By our staff

Epoxy matrix composites in yachting applications

Composite materials are made up of a number of different simple materials (phases): the matrix and the reinforcement. The matrix is a continuous and homogeneous phase whose job is to envelop the reinforcement, guaranteeing great cohesion and distributing stresses.

The reinforcement is a phase spread through the matrix that has the job of ensuring stiffness and mechanical resistance, bearing most of the external load. As figure 1 shows, the reinforcement usually determines the mechanical characteristics and the response to stresses, while the matrix transfers the stresses and strains applied to the composite on to the reinforcement and ensures that the composite behaves like a new material with its own intrinsic characteristics. It also has a substantial influence on all the final chemical and physical characteristics of the composite, in addition to determining its build process. Finally, as an amalgam, it also influences overall mechanical performance. So it is obvious that the matrix is a fundamental element in the construction of a composite. For this reason we need to pay attention to it, both in terms of the choice of the chemical used and in terms of process and operational variables. The choice of the matrix determines the production process and vice versa: the choice of a process imposes the use of a certain kind of matrix. In this article we will see how an epoxy matrix can influence the whole chain of values linked to the production of components in composite. The solution that Sika® has studied for these applications and which for some time now has been a safe and reliable opportunity for those who want to stand out in composite building in the yachting market are bi-component Sika® Biresin® CR83 epoxy resins for infusion processes and Sika® Biresin® CR82 for wet lay-up processes. A composite works as long as matrix and reinforcement collaborate continuously, so to improve the performance of a composite we need to extend this range of operation

STRENGTHS	WEAKNESSES
• Greater mechanical characteristics • Fewer aesthetic problems than laminate • Less material required a less weight • Better product quality • Products with characteristics very close to design requirements • Zero VOC	• Matrix cost • Material management (warehouse) • Production cost (environment and post-cure control)
• Control of overall process • Composite optimisation • Risk management • Possibility of using carbon fibre • Acquiring workforce competence and professionalism • Creating new infrastructures • Product innovation • Market appeal	• Working in an uncontrolled way, components not conforming to needs will very probably be produced
OPPORTUNITIES	**THREATS**

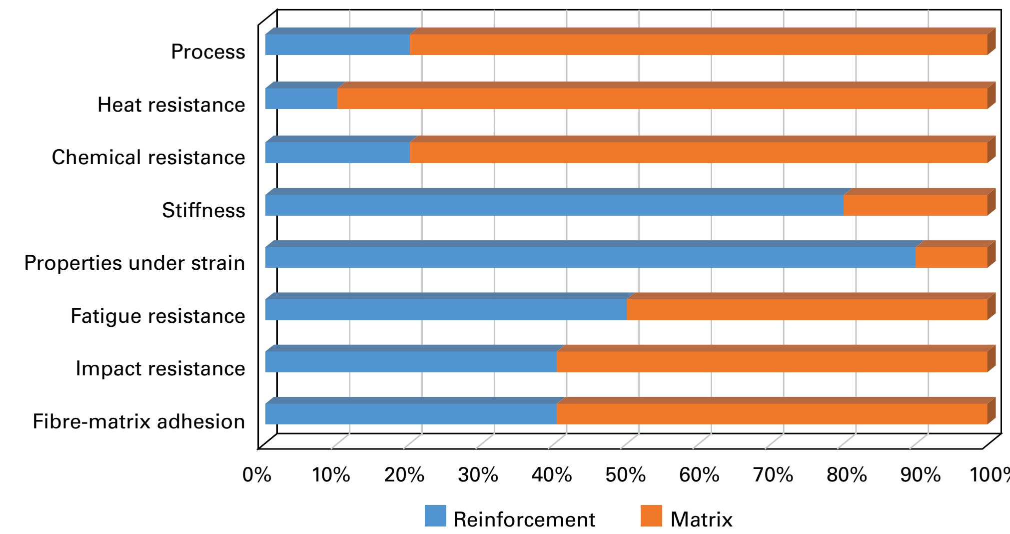


Figure 1 - Role of reinforcement and matrix in composite construction.

Figure 2 - GFRP with vinylester matrix.

