WHITE PAPER

Resin Uptake

Resin uptake during the infusion process determines the sandwich panels weight and cost level. It varies as a function of cell size and cut configuration.

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ArmaPET™

ArmaPET™ Struct RESIN UPTAKE

A high-performing core material is of less use if it adds complexity and costs to the manufacturing process. While a sufficient core-skin adhesion requires a certain amount of resin, any additional resin uptake on the core material's surface represents both extra cost and weight. ArmaPET Struct is a temperature resistant and process versatile material, which is suitable for various production methods like infusion or pre-preg and compatible with epoxy or polyester resin.

INTRODUCTION

All foam core materials have a porous surface, even closed cell, so the level of resin uptake must be taken into consideration. In case of open methods, i.e. hand lay-up or spray-up, the amount of resin used can be controlled. With these methods, the problem is rather to get enough resin into the core surface to avoid a resin-starved interface between the core and the laminate, since this can result in lowered peel strength or even no bond at all. Therefore, core producers often recommend minimum 'primer' amounts depending on the core's density, since lower densities normally require more resin to fill the surface cells that have been cut open during the slicing process.

Also for pre-pregs, RFI (Resin Film Infusion) etc., the resin uptake is not really crucial since the amount of resin available in the pre-preg is fixed. There has to be just enough resin to get a good enough bond between the core and the laminate, but this will likely require a film adhesive or a resin rich pre-preg layer next to the core.

However, for all liquid moulding methods, especially those that use vacuum, resin uptake is crucial for controlling weight and cost purposes. Resin uptake is not only clearly linked to the cell size, but also to the shape of the cells. Consider the sphere and the cylinder with the same diameter. They may look the same from above, but the cylinder's volume is clearly larger than the sphere's volume (see figure 1). This, in turn, means that an elongated cell will have a larger volume than a spherical one of the same diameter. The cells of the extruded PET core are more elongated, and will therefore absorb more resin than a rounder cell made from PVC, PUR foam, etc. with the same diameter. In order to get to the same level of resin uptake as PVC or PUR cores, we have to have an even smaller cell size than they do. Despite the average cell size, it is also the distribution of the cell size that matters. A few 'large' cells will absorb as much resin as many 'small' cells, since the volume is a function of the cube that takes the radius of the cells into account. Therefore, it is just as important to minimise the number of big cells, and not just the average cell size. Today, we have the required tools to scan and count the cell size and distribution. See figure 2.

