WHITE PAPER

RESIN UPTAKE

Resin uptake during the infusion process determines the sandwich panel's weight and level of cost. It varies as a function of cell size and cut configuration. Surface treatment is an efficient way to reduce the resin uptake of ArmaPET Struct, while fully maintaining the product's properties.

www.armacell-core-foams.com

armacell®

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).

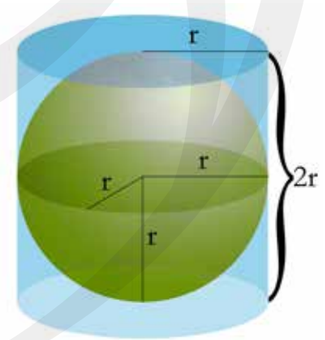


Figure 1: Volume of cylinder vs. sphere

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 table 1.

Next to the control of the cell size, it is possible to use the thermoplastic nature of the ArmaPET Struct and lightly surface treat the first layer of the cut open cell on the surface to lower the resin uptake.

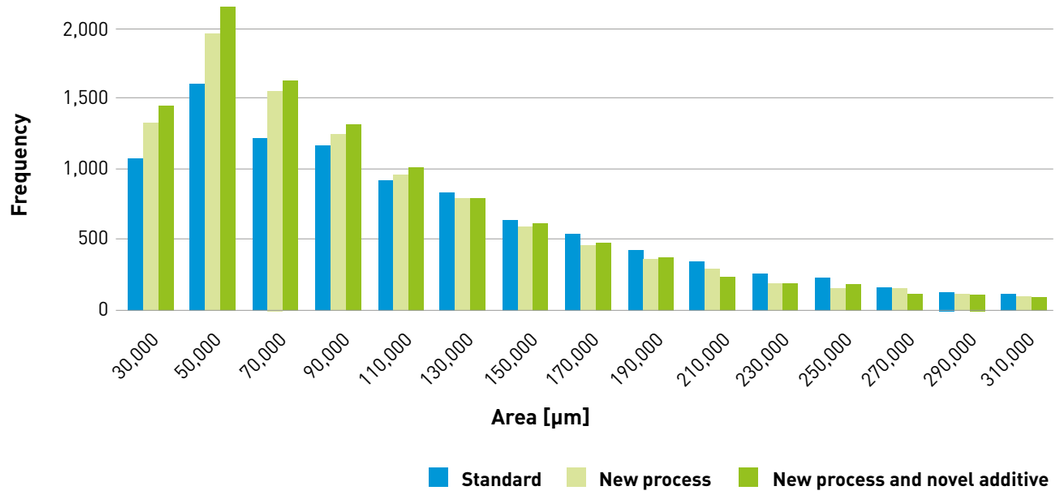


Table 1: Cell size distribution

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 x 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.

As previously discussed, using a peel ply directly on the core will increase the scatter as you tear out some resin from the core surface when you rip off the peel ply. In the past this method was used anyway, as it was quick and easy to perform. However, with incremental improvements in resin uptake, it became clear that the scatter was too high for this method to remain useful. Therefore, Armacell has changed the process by using the concept of testing with fibre on both sides of the core, tapered at the vacuum side to a single skin.

The panel is infused, then cured, and the sandwich (with skins) and single skin section is cut cleanly and weighed.

Finally, the area weight of the single skin and core is deducted from the sandwich section weight, and the resin uptake is calculated.

With this new and improved method, the resin uptake is displayed in g/m², i.e., for both sides of the core sheet (normally 25 mm in thickness, but the thickness effects are negligible for ArmaPET Struct foam core). The new method is more concise with less scatter and has the advantage of the single skin area that also works as a reference section for comparison over time. With the old method the results were displayed in g/m² and side, so the values displayed today are more than double with the new method, as it is for both surfaces of the sheet.

