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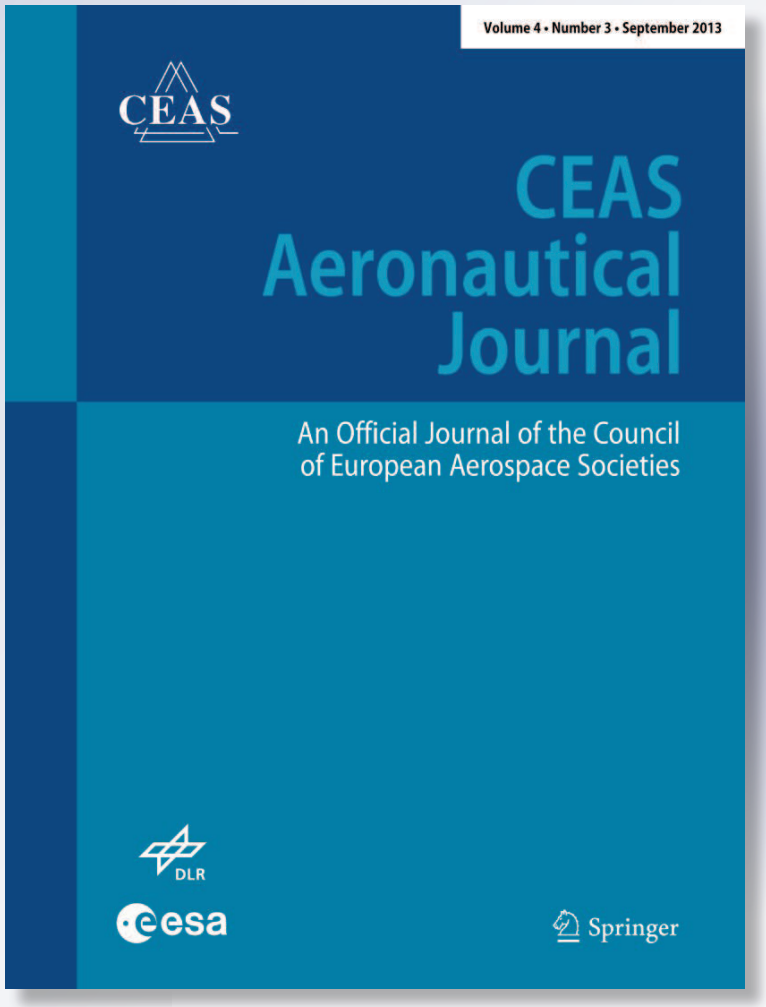

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ORIGINAL PAPER

Virtual autoclave implementation for improved composite part quality and productivity

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Abstract State-of-the-art of advanced composite manufacturing uses autoclave devices to ensure the overall curing of the polymer resins for large complex carbon–fibre–polymer composites (CFRP) helicopter structures. A homogeneous temperature distribution on the part surfaces is the key to obtain high and constant quality parts. Local heat transfer coefficients are, therefore, important monitoring factors of autoclave technology processes. Many researchers focussed on the exothermic curing reaction inside the composites, but the surrounding temperature field (inclusive air and mould temperature field) was often neglected. Thus, a thermal uniformity at the surface of the part was often not foreseeable. Due to the 3D arrangements of the parts in the autoclave, together with the design of the tools themselves, strong turbulences and velocity differences are created inside the industrial autoclave, affecting the heat transfer mechanisms at the surface of CFRP parts. Therefore, the temperature field is non-uniform in the spatial and temporal domains. This non-uniform distribution of part and mould temperatures has an important impact on the local degree of cure and on residual stresses in the composite parts. To better understand the process and to optimise the curing cycles, virtual autoclaves have been successfully implemented by MET together with Eurocopter. The validation phase showed very good agreement between measured and simulated temperature fields. On this basis, different internal arrangements of parts for helicopter airframes have been investigated leading to the development of practical solutions to reduce the cycle time, and improve the quality of the parts. Examples of application will be presented together with industrial benefits. This simulation methodology provides Eurocopter with a strong tool for the improvement of composites part quality and productivity. The article content was presented at the Eucomas Conference on February 7, 2012 in Hamburg, Germany.

Keywords Simulation · CFD · CFRP · Autoclave process · Load arrangement · Process optimisation · Control optimisation · Temperature · Degree of cure · Hot spot · Vacuum structure

Abbreviations

CFD	Computational fluid dynamics
CFRP	Carbon–fibre-reinforced plastic
RTM	Resin transfer moulding
CAD	Computer-aided design

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1 Introduction

The increasing application of carbon–fibre–polymer composite (CFRP) components in structural elements requires economically improved production processes for CFRP components which fulfil highest productivity and quality requirements. The development of such production processes cannot be based on a "trial-and-error" method due to the considerable costs of the CFRP components and of