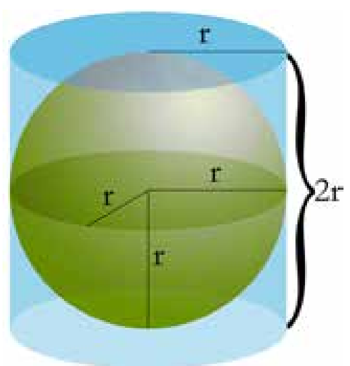

Figure 1: Volume of cylinder vs. sphere

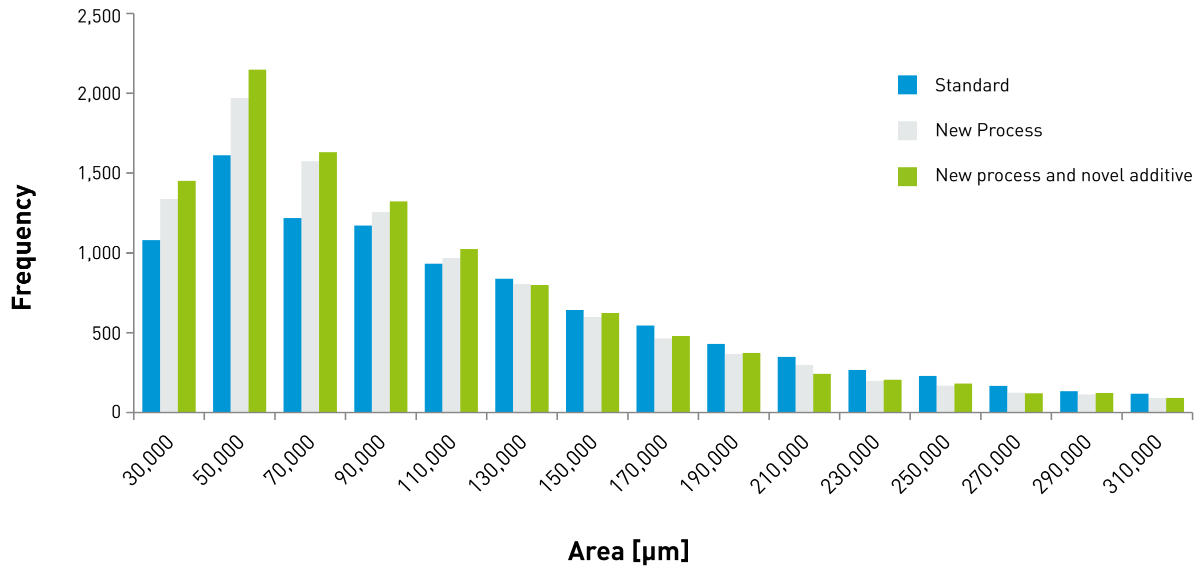

Figure 2: Cell size distribution

METHODS FOR RESIN UPTAKE

One big problem when talking about resin uptake is that there is no formal standard for resin uptake. There are several different ways to test the resin uptake and measure the weight increase in the core. Principally, two different ways have been identified for performing these tests.

With fibres

Cover the core with fibres and peel-ply/release film/ distribution media, taper off the core to a 'reference' section with single skins. Infuse the panel, clean cut the section with both the sandwich and the single skin section and then deduct the single skin area weight from the sandwich area weight to get the resin uptake.

+ More realistic lay-up
+ Less scatter
- More material used
- Longer lay-up time
- An even resin uptake / fibre fraction in single skin versus sandwich is not necessarily given in case of a short gel time.

Without fibres

Cover the core material only with peel-ply/release film/distribution media. Infuse the panel, remove the peel-ply and other layers from the core, clean cut the section of the sandwich and measure the core's infused weight.

+ Less time-consuming
+ Less material used
- More scatter
- Uneven wet out due to tearing when removing the peel-ply

As there is no commonly accepted standard for resin uptake testing and, since it is difficult to compare values from different manufacturers or test institutes, Armacell has developed a proprietary method based on infusion processing to measure the resin uptake of its ArmaPET Struct material. Looking at the industry today, most companies use some kind of infusion method for resin uptake testing. However, due to differences in resin type, viscosity, temperature, curing time, vacuum level, etc., results can vary significantly, and it is not possible to compare results from different sources.

For Armacell's internal test method, the results are presented in 'kg/m^2' and 'side', which is in line with how other core producers present their information. To obtain the true uptake per m^2 for a plain sheet of core material, the result needs to be doubled. This is also to make it possible to combine results, e.g. for a core with one grooved side and one plain side, and in order to get a realistic estimate on the resin uptake for that combination.

ARMAPET RESIN UPTAKE RESULTS

Plenty of results are available for ArmaPET Struct in 115 kg/m³ density, but scatter is relatively high due to many factors that influence resin uptake. It is important to perform a number of tests in order to be able to draw conclusions. For other ArmaPET Struct densities, the number of tests is less but may still be enough to show indicative results.

Resin uptake results for different ArmaPET Struct densities are given in the table 1 below for plain core only and in 'kg/m² per side'. **In general, a falling trend in resin uptake is expected with increased density due to the relative decrease in cell size.**

For a number of years, progress was made to reduce the resin uptake of the first generation of ArmaPET Struct, made of virgin PET (called AC grade). The next step was taken with the new GR grade, based on 100% recycled PET plastic bottles. To reach the next level in reducing resin uptake requires an even finer cell structure, which is under development for the third generation of ArmaPET. Full-scale trials have been performed and the results show that it will be possible to compete with PVC cores in this respect.