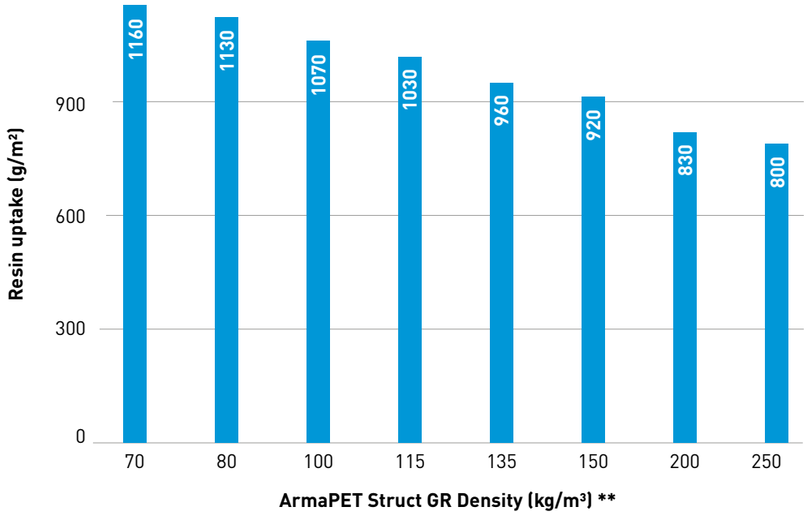
ARMAPET RESIN UPTAKE RESULTS

As scatter is relatively high due to the many factors that can influence resin uptake, it is important to perform several tests to be able to draw the proper conclusions.

Resin uptake results for different ArmaPET Struct densities are given in table 2 below for plain core only and in g/m². 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.

RESIN UPTAKE AS PER THE ARMACELL INTERNAL TEST METHOD*



Resin uptake values are average/ nominal and based on Armacell's revised test method for resin uptake testing. Data is under steady validation and will regularly be reviewed and updated.

* The values can vary with the test method.
** The resin uptake consumption can be decreased using Armacell's surface treatment technology.

Table 2: ArmaPET Struct GR resin uptake per plain core in g/m²

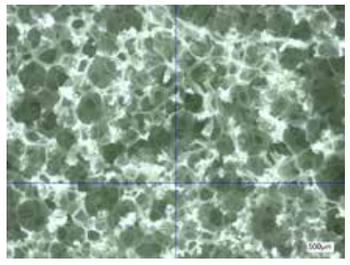
SURFACE TREATMENT

With all core material there is the option of using a surface treatment to minimise the resin uptake. This has been principally used with end-grain balsa wood (EGB) due to this material having a very high resin uptake. For balsa, the common method is to coat the surface with a very thin layer of ultra-fast curing resin. With this coating the resin uptake can be limited at least for open moulding methods. However, for closed moulding the coating layer is often not strong enough to withstand the pressure of the resin, and again the uptake will be even higher. Peel strength for coated surfaces is often lower as well, so this is a trade-off that needs to be taken into account, as well as ensuring that the coating is compatible with the resin system to be used.

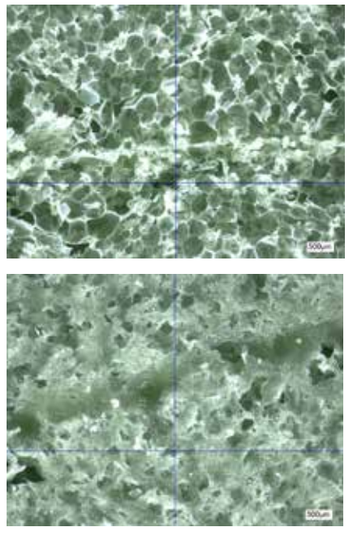
For foam core materials it is less common to use coating, but for a PET-based foam core you have the option (as already stated) of doing a surface treatment without adding additional material. Instead, you can seal, more or less, all of the surface cells without introducing an additional material. Typically, for a plain core material sheet you can save in the region of 40% of the resin uptake without compromising the adhesion and peel strength. It is fully possible to close the surface completely as well and minimise the resin uptake, but then the peel strength will also be lowered, so there is a compromise there that should be carefully considered. In the case of surface treatment of ArmaPET Struct, the level of sealing is set so that the integrity of the sandwich structure (adhesion and peel strength) is unaffected.

