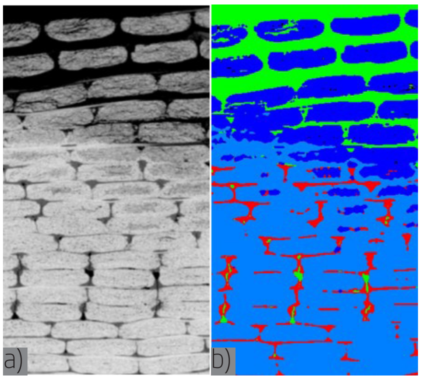
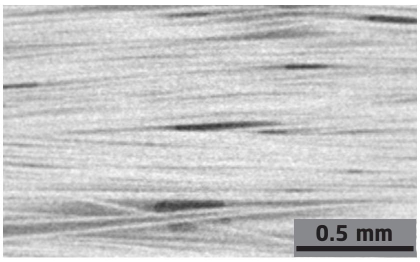
Wind turbine blade casting at the microscale

With the need to reduce CO_2 emissions, the use of renewable energy sources, e.g. wind power, is highly important in the fight against climate change. LM Wind Power produces every 5th of the wind turbine blades in the world. An important process in the manufacturing is blade casting where a liquid resin diffuses into bundles of glass and carbon fibres. The process is controlled by the resin flow and by keeping the network fibre bundles under vacuum. LM Wind Power entered a collaboration with the 3D Imaging Centre at DTU through LINX, a project funded by the Innovation Foundation in Denmark, in order to better understand the blade casting process on a micrometer scale. With X-ray micro Computed Tomography (CT), the resin flow front was analysed to reveal the process of resin diffusion into fibre bundles.

Photograph of a wind turbine blade. Courtesy of LM Wind Power.



2D slices showing the flow front of the resin. a) Image in grey scales. The less the material is absorbing X-rays, the darker the grey tone. b) Colour-coded image of the same position, showing air around the fibre bundles where the flow front did not arrive yet in green, the non-filled fibre bundles in dark blue, the filled bundles in light blue and pure resin between the bundles in red.



2D slice of the high-resolution scan indicating the individual fibres in light grey, the resin in a medium grey and air in black.

Challenge

LM Wind Power holds world records for producing the longest blades, now with lengths above 100 meters. Wind turbine blades are far too large samples to be analysed in a conventional micro-CT scanner. Therefore, the blades have to be cut in smaller pieces to be scanned, which can only be done once the resin has hardened. This means that the dynamic casting process cannot be analysed. For this reason, model samples, which imitate what happens during the dynamic process, were to be analysed.

Collaboration

LM Wind Power performed casting experiments on smaller pieces of glass fibres which were studied at the 3D Imaging Centre at DTU. This collaboration was part of the LINX project in which researchers at leading Danish universities collaborate with scientists in industry to solve industry relevant problems using advanced neutron and X-ray techniques.

Results

LM Wind Power made blade model samples for which the casting process had been abruptly stopped. By this approach, the process of resin diffusion into the fibre bundle network can be imitated. These model samples were studied by X-ray CT in regions where the resin had only partly diffused into the fibre bundle network. The analysis of the resin flow front gave insight into the resin diffusion process in and around fibre bundles. It revealed that the resin was flowing faster around fibre bundles than into the interior of the bundles. From the obtained 3D images the volume of filled fibre bundles, non-filled fibres bundles, air voids and pure resin was quantified in 3D. Complementary to fibre bundle analysis was a high-resolution scan where the resin could be observed around individual fibres in the bundles.

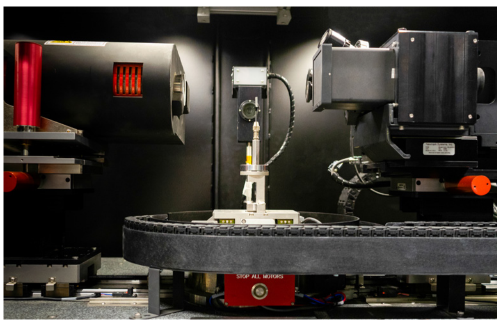
Perspectives

A next step would be to develop an *in situ* method for casting small model blades simultaneously to micro-CT measurements. With such a method the dynamics of the casting process can be better understood as this is step further to studying the realistic blade production.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Centre at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/Industry-Portal



DTU 3D Imaging Centre