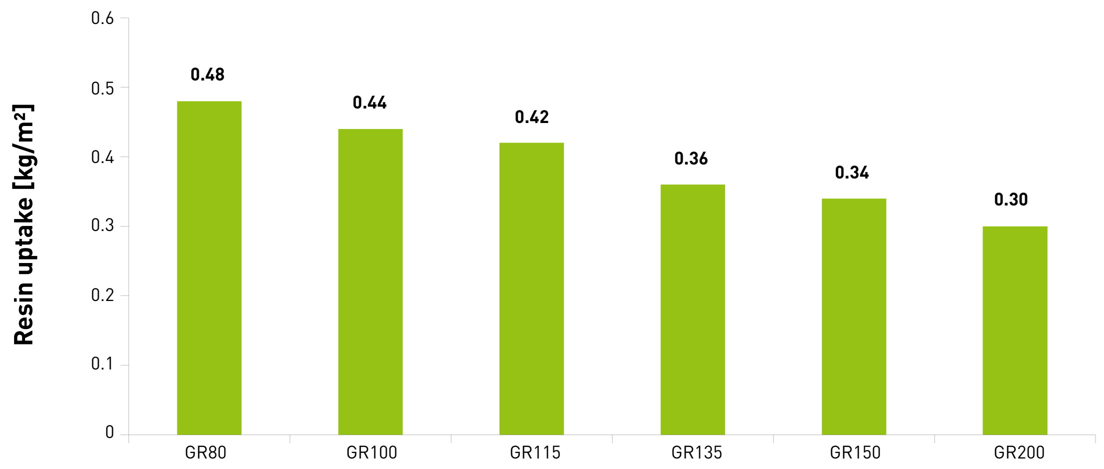

Table 1: ArmaPET Struct resin uptake per side and plain material

SURFACE TREATMENT

For all core materials, there is the option of using a surface treatment to minimise the resin uptake. This has been utilised mainly with end-grain balsa wood due to its very high resin uptake. For balsa, the common method is to coat the surface with a very thin layer of ultra-fast curing resin. In this way, the resin uptake can at least be limited for open moulding methods. However, for closed moulding the coating layer is most often not strong enough to withstand the pressure of the resin, and the uptake will be even higher. The peel strength for coated surfaces is often as well lower making this a trade-off that needs to be taken into account.

It is less common to use coating for foam cores, but with PET-based material you have the option of using a surface treatment without introducing additional material as it is usually necessary. Instead you can seal most of the surface cells and save about 40-50% of the resin uptake without compromising the adhesion and peel strength. It is also possible to seal or better close the surface completely and thus reduce the resin uptake again, but this will lower the peel strength.

It is important to bear in mind that surface treatment only affects the top and bottom surface of the core. Any further processing afterwards, e.g. grinding or chamfering will open up new surface cells that absorb resin again. **While surface treatment might save a couple of hundred grams, converting can often take up several kilograms of resin per square metre.**

CORE FINISHING PLAYS A MAJOR ROLE

A factor that is often forgotten when discussing resin uptake is that it is usually is of secondary importance as soon as any converting is applied. Each time the material is cut, it increases the effectice surface area susceptible to resin absorption. **Table 2 on the next page shows the heavy influence on the resin uptake for the core when converting methods such as gridscoring, conturing, grooving or perforation is applied to the core.** In this example the pattern is 30 x 30 mm with a cut depth of 1.0 mm. Here the scatter from testing is even higher than for plain material, which is probably related to the manufacturing process of gridscoring.

Gridscoring is the standard converting method for single or slightly double-curved foam cores. In case of less weight and less cost sensitive sandwich applications, it might be acceptable but can have two major disadvantages: weight increase and decrease of peel strength. A gridscored flat sheet of 20 mm thickness in combination with the infusion process can easily take up 2.0 – 3.0 kg of extra resin per square metre. When applied with curvature, this can lead to an additional 50% of resin absorption. The second drawback is the stress concentration caused to the material when infusing the cuts. Although a proper resin filled gridscored cut is as strong and stiff as in case of a plain non-cut material, empty or half-filled cuts are up to 40% weaker. That makes it so important to have a reliable manufacturing process in place that ensures proper filled voids.

Much has been said about gridscoring, but perforation can have a major impact as well. The thicker the perforated material is, the more resin is absorbed. Thicker core materials require larger drills. Going from a 3 to 5mm drill can increase the amount of resin absorbed by 277%.