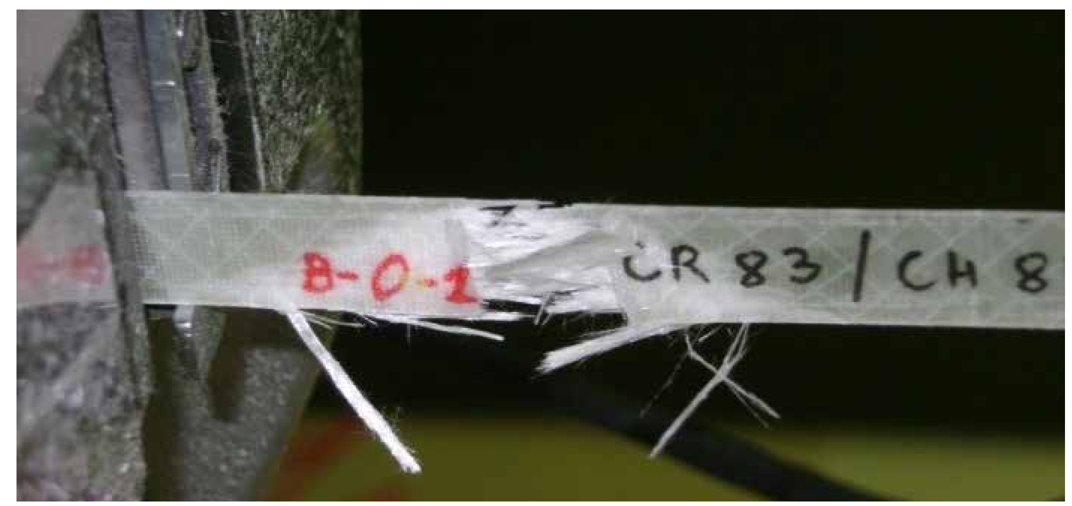


Figure 3 - GFRP with Sika® Biresin® CR83 epoxy matrix.

ensuring that the behaviour of the two phases is as homogeneous as possible.

Mechanical properties - GFRP

Glass fibre has remarkable elasticity, lengthening at breaking point by about 2%. So, to exploit fully this reinforcement, the matrix must guarantee adhesion to the fibres and integrity beyond this value: the epoxy resins offered by Sika® have breaking point lengthening of about 7%. For a demonstration of this, note how the samples in the two figures alongside break. In the first case the reinforcement breaks and we can see how the sample remains compact before and after breakage: the lengthening of the matrix is greater than that of the fibres. In the second case the matrix breaks, so the fibres are basically without load. Fibre lengthening is

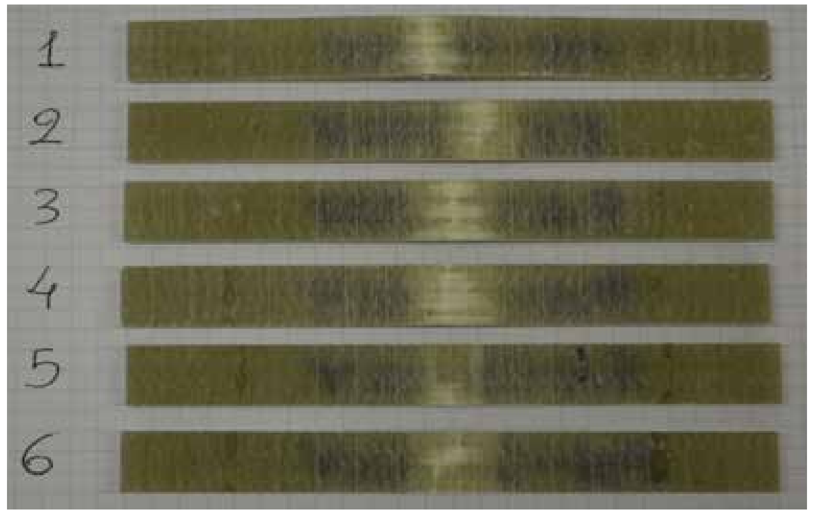


Figure 4 - GFRP with vinylester matrix.

