Post-doc proposal / Starting as soon as possible / 12 months, with possible extension

Ref. 202206BFMOD

Body-Force modelling of BLI thrusters in severe off-design conditions and distorted inflow

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Context

Hybrid-electric distributed propulsion concepts are being studied as potential subsonic commercial transport aircraft meeting aviation's long-term sustainability targets. One promising approach involves boundary layer ingestion (Fig. 1), which leads to a close coupling between the thruster performance and the external aerodynamics. In order to simulate and design such systems, we propose to model the fan stages by using a body force approach (Fig. 2). This principle, not new in turbomachinery, has recently been used to deal with short nacelles[1], cross-wind conditions[2] or aero-propulsive coupling[3] (Fig. 3). Although this method cannot give access to the whole phenomenology of the flow inside the thrusters, it is able to capture first order phenomena with lower computational cost, compatible with preliminary design.

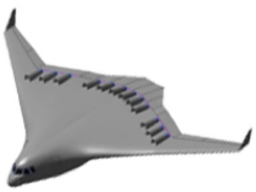

Fig. 1. Illustration of a blended-wing-body aircraft with partially-embedded engine intakes.

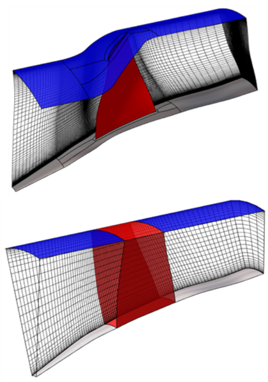

Fig. 2. Computational domain of blade RANS (top) and BFM RANS (bottom) [5]

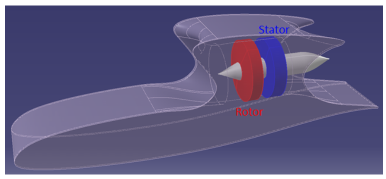

Fig. 3. Example of aero-propulsive assembly[3]

The current body force formulation used at ISAE has satisfactorily been validated with a low-speed fan operating at nominal conditions[4]. However, the accuracy of this method is limited and new developments are required to improve the prediction in fan (stage and/or rotor) performance, with a special focus on idle and sub-idle conditions (including

[1] Thollet, W. Body Force Modeling of Fan—Airframe Interactions. Diss. Ph. D. thesis, ISAE-SUPAERO, 2017.

[2] Minaker, Quentin J., and Jeffrey J. Defoe. "Prediction of Crosswind Separation Velocity for Fan and Nacelle Systems Using Body Force Models: Part 1: Fan Body Force Model Generation without Detailed Stage Geometry." International Journal of Turbomachinery, Propulsion and Power 4.4 (2019): 43.

[3] Benichou, Emmanuel, et al. "Numerical Low-Fidelity Method for Improved Analysis of Breakthrough Aero-Propulsive Systems ." 1st Aerospace Europe Conference, 2020.

[4] Benichou, Emmanuel, et al. "Body force modeling of the aerodynamics of a low-speed fan under distorted inflow." International Journal of Turbomachinery, Propulsion and Power 4.3 (2019): 29.

windmilling[5]) and potentially under distortion. For this reason, the idea is to complete the available baseline by improving the loss modelling. A first way to achieve this goal is to consider additional terms in the formulation. Another possibility is to rely on data from experiments or from higher-fidelity URANS simulations, by post-processing them in order to address the calibration of the loss model, as illustrated for example by Hill[6].

The proposed work will pursue ongoing efforts to develop a BFM calibration method and validate against numerical simulations (single-blade or full-annulus RANS) as well as experiments in off-design and idle conditions. Experimental set-ups available at ISAE include a small ventilation and the DGEN-380 geared turbofan fan, for which databases are available in nominal and windmilling conditions, and experiments under inflow distortion are in preparation. The calibrated model will be tested under distortion, and employed in the design of nacelles and intake ducts for a distributed-propulsion blended-wing-body concept.

Requirements

We are looking for an enthusiastic researcher with a PhD degree in Fluid Mechanics, Energetics or a closely related discipline and a strong background in computational fluid dynamics, modelling and post-processing techniques. Experience in CFD of turbomachinery or optimization will be highly appreciated.

Excellent English, communication and reporting skills are required. Comfort with working both independently and in a team, as well as a pro-active, problem-solving and result-oriented work attitude is highly regarded. The candidate is expected to publish and participate in international conferences, as well as in the regular internal project status reports.

Information and Application

The position is open for a 12-month fixed-term period, with a possible extension after the first 12 months.

For more information about this position, please contact Dr. Nicolás García Rosa (nicolas.garcia_rosa@isae-supaero.fr).

Applicants should submit their letter of application along with a detailed curriculum vitae, a list of publications, title and abstract of PhD dissertation, contact information of at least one academic reference and all other information that might be relevant to Dr. Nicolás García Rosa (nicolas.garcia-rosa@isae-supaero.fr).

[5] Dufour, Guillaume, and William Thollet. "Body Force Modeling of the Aerodynamics of the Fan of a Turbofan at Windmill." ASME Turbo Expo 2016: Turbomachinery Technical Conference and Exposition. American Society of Mechanical Engineers Digital Collection, 2016.

[6] Hill, David J., and Jeffrey J. Defoe. "Innovations in body force modeling of transonic compressor blade rows." International Journal of Rotating Machinery 2018 (2018).