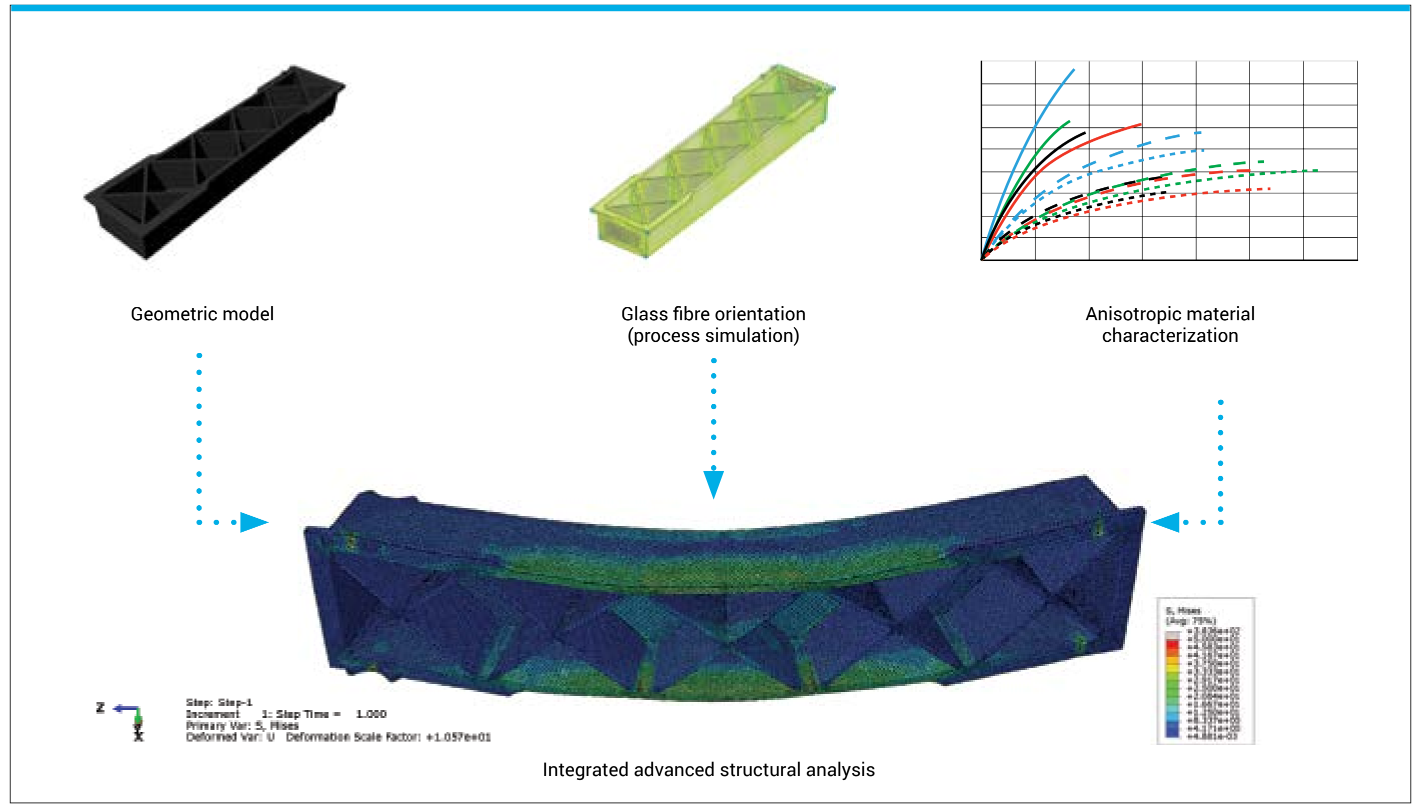
Integrated simulation approach

Reinforced engineering plastics exhibit a complex physical-mechanical behaviour, characterized by nonlinearity, even at low loads, and a tight dependency on a variety of process parameters.
Therefore, an analysis of such materials requires accurate modelling of their distinctive properties, as well as the use of computation methods capable of taking into account all the aspects of their composite material nature.