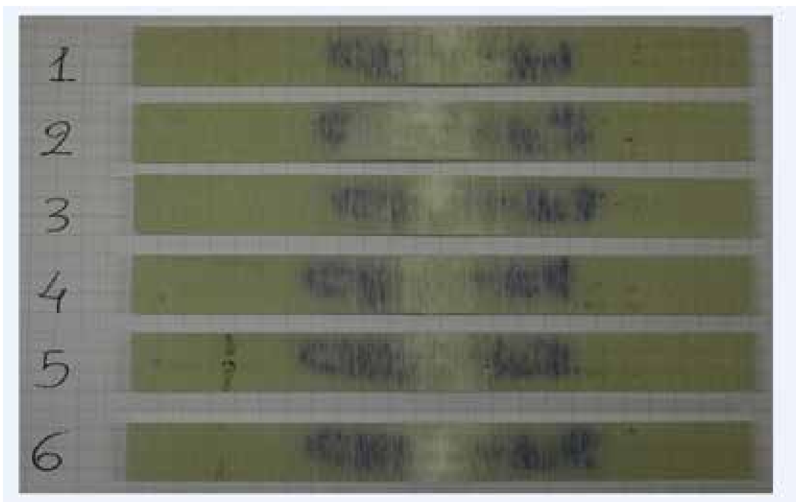


Figure 5 - GFRP with Sika® Biresin® CR83 epoxy matrix.

APPLICATIONS

SIKA and Ferretti Group have started up a new project to transfer this new composite build and design concept to the manufacturing of their products. Currently particularly complex and stressed components, where lightness and high performance are essential, are produced in composite with a Sika epoxy matrix and reinforcement both in glass and carbon fiber. Very large elements are also being built, where the advantages listed in the article make it possible to produce very light and rigid structures, minimising their presence and bulk so as to improve interior living space and comfort.

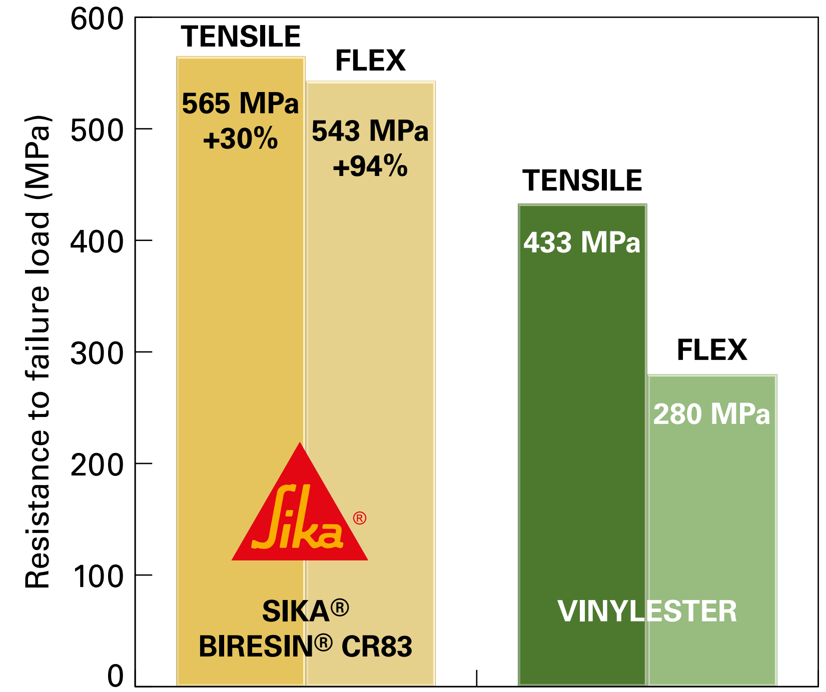
greater than that of the matrix. The failure load of the second sample will be very close to that of the matrix. In the case of flexural load, the differing behaviour of the matrix translates into internal delamination (white areas) and uncoupling of the various layers: apparently the composite does not seem to have suffered damage, but in reality, subjecting the samples to compression stress, there will be substantially different behaviour. In the first case it will resist, in the second the layers will disintegrate completely. This translates into better mechanical characteristics which in turn means a reduction in the amount of material needed. If we look at the resin infusion construction process, by using an epoxy matrix we eliminate all the problems of excess solvents in the composite, which polymerise under vacuum and are less likely to evaporate.
An excess of solvent makes the matrix less stable under temperature, increases the print-through phenomenon and increases stiffness while penalising behaviour under stress, also reducing adhesion to the fibres.

