6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

ALGORITHMIC DIFFERENTIATION OF THE PARABLADING AIRFOIL DESIGN TOOL COUPLED WITH AN ADJOINT CFD METHOD

Mladen Banović[1]*, Ilias Vasilopoulos[2], Andrea Walther[1] and Marcus Meyer[2]

[1] Universität Paderborn,
Warburger Str. 100, 33098 Paderborn, Germany
{mladen.banovic, andrea.walther}@math.uni-paderborn.de
[2] Rolls-Royce Deutschland (RRD)
Eschenweg 11, Dahlewitz, D-15827 Blankenfelde-Mahlow, Germany
{ilias.vasilopoulos, marcus.meyer}@rolls-royce.com

Key words: *Algorithmic Differentiation, Airfoil Design Tool, Adjoint CFD Method*

In industrial workflows, geometric design process is driven by Computer Aided Design (CAD) tools and systems. They describe a certain model in a parametric sense, i.e. with an arbitrary set of design parameters. To incorporate the parametric description in a gradient-based shape optimisation loop, one requires the calculation of shape sensitivities w.r.t. design parameters of the model. Within commercial CAD packages, these sensitivities are usually calculated using non-robust and inaccurate finite differences. On the contrary, to get the exact shape sensitivities, algorithmic differentiation (AD) can be applied if the CAD sources are available [1]. In this study, the Rolls-Royce in-house airfoil design and blade generation tool named 'Parablading' [2] has been differentiated in forward mode of AD, using the AD tools ADOL-C (*Automatic Differentiation by Overloading in C++*) and Tapenade. ADOL-C has been used to differentiate a large part of the Parablading sources written in C++, while Tapenade has been used to differentiate the rest of the sources written in Fortran. The two AD tools impose different ways of derivative computation. Therefore, different parts of the differentiated Parablading sources are linked to correctly propagate the derivative information. Furthermore, the differentiated Parablading tool has been coupled with a discrete adjoint CFD solver that is part of the Rolls-Royce in-house HYDRA suite of codes, also produced by algorithmic differentiation. This differentiated design chain is used to perform gradient-based optimisation of the TU Berlin TurboLab Stator test-case to minimise the total pressure loss.

REFERENCES

[1] Banovic, M.; Mykhaskiv, O.; Auriemma. S.; Walther, A.; Legrand, H.; Müller, J.-D.: Automatic Differentiation of the Open CASCADE Technology CAD System and its coupling with an Adjoint CFD Solver. `http://www.optimization-online.org/DB_HTML/2017/03/5931.html`

[2] Gräsel, J.; Keskin, A.; Swoboda, M.; Przewozny, H.; Saxer, A.: A full parametric model for turbomachinery blade design and optimisation. In Proceedings of ASME DETC (pp. 907-914), 2004.