FF4EuroHPC Success Story

Multiphysics and Multiscale Modelling of Aeronautical Components

Organizations

Manta Group is an Italian SME that operates in the aeronautical field and specializes in the production of composite aircraft parts.

CETMA is the technology expert, a private Research and Technology organization, which has acquired skills and know-how focused on composite materials and numerical modelling of these advanced materials and their manufacturing processes through over 25 years of applied research.

CINECA is the largest Italian supercomputing centre with an HPC environment equipped with cutting-edge technology and highly qualified personnel which cooperates with academia and industrial partners.

End User — MANTA GROUP

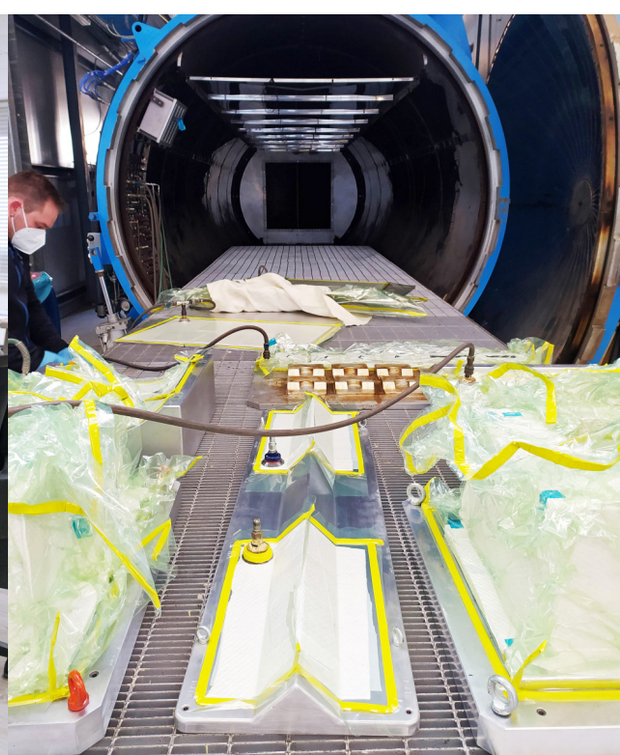
Technology Expert — CETMA

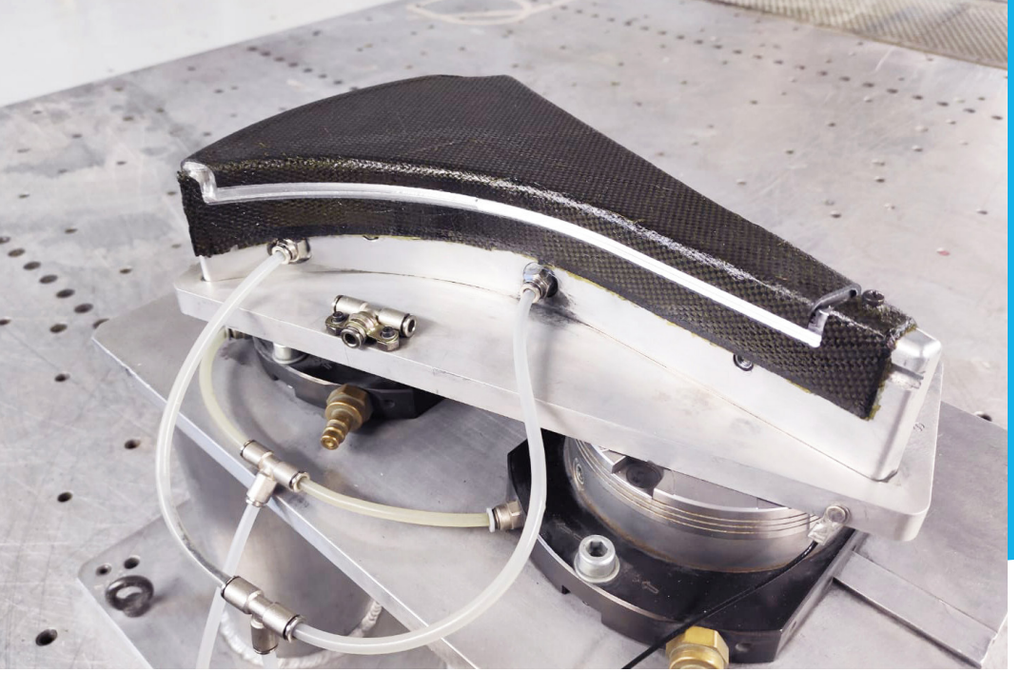
HPC Centre & Provider — CINECA

Partner CINECA is part of the NCC Italy. EUROCC ITALY

The Challenge

Autoclave moulding is the main fabrication method for composites used in the aerospace field. This process involves both mechanical and chemical phenomena, and a correspondingly high number of variables affect the final result. Working with innovative materials and geometries leads to an increased number of defects and voids in the finished components which then are rejected. During the curing process, the mechanical stresses in the various materials rise, and this can lead to undesirable consequences. Given the expense of the autoclave process, it is important to minimize defects in the finished components. Currently, an expensive trial-and-error approach is used to find the optimal process parameters to produce complex-shaped components while minimizing the risk of voids or geometric distortions. This leads to long development times and high costs. Manta Group's aim is a more effective manufacturing process for its products: finding the optimal process parameters by multi-scale and multi-physics numerical simulations.





Industry Sector
Manufacturing

Technology used:
HPC,
FEM Simulation

The Solution

To optimize the autoclave process parameters, the different phenomena during the curing process need to be simulated to predict the parameters' effects on the quality of the components to be manufactured. To this end, two separate multiphysics and multiscale numerical models were set up, employing HPC resources. In detail, these are a thermo-mechanical model (on the macro scale) to predict the dimensional variations of the laminates due to the residual stresses generated during the autoclave process, and a fluid-structure model (on the micro-scale) to simulate the resin flow during the pressure application. Both numerical models were validated by comparison with the results of experimental tests done by Manta Group. Using the material properties, the lamination sequence, the geometry of the parts, and the specification of the autoclave curing cycle as input parameters, the HPC simulations set up in the first step proved to be able to provide the required information about the resulting part distortion and possible defects in the finished part in a very short amount of time. This HPC-backed simulation workflow now enables Manta Group to easily find the optimal parameters for the manufacturing process in a few minutes, thereby cutting down development times and minimizing the number of physical tests significantly.

The Impact

Thanks to the MULCOM experiment, MANTA now uses HPC-based simulations to produce high-quality composite components, reducing development time and costs while increasing its competitiveness. Since autoclave moulding will remain the main manufacturing technology of aerospace structures at least for the next 10 years, this significantly strengthens Manta Group's business position.

In addition, the improved autoclave process know-how can enable MANTA to profitably enter many other sectors besides aerospace (e.g. luxury boats, automotive, sport). All this helps to attract new customers by offering a full service, from design to the production of the component. The expected business impact has been quantified at €1million three years after the end of MULCOM experiment.

Benefits

- MANTA expects to reduce design costs by 50% (about €100,000 saving per year), material waste by 70% (about €60,000 saving per year), and raw materials usage by 15% (about €150,000 saving per year).
- CETMA expects the success story will lead to new R&D projects and consultancy services with an increase in its turnover of about €50,000 per year.
- CINECA aims to become MANTA's provider of HPC resources estimating its related increased turnover to €20,000 per year and to exploit the success story to attract new customers with an additional increase of turnover of the same order.