6// RESIN UPTAKE

Due to its thermoplastic nature, ArmaPET Struct allows for an additional way of processing the core material into 3D-shaped curved form: **thermoforming**.

Thermoforming is carried out by heating the foam to its softening point and then forcing it against the contour of a female or male mould. ArmaPET Struct thermoforms very well to single sheets, for double curved surfaces thinner sheets are used. The advantages of thermoforming are a homogenous core material, without any stress concentration caused by over filled cuts, or even worse empty cuts. In addition, the lay-up time in the mould is shorter and the final weight is lowered thanks to the resin uptake being significantly lower. The freedom of design offered with the thermoforming method opens up a wide scope of design concepts even for limited series.

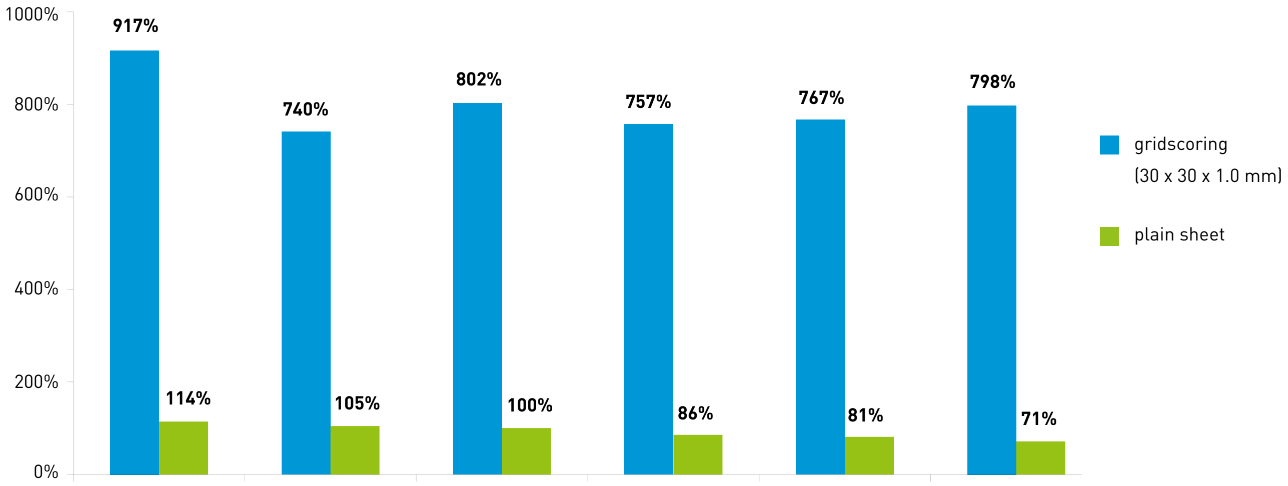

Table 2: ArmaPET Struct resin uptake plain material vs. gridscoring

OUTLOOK

Obviously, the most efficient way to minimise resin uptake is to apply the minimum of converting on the core. This is of crucial importance, since cores with finer cell structures will soon take advantage of this. Over the past few years, we constantly improve our cell structure to reduce the resin uptake. For the coming third generation of ArmaPET Struct, we are working to achieve an even finer cell structure as compared to today's. This will be done by installing novel extrusion equipment that has been developed using CFD-Simulations (Computational Fluids Dynamics), and which provides a more homogeneous cellular structure of the foam. Using novel additives also provides a significantly finer cellular structure than the conventional solution. In the near future, pressure optimisation in the extrusion process can also influence the cellular structure in a positive manner.

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ABOUT ARMACELL

As the inventors of flexible foam for equipment insulation and a leading provider of engineered foams, Armacell develops innovative and safe thermal, acoustic and mechanical solutions that create sustainable value for its customers. Armacell's products significantly contribute to global energy efficiency making a difference around the world every day. With 3,135 employees and 24 production plants in 16 countries, the company operates two main businesses, Advanced Insulation and Engineered Foams. Armacell focuses on insulation materials for technical equipment, high-performance foams for high-tech and lightweight applications and next generation aerogel blanket technology.

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