Abstract for AEC2020

Evaluation of Thermal Comfort for Novel Aircraft Cabin Ventilation Concepts

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Introduction

Flexible cabin layout, high demands on thermal comfort and energy efficiency as well as industrial modular design are the main challenges for aircraft engineers when addressing the ventilation of the aircraft cabin. Nowadays, mixing ventilation is installed in all commercial aircraft, guaranteeing a high degree of mixing and therefore a robust and stable ventilation concept for the cabin [1]. However, complex and weight-intensive ducts are required. In addition, the system provides only limited heat removal efficiency and high velocities are prone to draft on single seats [2]. Addressing these challenges, we are investigating novel ventilation concepts within the ADVENT project - Advanced ventilation techniques for modern long-range passenger aircraft to promote future energy management systems.

Discussion

To analyze promising ventilation concepts regarding outlet and exhaust dimensions and locations as well as momentum and temperature of the inflowing air, numerical simulations are performed. The transient numerical simulations (URANS) are based on second-order finite volume schemes. In a post-processing tool chain, thermal comfort quantities, such as predicted percentage of dissatisfied (PPD) and predicted mean vote (PMV) are calculated. Further, the local mean age-of-air is computed. The test configuration is a slightly simplified Airbus A350 geometry with nine-abreast seating. The computational domain spans five rows with adiabatic, non-permeable boundary conditions in flight direction.

At the conference, we will present temperature and velocity fields, streamline visualizations, heat removal efficiencies as well as the above-mentioned comfort indices determined for selected ventilation configurations. Exemplarily, results of temperature and mean age-of-air fields as well as PMV and PPD are shown in Figure 1 for different ventilation concepts. Differences regarding the temperature stratification and the local mean age-of-air are detected. Further, different locations and dimensions of the air inlets resulted in locally different flow fields. Here, promising locations providing a good overall comfort were detected.

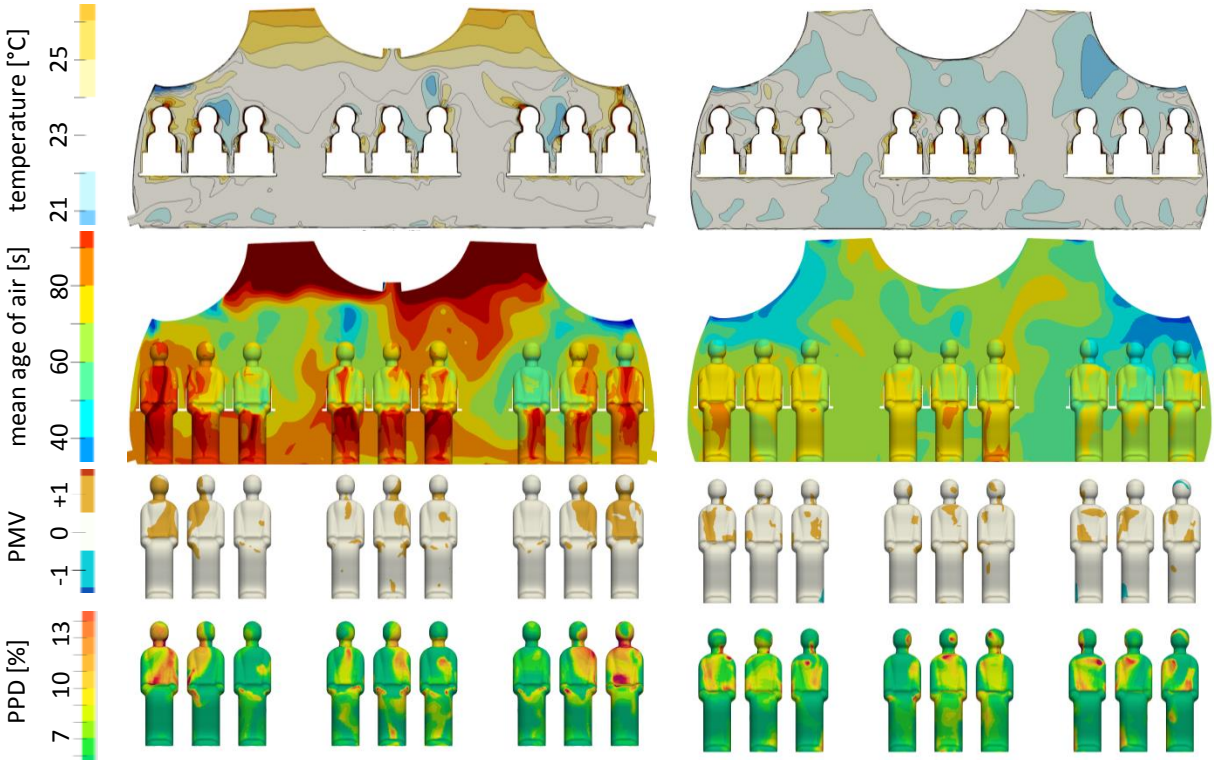

Figure 1: Temperature and mean-age-of-air fields as well as PMV and PPD for two selected ventilation concepts

Conclusion

As of today, more than 50 different parameter configurations for various outlet and exhaust concepts as well as temperature and momentum levels are analyzed. The results proved the existence of promising concepts, which provide good overall comfort while simultaneously reveal higher heat removal efficiencies as compared to state-of-the-art mixing ventilation. Further, the novel concepts are evaluated with regard to their feasibility of integration in an aircraft. Here, a modular industrial design process, the availability of space in the cabin and the required duct lengths are assessed.

Simultaneously, a new test facility is under construction at the German Aerospace Center in Göttingen. It will allow for experimental simulation of novel ventilation concepts at different flight phases (static and dynamic) promoting realistic thermo-dynamical boundary conditions.

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Bibliography

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