In general, it is a reasonable approximation to adopt simplified models that treat materials as macroscopically homogeneous and isotropic. However, for more in-depth analysis and to perform more aggressive optimizations, particularly in innovative metal replacement applications, an **integrated approach** is now available. This more technically advanced method allows for taking into consideration the material properties induced by the process, such as **anisotropy** caused by glass-fibre orientation, directly in the FEM calculations.
Dedicated software uses the output of process simulation to assign to the geometric model the "local properties" of the material acquired during the moulding process for any individual point of the part. These properties will be then utilized as inputs for the subsequent structural analysis.
Changing the position of the injection gate will lead to a structurally different part, due to the different melt front flow pattern, which is what determines the orientation of the fibres inside the moulded part. This approach, if correctly applied, enables obtaining more reliable results and reduces the need to introduce arbitrary safety coefficients.



Integrated advanced structural analysis

RadiciGroup Performance Plastics CAE Service: a development partner

RadiciGroup Performance Plastics, through its *Marketing and Applications Development* team, can also provide full support during all phases of the design process, including:

- **Concept phase proposals and consulting.**
- **Translation** of functional requests into material properties.
- **Selection** of optimal material, either Standard or Special, from RadiciGroup Performance Plastics' range of engineering plastic grades.
- Support and consulting on **comparative cost analysis.**
- Support and consulting during **re-design** phase.
- Support with **CAE analysis**, both **process simulation** and **structural simulation** (integrated approach available for advanced projects).
- Environmental impact and **LCA analysis**: full, certified support on the material side.
- Technical service support during **prototyping, moulding trials** and **part testing.**

RADICI NOVACIPS SpA
Via Bedeschi, 20 – 24040 Chignolo d'Isola (BG) – I
Tel. +39 035 4991311 - Fax +39 035 994386
e-mail: italia.plastics@radicigroup.com

RADICI NOVACIPS SpA
Via Provinciale, 1331 – 24020 Villa d'Ogna (BG) – I
Tel. +39 0346 22453 – Fax +39 0346 23730
e-mail: italia.plastics@radicigroup.com

RADICI PLASTICS GmbH
Glockengiesserwall 2 – 20095 Hamburg - D
Tel. +49 40 3095410 – Fax +49 40 30954199
e-mail: deutschland.plastics@radicigroup.com
Production:
Elso-Klöver-Strasse, 10 – Industriegebiet Hafen
21337 Lüneburg - D

RADICI PLASTICS IBERICA SL
Avda. Josep Tarradellas, 130 5º1ª
08029 Barcelona (ES)
Tel. +34 93 5416500 – Fax +34 934943326
e-mail: iberica.plastics@radicigroup.com

RADICI PLASTICS UK Ltd.
High Hill House, 6A Hampstead High Street
London NW3 1PR – UK
Tel. +44 20 74314554 – Fax +44 20 74314544
e-mail: uk.plastics@radicigroup.com

RADICI PLASTICS FRANCE SA
65, Rue du Dauphiné – 69800 St. Priest – F
Tel. +33 4 72782090 – Fax +33 4 72782089
e-mail: france.plastics@radicigroup.com

RADICI PLASTICS LTDA
Rua Giuseppe Marchiori, 497
CEP 18147-970 Araçariguama – São Paulo – BR
Tel. +55 11 4136 6500 – Fax +55 11 4136 2166
e-mail: brasil.plastics@radicigroup.com

RADICI PLASTICS USA Inc.
960 Seville Road, Wadsworth, OH 44281 - USA
Tel. +1 330 3367611 – Fax +1 330 3362143
e-mail: usa.plastics@radicigroup.com

