is to say, filling the mold with resin. Once the glass is adequately saturated, the laminate still must cure.

An open mold does not deal with resin flow.

In both of these cases, the surfacing veil reduces the resin shrinkage at the surface. This serves as an advantage for a demolded part. As exotherm continues to cure the part, the resin continues to shrink. This is also true if a part is pulled from the mold early. The surfacing veil greatly reduces shrinkage, even after a part is pulled from the mold early.

Great care is to be taken with this concept. Because of the countless variables, testing is required of this type of timing. Even in open mold hand spray-up, a laminate made at the beginning of the day will be different than the laminate made at the end of the day. The difference in resin amount will alter the cure time.

Protects pultrusion dies

In the process of pultrusion, glass rovings are pulled through a mold. A lot of glass is packed into a small area with a lot of pressure.

The addition of a surfacing veil reduces the wear from the rovings. The veil protects the costly die from accelerated deterioration.

Strengthens the gel coat

The concept of surfacing veil strengthening the gel coat is very similar to the concept of reinforcement mat strengthening the resin.

Gel coat with no surfacing veil on a laminate is vulnerable to chipping and cracking. It has no reinforcement. The surfacing veil is a hidden benefit for strengthening gel coat.

No matter if the process is open mold or closed mold, apply a continuous-strand glass surfacing veil to a gel coat that is still tacky or not completely cured. The loft of the veil keeps each glass fiber independent from the others. These independent glass fibers sink into the gel coat. Once cured, the veil reinforces the gel coat.

Bonds gel coat to reinforcement

Just like above, a veil applied to a tacky gel coat will sink into the gel coat. Not the entire veil sinks into the gel coat. The remaining veil will combine with the resin that is interacting with the reinforcement mat.

The surfacing veil in a composite laminate between the gel coat and reinforcement is similar to giving a smooth surface an abrasive surface before applying paint. The veil acts as a bridge, interlocking the gel coat with the reinforcement.

CONCLUSION

In the automotive industry, class “A” surface is King. A poor surface profile due to printout is a major obstacle when a class “A” finish is required. A surfacing veil added to the lamination process

eliminates that obstacle by producing a consistent resin-rich surface.

This resin-rich surface does more than simply eliminates printout. A resin-rich surface also provides a barrier against corrosion from chemicals and UV. Additionally, surfacing veil and a resin-rich surface greatly reduces porosity.

Surfacing veil’s relationship with gel coat is an important one. Not only does veil strengthen the gel coat, veil also bonds the gel coat to the reinforcement.

Surfacing veil is a low-cost addition to a lamination process also. At pennies a part, veil is very attractive, as it not only improves the surface, but also adds efficiency to the process and brings with it benefits such as strengthening gel coat, earlier demold time, and quicker resin flow in a closed mold. This means increased production.