ArmaPET Struct is a closed cell foam; however, after slicing operations a certain number of open cells is formed at the surface. In composite panels manufacturing, these cells are filled in with the liquid resin, which solidify inside, providing a good adhesion with facing materials (laminated skins) mainly by the mechanical anchoring mechanism.

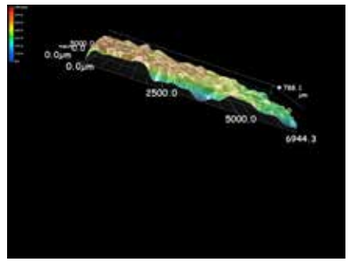
After additional operation of surface treatment, the surface cells could be partially sealed or closed. This could be achieved by different means: by thermal, mechanical, and chemical treatment, for example, or a combination thereof. The level of surface sealing will affect the resin intake of the foam in the final application, but also the adhesion (peel-off behaviour) of the skins, so it is very important to keep the right balance.

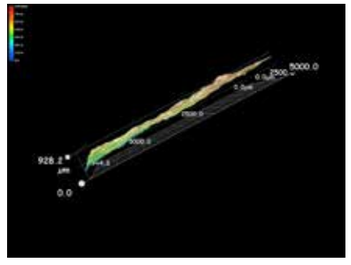


Pictures 2 & 3: Microscopic photo of the centre of ArmaPET Struct (magnification 50x)



Pictures 4 & 5: Microscopic photo of the welding seam area of ArmaPET Struct (magnification 50x)





Pictures 6 & 7: Surface depth analysis

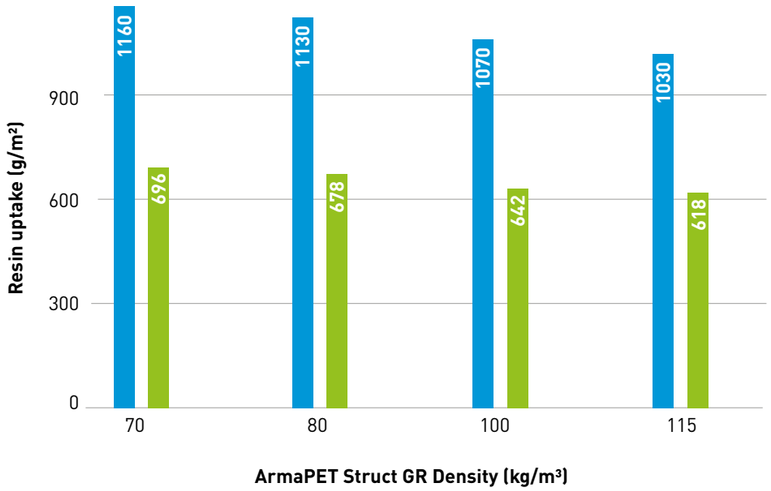
The pictures depict the visual appearance of the ArmaPET Struct foams before and after surface treatment. In all of the examples, the same grade of ArmaPET Struct GR100 has been used. The pictures 2 and 4 show the foam without any treatment, while pictures 3 and 5 show the surface treatment method. The microscopic pictures reveal the number of surface-opened cells, which are much reduced for treated samples. The welding seam is relatively thin in the case of a neat sample, but it is getting thicker for surface-treated products.

The depth analysis (pictures 6 and 7) shows the surface elements height variations applying the colour scale – from blue (representing the deepest areas) to red (representing the highest structural elements). One may observe that the surface-treated samples are characterised by the reduced depth of the cells, and a flatter surface.