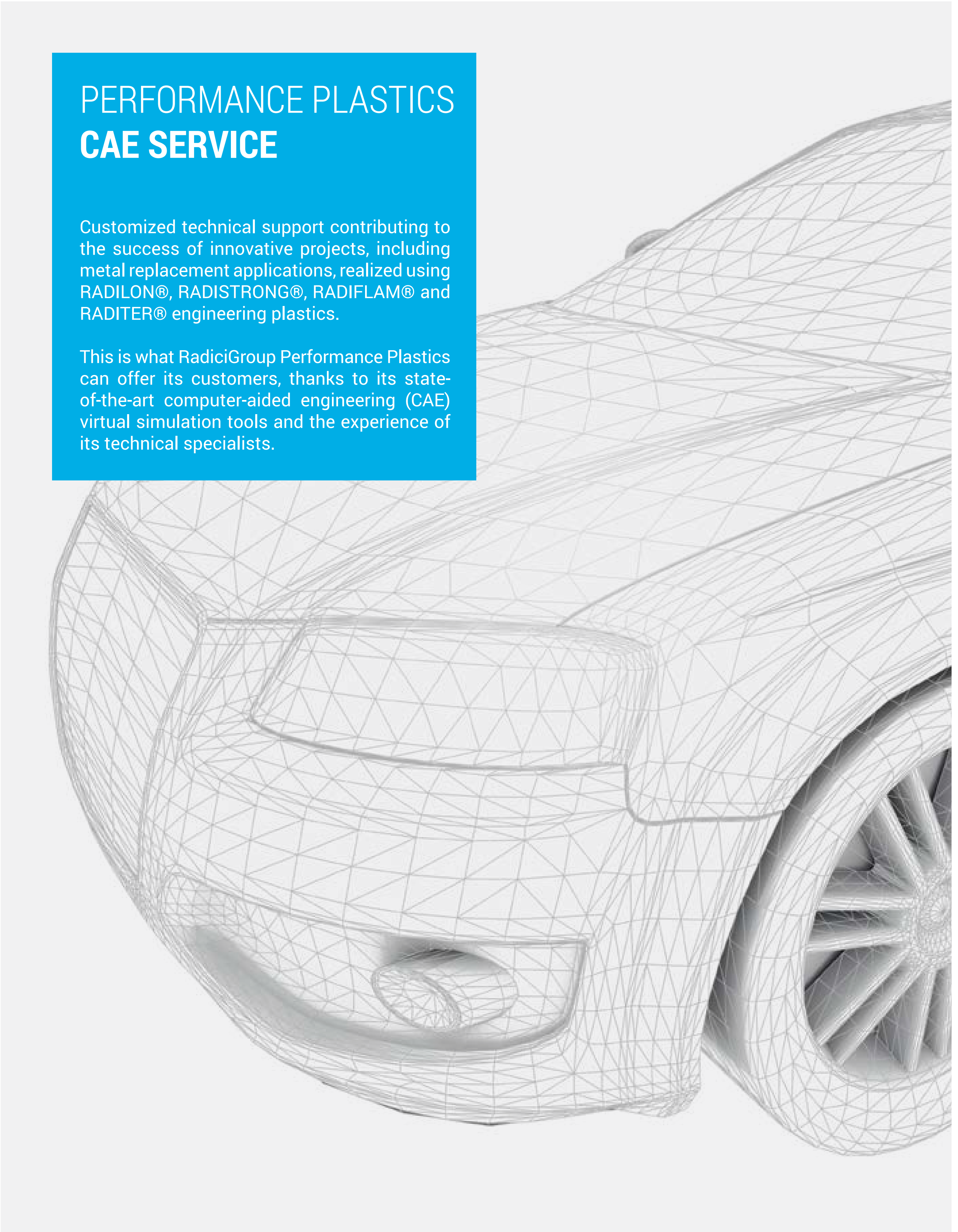
RADICI PLASTICS (Suzhou) CO., LTD.
No. 49 Ping Sheng Road, SIP
215126 Suzhou, Jiangsu Province – PR China
Tel. +86 512 62952290 – Fax +86 512 62952291
e-mail: china.plastics@radicigroup.com

RADICI PLASTICS INDIA PVT. LTD.
C-5 1st Floor, Amar Colony Market, Lajpat Nagar-IV
New Delhi - 110024 - IN
Tel. +91 11 41638170
e-mail: info.plastics@radicigroup.com