Mechanical properties – CFRP

In the case of carbon fibre reinforcement, the role of the matrix becomes even more important for fully exploiting the high performance of the fibre. As we can see from the experimental data shown in the figure 6, comparing infusion laminates produced with the same reinforcement with vinylester and Sika® Biresin® CR83 matrices, the breaking load is strongly influenced by the kind of matrix. In collaboration with the LinseT experimental engineering and testing laboratory in Fano (PU), we studied in depth the interaction between the two matrices and the carbon reinforcement. From the data[1] of comparative mechanical testing on samples of laminate produced by infusion we did used results (see figure 1) that would confirm the thesis of the Florida Atlantic University[2] and many others that a vinylester matrix is not the ideal when using carbon fibre, since the interaction between the two systems would remain weak. Again according to the study, the differing interaction between epoxy resin and carbon fibre would lead to the resulting composite being much less subject to osmosis, increasing its mechanical properties by up to 40%, without taking account of the reduction of aesthetic defects due to the greater stability of the matrix once it is well processed. In addition, considering the incidence of carbon fibre and matrix on the overall cost of the composite, we can see that it is economic lead is advantageous to face the increase in cost of which 90% is generated by the presence of this reinforcement without being able to exploit its potential to the full.

1) Cfr Report Linset n° RP461-16)

2) "Mechanical Properties of Carbon Fiber/Vinylester Composites Exposed to Marine Environments", Alexander M. Figliolini, Leif A. Carlsson, Department of Ocean and Mechanical Engineering, Florida Atlantic University, Boca Raton, Florida 33431



SIKA ITALIA SPA
Via L.Einaudi 6
20068 Peschiera Borromeo Italy
Phone +39 02 54778.111
Fax +39 02 54778.119
www.sika.it - info@sika.it

Article in collaboration with:
MDS Engineering - Ing. Matteo del Sorbo
www.mds-engineering.com

Figure 6 - Graph comparing the breaking loads in strain and flexion of CFRP samples produced by infusion with vinylester matrix versus Sika® Biresin® CR83 epoxy matrix.

Process variables

As we have seen in figure 1, the process variables influencing the result in composite production are certainly linked to the matrix. In the case of epoxy resin (but in general this is true for all heat-setting polymer matrices) these variables, in yachting applications, translate into adequate and controlled working environments, precision makes in and correct cure and post-cure procedures, which are essential for the success of the application.
In the SWOT analysis illustrated in the first page, we compare the use of SIKA® epoxy matrix with the current working standards of polyester and vinylester matrices in yachting. In particular, reference is made to the fact that today the minimum working standards of resins, well indicated by producers with remarkable practical experience, are completely ignored. In fact by improving and controlling the production process, we get close, while we must make the necessary distinctions, to an industrial type process, where the standardisation of process parameters leads to a reduction of problems and so of occasional and unexpected defects, and to repeatability of the process in terms of product characteristics, parameters and process costs.

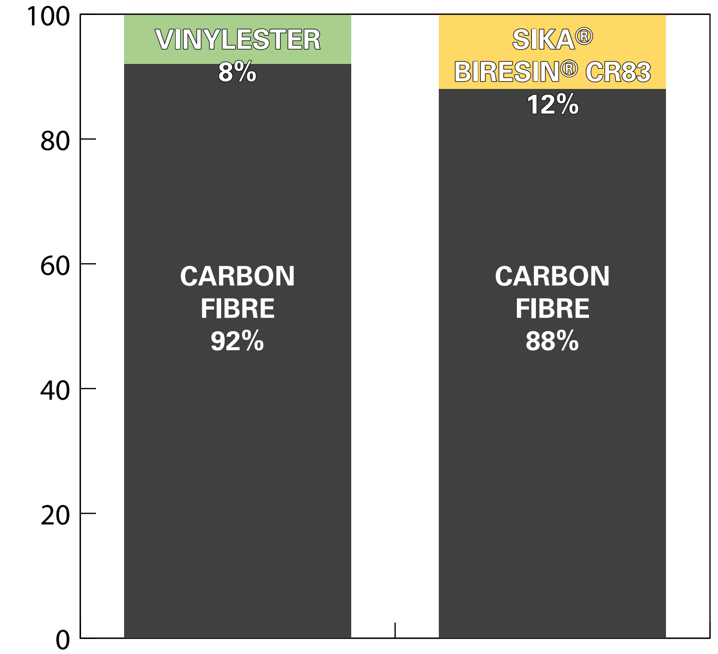


Figure 7 - Incidence on the cost of 1 kg of carbon composite.

Conclusion

Composites, from being an economic material of no great quality, initially thought of solely as "fibreglass", have now become a valuable material with a high technological content and infinite potential and applications. In addition, the costs of purchase and production of epoxy matrix composites, given their wide distribution in such industrial sectors as automotive, sporting goods, wind turbines and transportation, have become comparable with those of current production. It is thus important for the yachting industry to exploit these new opportunities to bring the construction of composites into line with other sectors and properly highlight their abilities to innovate and improve always.