SURFACE TREATMENT AND RESIN UPTAKE

As already stated, you can more or less seal the surface cells without introducing an additional material. For a plain core material sheet, saving in the region of 30-40% of the resin uptake without compromising the adhesion and peel strength is typically possible. It is fully possible to close the surface completely and minimise the resin uptake, but then the peel strength will also be lowered, so there is a compromise there to be carefully considered. In the case of surface treatment of ArmaPET Struct, the level of sealing is set so that the integrity of the sandwich structure (adhesion and peel strength) is unaffected. Resin uptake savings will also be affected by the density of the material, where it will be relatively more efficient for low and medium densities.

RESIN UPTAKE ST VS. NON-ST AS PER THE ARMACELL INTERNAL TEST METHOD *



Resin uptake values are average/ nominal and based on Armacell's revised test method for resin uptake testing. Data is under steady validation and will regularly be reviewed and updated.

* The values can vary with the test method.

NON-ST ST

Table 3: Resin uptake per density and related typical savings when applying surface treatment

MECHANICAL PROPERTIES OF ARMAPET STRUCT GR100 VS. GR100ST

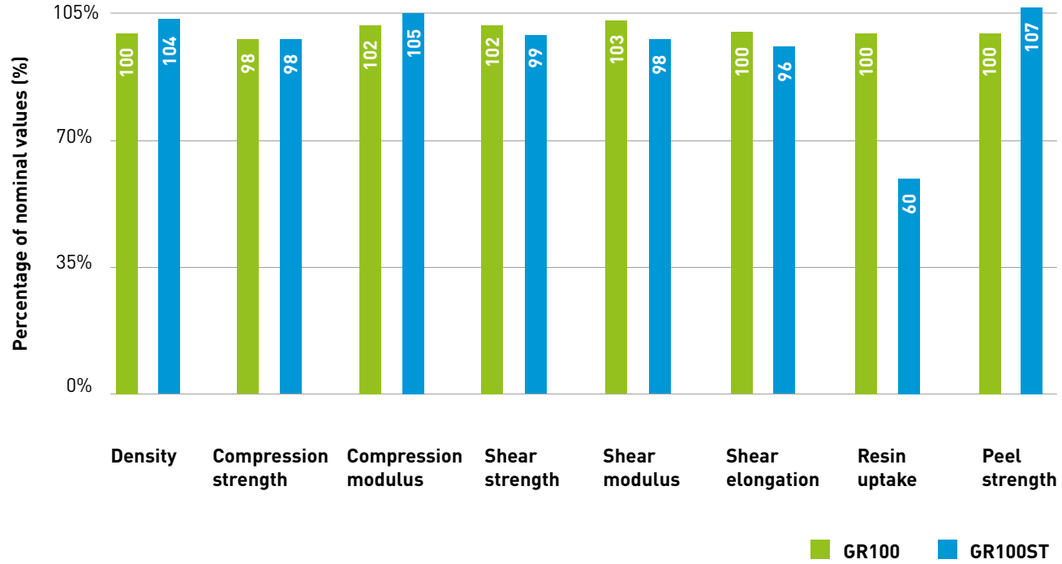


Table 4: Mechanical properties of ArmaPET Struct GR 100 standard vs. surface-treated

SURFACE TREATMENT AND MECHANICAL PROPERTIES

In table 4 on the next page the test result with and without the surface treatment is presented in comparison with the data sheet properties for ArmaPET Struct GR100. The first point to observe is that the apparent density of the core will increase due to the melting of the surface cells. This effect will normally be small and neutralised by the savings in resin, but in the case of thinner sheets it could be an important consideration.

Compression strength is unaffected while the compression modulus is increased on paper, but this is due to a change in the failure mode that you will see in any case when the core is being laminated. In reality, the modulus is also unaffected. In the same way the shear properties are within the scatter of the testing and well in line with normal test results. Peel strength is slightly increased when compared with material that is not surface treated, but the resin uptake has been decreased by 40%.