RADICI PLASTICS MEXICO S. DE R.L. DE C.V.
Av. Francisco Zarco 2688
C.P. 47810 - Col. Loma Bonita - Ocotlán Jalisco -MX
Tel: +52 392 923 2390
e-mail: info.plastics@radicigroup.com

To request consulting service by the RadiciGroup Performance Plastics team of experts, please contact: cae.plastics@radicigroup.com

April 2016



PERFORMANCE PLASTICS
CAE SERVICE

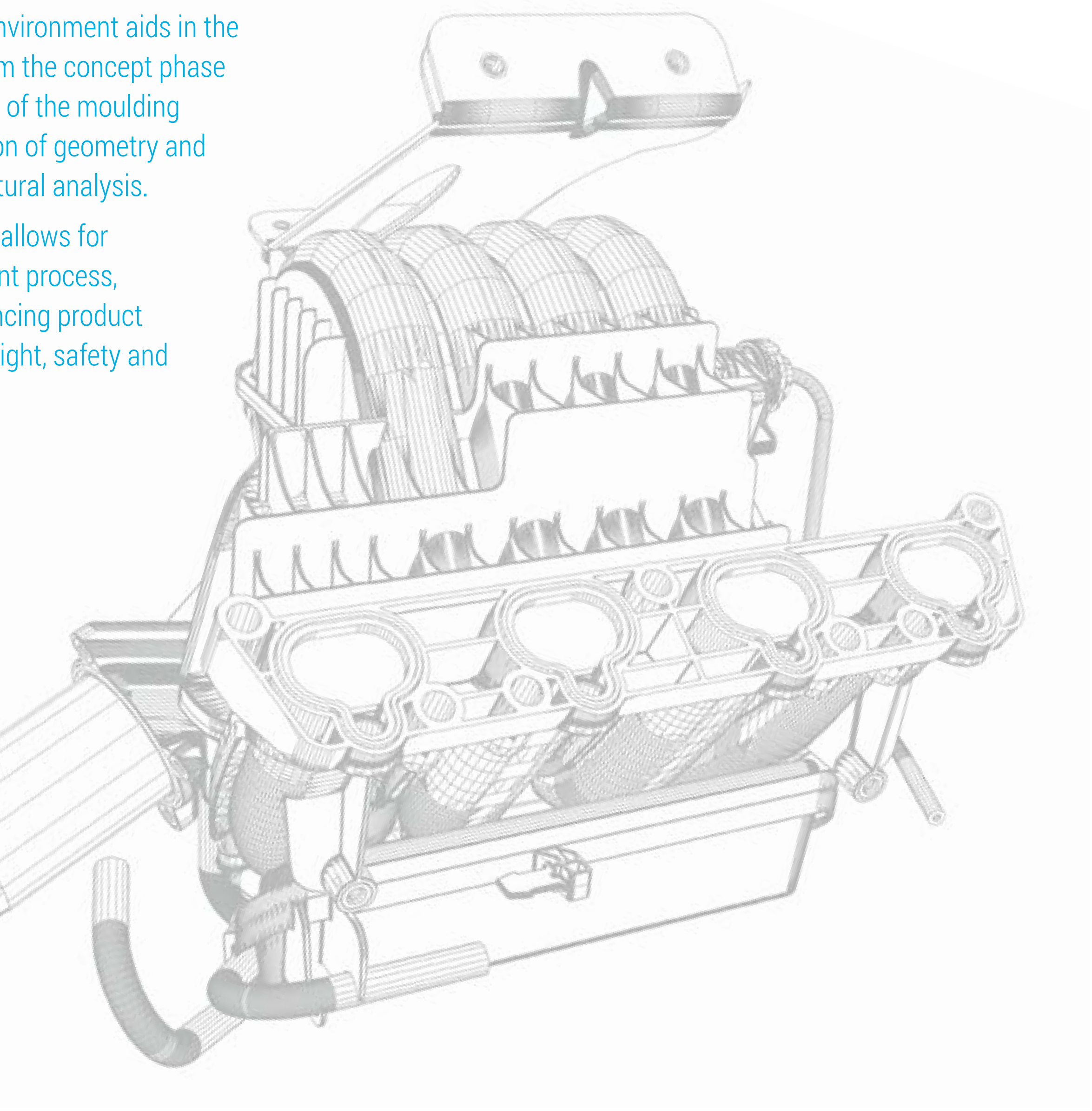
Customized technical support contributing to the success of innovative projects, including metal replacement applications, realized using RADILON®, RADISTRONG®, RADIFLAM® and RADITER® engineering plastics.

