Nacelle Design for Advanced Aircraft Concepts

Three dimensional UHBR engine nacelle aerodynamic design and airframe integration

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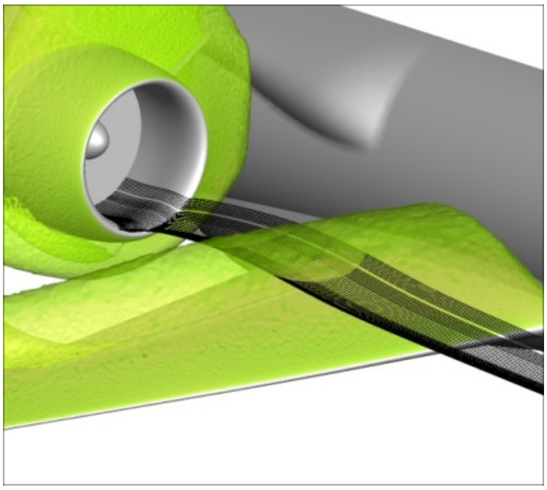

Figure 1: Over wing nacelle: interaction of wing shock and engine stream tube

In Short

- 3D nacelle design and optimization
- UHBR engine nacelles
- Over wing nacelle configuration
- Enigine integration and Installation aerodynamics
- Active flow control in engine intakes

Next generation of turbofan engines for commercial transport aircraft show trends toward higher bypass ratios. This is driven by the improved fuel burn and reduced emissions from these Ultra High Bypass Ratio (UHBR) engines[1]. The successful implementation of these engines pose certain challenges. As the BPR increases and the fan diameter increases the design of the nacelle becomes more critical in order to avoid drag and weight penalties. Furthermore, conventional under wing installation becomes increasingly complicated due to the large size of these engines, this would require the evaluation of over wing nacelle (OWN) installation concepts[2].

Within the LuFo funded project AVACON the integration of such UHBR engines over the wing of the aircraft is evaluated. Research at TU Braunschweig is focused on the three dimensional nacelle design and optimization along with the aid of consortium partners such as Airbus, DLR, Rolls-Royce and MTU. In collaboration with industrial partners a three dimensional nacelle design system has been established and tested on the AVACON research aircraft OWN configuration[3]. The tool is also capable of designing axisymmtric isolated nacelles [4] [5] . The three dimensional design system uniquely combines the intake design, external cowl design and nozzle design frameworks, allowing for a wholistic nacelle design approach.

The nacelle design framework was applied to the fuselage mounted OWN concept, figure 1. The resulting 3D nacelle was able to operate at off-design conditions such as 30knots crosswind efficiently. Furthermore, the cruise performance of the nacelle was improved by 5 drag counts (dcts). This was achieved by identifying key aerodynamic phenomena such as nacelle-wing and nacelle-pylon interactions. The design method was also able to improve the nozzle performance significantly, identifying the ideal nozzle configuration for such installations.

Despite the successful application of the design system the drag from the OWN configuration was 13dcts higher than the underwing reference. The current project proposes to address the open questions from the study. Firstly, it is planned to do repeat the installation study with a medium length intake 23% shorter than that of the previous study. The application of the design system to an underwing configuration would give a better insight into to the aerodynamic effects responsible for the lower drag of this configuration. A parameter study of the nozzle in the installed airframe environment would potentially give deeper insight into drag reduction possibilities.

A deeper understanding into off-design characteristics of intakes, particularly the variation of parameter trends as the intake length gets shorter is desired. This would help in the design of shorter and lighter nacelle designs. As the intake gets shorter, active flow control technologies would be required for its efficient off-design operation. The evaluation of AFC concepts for intakes would also be undertaken in this project

WWW

https://www.tu-braunschweig.de/ifas/forschung/projekte/avacon

More Information

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[3] Wegener, P., Integration of fuselage-mounted over-wing engines on a mid-range aircraft *32nd Congress of the international council of Aeronautical Sciences* (2021)

[4] Legin Benjamin, Constance Heykena, Design and Optimization of a Nacelle for a UHBR Turbofan engine using an Intuitive Class Shape Transformation based parameterization *Proceedings of Global Power and Propulsion Society* (2020)

[5] Lennart Harjes, Legin Benjamin, Development of Aspirated Ultra-Short Intakes for Aerodynamic Off-Design Analysis *Proceedings of Global Power and Propulsion Society* (2021)

Project Partners

Airbus; DLR; Rolls-Royce Deutschland, MTU Aero-Engines

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