CONSIDERATIONS FOR SURFACE TREATMENT

The surface treatment offered today is more effective than earlier methods, with higher savings in resin uptake. Compared with the earlier method, the surface looks less shiny but will still offer similar resin uptake and better peel strength.

What to keep in mind with surface treatment is that it is only affecting the top and bottom surface of the core. Any converting (grooves, cuts, perforations or grid scoring) will open up new surface cells that will, in turn, take up resin. Converting can often take up kilos of resin per square metre, while the surface treatment perhaps saves a few hundred grams. Also, any grinding or chamfering will also destroy the surface treatment, rendering the savings for those areas null and void.

Another issue is that for thin sheets the density of the core will increase due to the melting of the surface cells. Normally, this increase in density is compensated for by the decrease in resin uptake, but this should still be given consideration.

Finally, even though Armacell has made tests with all common resin systems and seen no effect on adhesion to the laminates, it is impossible to check all of the possible combinations or resin, adhesives and processing parameters, so it is advisable to produce and test parts made with the particular material combinations to be used under actual production conditions to verify their final suitability.

LIMITATIONS FOR SURFACE TREATMENT

ArmaPET Struct grades can all be surface treated. We currently offer all densities from GR70 to GR115 with surface treatment as the default procedure if not agreed upon differently. Higher densities can be evaluated on request. We are continuously working on improving our offerings and are therefore currently reviewing the benefit of surface treatment for high densities and optimising its parameters.

We also investigate surface treatment offerings for other products like ArmaPET Struct FR grade.

Surface treatment can be offered for thickness from thickness of 10 mm onwards to the maximum available foam thicknesses.

ArmaPET Eco cannot be surface treated.

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 5 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 halffilled 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%.

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.

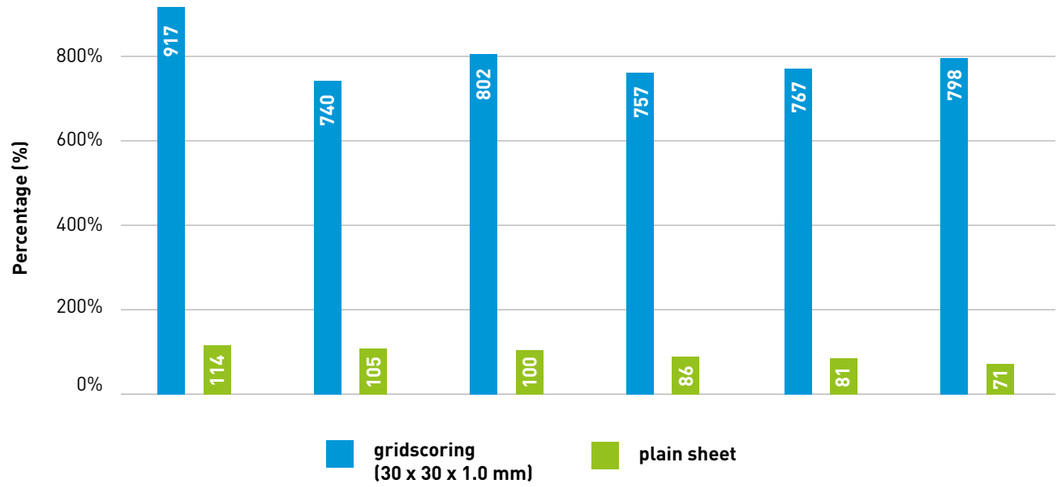


Table 5: ArmaPET Struct resin uptake plain material vs. gridscoring

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.

00476 | ArmaPET Struct | Resin Uptake | WhitePaper | 012022 | Global | EN MASTER

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 3,000 employees and 23 production plants in 15 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.

For more company information, please visit:
www.armacell.com

For product information, please visit:
www.armacell-core-foams.com

armacell®
MAKING A DIFFERENCE AROUND THE WORLD