This is what RadiciGroup Performance Plastics can offer its customers, thanks to its state-of-the-art computer-aided engineering (CAE) virtual simulation tools and the experience of its technical specialists.

www.radicigroup.com

An integrated CAE virtual environment aids in the design of a component, from the concept phase to the numerical simulation of the moulding process and the optimization of geometry and performance through structural analysis.

The use of CAE technology allows for a more efficient development process, while simultaneously enhancing product features, such as lighter weight, safety and performance.



Why use CAE?

The **RadiciGroup Performance Plastics CAE Service** can use various simulation and **finite element numerical analysis (FEM)** software packages to model, validate and optimize projects in a virtual environment.

Computer-aided engineering simulation allows developers to:

- Minimize trial and error and the use of physical prototypes.
- Obtain immediate confirmation of project feasibility.
- Detect and correct any problems in the virtual environment, when the costs of making changes are still relatively low.
- Optimize component geometry through maximum leverage of material performance.
- Explore and compare alternative solutions to a project.
- Decrease project development cost and time-to-market.

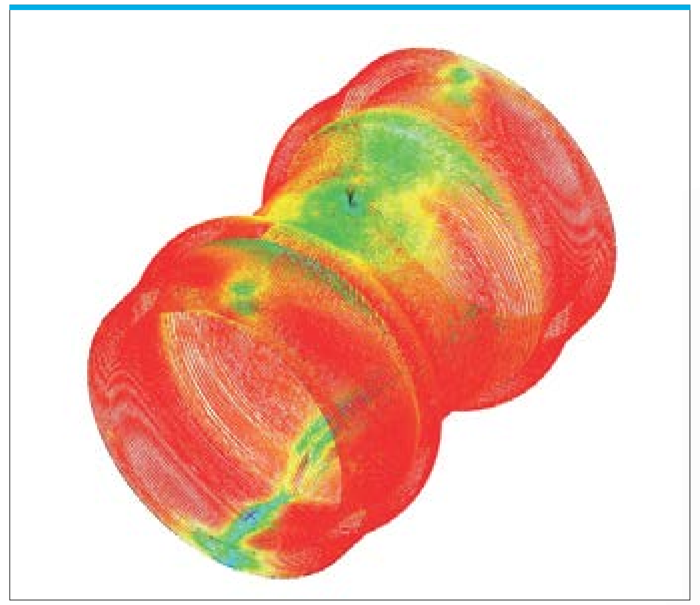


Figure 1 | Glass fibre orientation prediction in a fitting for a pressurized hydraulic system.

Process simulation

Can the part, in its present geometric configuration, be correctly filled and packed using the chosen material?

What is the best gate position on the plastic part to optimize melt fill and minimize warpage?

Is it possible to mould a multiple-cavity part with a 150-ton press? What is the required fill pressure?

Will there be any moulding defects, such as air bubbles or weldlines, that could have a negative impact on the aesthetic or structural specifications for the part?

These are just some of the questions that a project engineer faces. By using **process simulation**, the RadiciGroup Performance Plastics CAE Service can readily find the answers, already during the early project development phase.

Numerical simulation of the complex physical and fluid-dynamic process taking place during **injection moulding** (including gas- or water-assisted injection moulding – GAIM/WAIM –, over-injection and co-injection) can provide information predicting the final result, which will help engineers to make decisions regarding the design of the part and the mould.

