EUROS uses simulation to develop a VARI process for an 80 meter long composite rotor blade

The trend in the wind industry is for larger and longer blades. EUROS manufactures its long rotor blades by vacuum infusion for resin impregnation. The benefits of this production method are high quality and high strength composite parts. However, to realize a successful infusion process, EUROS had to determine several parameters to define the manufacturing strategy: the complexity increases with the dimension of the blade and the thickness of the laminates.

With a wealth of experience in infusion process development for rotor blades, EUROS started in its Berlin headquarters to develop the infusion manufacturing process of an 80-meter long wind turbine blade to be produced in its manufacturing site in Sassnitz, Germany.

Focusing on the root area of the blade

Whereas the last 60 meters of the rotor blade can be considered state-of-the-art, the root area, with an outer diameter of 4.4 meters and up to 160 plies of glass fabrics, is extremely challenging – especially in light of its very complex laminate definition. The root plays a key structural role for the blade since it will support all applied loads. Any defects in the root would highly impact the blade’s performance so EUROS gave special attention to how it should be manufactured.

The engineering team set an objective to achieve an infusion time of less than 90 minutes. Based on standard infusion strategies used by EUROS, a new strategy had to be developed in order to reach good results in terms of: product quality, process time, control and repeatability of the process.

THE CHALLENGE

EUROS needed to develop the process strategy for an 80-meter long wind turbine rotor blade made using Vacuum Assisted Resin Infusion (VARI). Normally this would require several very costly infusion trials, as the cost of trials and process development time quickly rise with increasing blade length and design complexity.

In order to support their physical tests EUROS engineers relied on PAM-RTM, with which they were able to determine the best strategy to minimize risks while optimizing product quality, reducing manufacturing time and assuring process repeatability.

THE BENEFITS

The introduction of PAM-RTM in the process development helped:
- Reduce the cost of trials by saving time and material costs;
- Accelerate the development process;
- Provide more flexibility for design changes during the development;
- Enable the development and production of blades meeting particular end user specifications.

“Thanks to PAM-RTM, we can develop several infusion strategies in a short time for the manufacturing of different types of onshore and offshore wind turbine rotor blades”

Dipl. Ing. Mathias Marois,
Head of Production Technology Department,
EUROS Germany

An 81.6 meter long offshore wind turbine rotor blade.
Validating process parameters on small samples with PAM-RTM

EUROS decided to introduce simulation in order to better understand the process and its influencing parameters. The team chose PAM-RTM: ESI software dedicated to the infusion process of large composite parts.

They followed a step-by-step approach:
- First, determine key input data for the simulation by measuring for instance in-plane and through-the-thickness permeability of all the glass fabrics used in the root.
- Then, validate measured permeability values and calibrate process parameters, such as pressure and viscosity, on small infusion models and compare with experiment.

By verifying and optimizing on simple parts, EUROS gained confidence in the simulation and process parameters used. They were able to achieve good similarity between predicted and experimental resin flow patterns and filling times.

**Full scale tests with PAM-RTM**

EUROS built a representative test mold (4.3 meters outer diameter) and used it together with PAM-RTM to validate their infusion strategy. The first simulation of a one shot infusion on a stack of 130 plies conformed to reality. The resin flow front and flow speed predicted with PAM-RTM were very close to the ones observed in the experiment.

During a whole year, EUROS conducted additional tests using the same methodology described above on critical segments from the first 20 meters of the blade. These pre-trials on representative samples of the root of the rotor blade allowed EUROS to validate their numerical models by comparing simulation and experimental results. PAM-RTM simulation also contributed to a better understanding of the parameters influencing the process and allowed the virtual testing of multiple process variations in order to retain only the optimal ones.

With PAM-RTM, EUROS gained a better understanding of the infusion process and the influence of many different parameters on product quality.

Thanks to ESI’s PAM-RTM simulation software, EUROS was able to evaluate upfront several process alternatives with varying parameters in order to get the best results in terms of product quality, filling time, and process repeatability. Simulation allowed EUROS to reduce testing costs and to accelerate process development.

Early in the second quarter of 2013, EUROS built the first offshore blade, 81.6 meters long and weighing 32.8 tons. They reached all of their pre-defined goals for product quality, infusion time, resin consumption and repeatability of the process.