The output of a simulation process supplies a wealth of data on mould filling, material packing and cooling, and the characteristics of the moulded part, such as glass-fibre orientation, sink marks, weldlines and post-mould warpage.

With the aid of appropriate mapping tools, some of this information (fibre orientation, weldlines, post-mould warpage and residual stress) can then be transferred to non-linear structural analysis software programmes for advanced integrated analysis.

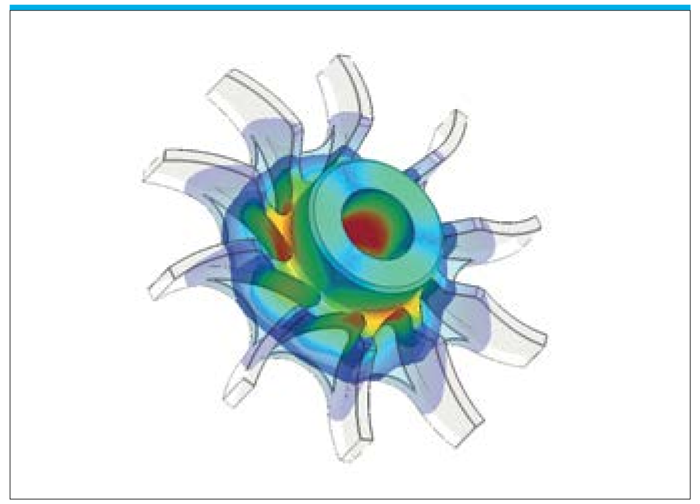


Figure 2 | Fill Pattern – simulation of mould cavity filling for a pump impeller.

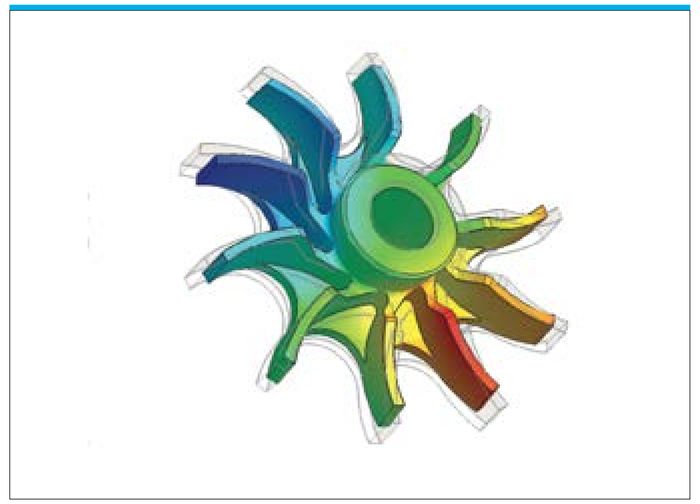
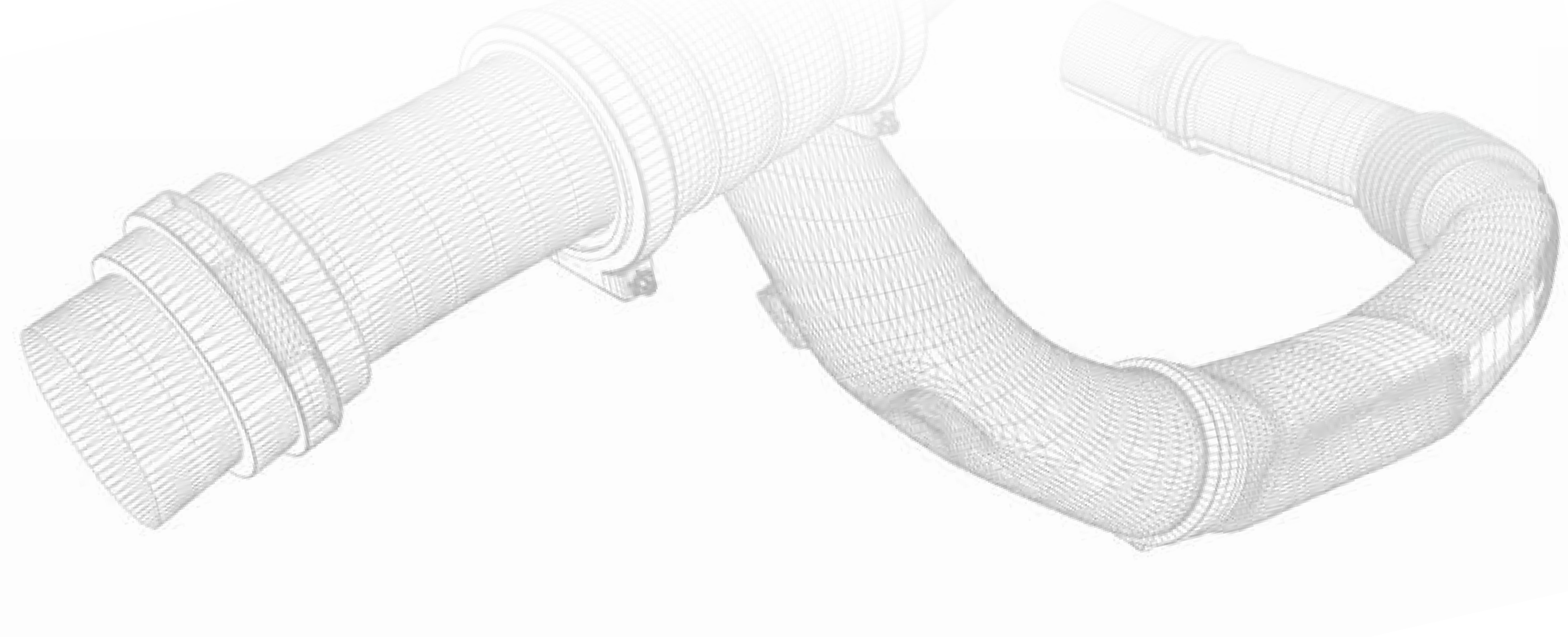


Figure 3 | Warpage prediction for a pump impeller (magnified scale).



Mechanical structure simulation

Will the plastic part withstand operating loads and conditions without any damage or breakage?

Will the expected warpage of the moulded plastic part under load remain within acceptable functional limits?

Under what load is breakage of the component expected to occur?

What are the natural vibration modes and frequencies of the moulded part under consideration?

The increasing use of engineering plastics for technical applications, including metal replacement and other uses with high mechanical requirements, makes computerized **structural analysis** indispensable. This type of analysis helps to predict the mechanical behaviour of moulded parts, compute the maximum load the moulded parts can withstand and uncover the critical issues or strengths of the project. And that is not all. Already in the research and pre-development phase, computerized structural analysis allows for performing optimizations that would otherwise require building a prototype, with a considerable outlay of time and financial resources.

For a precise analysis to predict the behaviour of a part (shift, stress and warpage), it is necessary to specify the operating conditions, the mechanical assembly in which the part will operate with all operating loads and constraints, and all the other relevant components coming into contact with the part.

In order to accurately predict a material's behaviour, a careful characterization of the material is needed, comprising not only its basic mechanical properties (modulus of elasticity, load at break, etc.) but also its non-linear behaviour at different temperatures, the anisotropy of the fibre-reinforced material, and long-term effects, such as creep, fatigue and heat ageing.

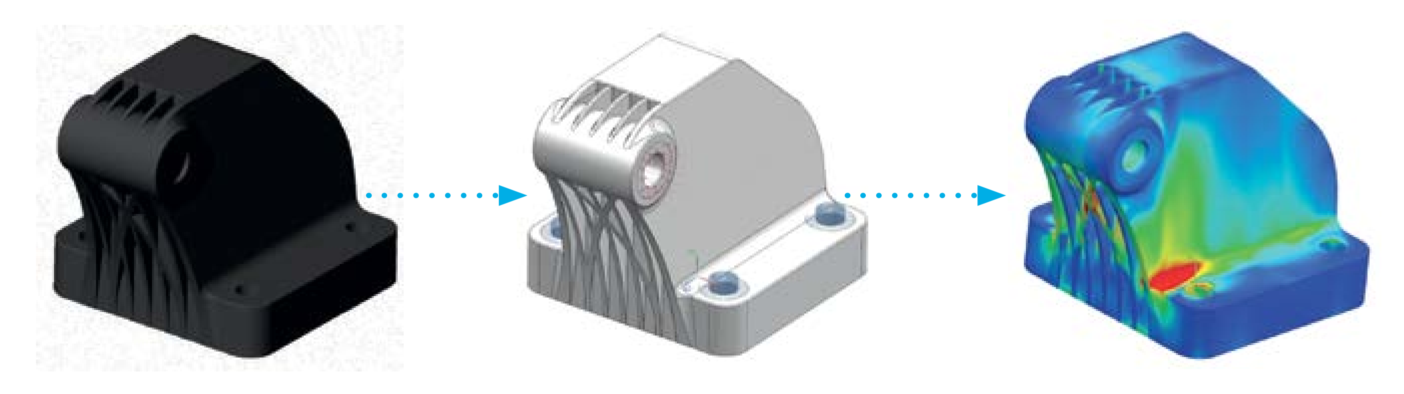


Figure 4 | Structural analysis of an engine support made of glass-fibre-reinforced Radilon® PA66, from load and constraint definition to tension state prediction.

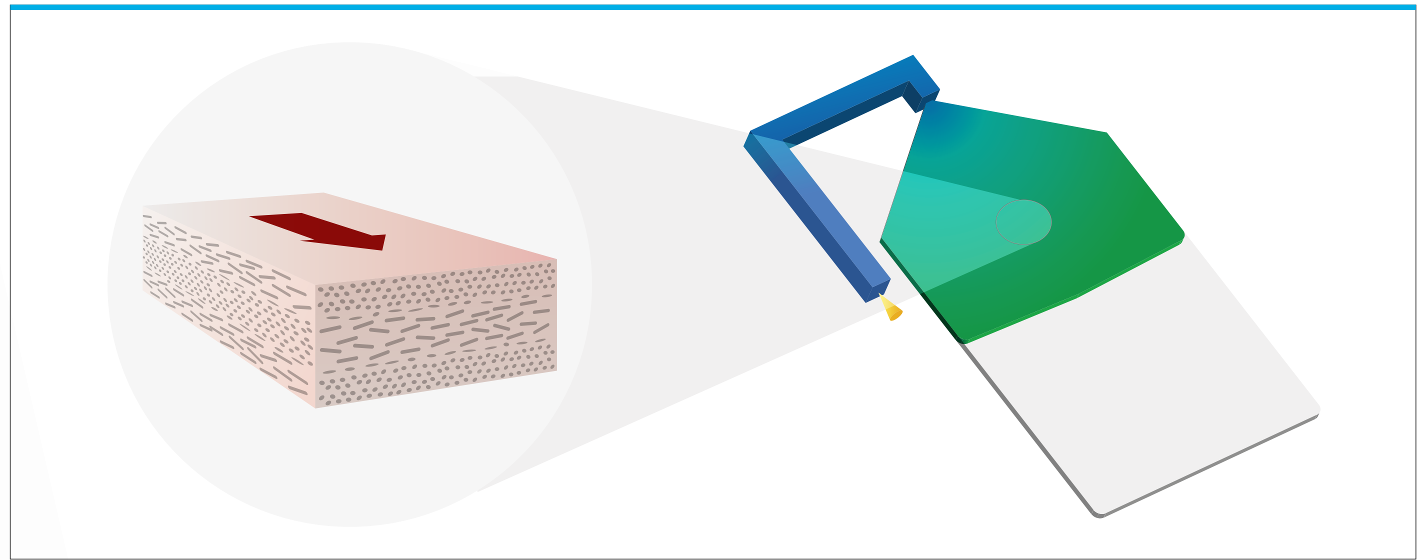


Figure 5 | Glass fibre orientation in a part depends on how the cavity is filled during moulding.