Conference Agenda

15th ROOMVENT Conference

Session

VT: Ventilation for means of transport

Session Chair: **Shin-ichi Tanabe**

Presentations

Hybrid Train Ventilation Systems for Summer and Winter Conditions

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The HVAC system of a train is the second largest energy consumer during a train journey, requiring up to 20-30% of the total energy demand. Therefore, new technologies, such as heat pumps or demand-oriented ventilation have been tested and integrated [1]. Further, novel ventilation concepts for future high-speed trains have been investigated in recent years in the lower deck of a 1:1 scale generic train mock-up at the DLR in Göttingen within the framework of the Next Generation Train (NGT) project [2]. One main objective of this project is to improve the ventilation system in terms of thermal passenger comfort, heating and cooling performance and energy efficiency.

Beside state-of-the-art "micro-jet" ventilation used as reference case, two novel ceiling-based ventilation concepts were investigated in previous studies: low-momentum ceiling ventilation with a trickle ceiling above the aisle and hatrack-integrated low-momentum ventilation (HLMV) with a trickle ceiling above the seats. In the present study, all three ceiling ventilation concepts were combined with cabin displacement ventilation (CDV), realized by a low-momentum air supply on floor level. The windows of the mock-up were replaced by a jacket heating/cooling system based on capillary tubes mounted on aluminum sheets to allow for the experimental simulation of winter and summer conditions. To simulate the obstructions and the heat release of real passengers, 24 thermal manikins were used. Up to 200 resistance temperature detectors and 16 omnidirectional velocity probes were installed in order to capture the boundary conditions and to investigate the fluid temperatures as well as the velocities near the TMs. The surface temperatures of the manikins and the cabin interior were captured using an infrared camera.

In this study, the influence of warm and cold windows on hybrid ventilation concepts with different air-mass flow distributions between ceiling and floor supply was evaluated in an experimental analysis with regard to the requirements of the standard [3]. At the conference, we are going to present the results in terms of spatial temperature homogeneity, local temperatures and velocities, temperature stratifications, heat removal efficiency as well as surface temperatures of the manikins and cabin interior under summer and winter conditions. First results of the present study show a high potential of the novel ventilation concepts with regard to thermal comfort improvements. The lowest energy requirement was observed for the ceiling-based ventilation concepts in case of heating and for CDV in case of cooling.

[1] P. Danzer, (2017) ifv Bahn-Klimatechnik (Rail-HVAC) und Bahn-Komfort (Rail-Comfort) Fachtagung.
[2] Schmeling D., Hörmann H.-J., (2018) Proceedings of the 4th Int. Conf. on Railways Technology.
[3] EN 13129 (2016), Railway Applications; Air Conditioning for Main Line Rolling Stock.

Novel Ventilation Concepts for Long-Range Aircraft Cabins – Thermal Comfort and Energy Efficiency

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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 cabins. Nowadays, standard mixing ventilation is installed in all commercial aircraft, guaranteeing a high degree of mixing and therefore a very robust and stable ventilation concept for the cabin. However, complex and weight-intensive ducts are required, the system provides only limited heat removal efficiency and high velocities are prone to cause draught on single seats.

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. Low-momentum and micro-jet based concepts integrated in the ceiling, floor or sidewall modules are analyzed. 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 or predicted mean vote are calculated. The test configuration is a slightly simplified Airbus A350 geometry with a 9-abreast seating. At the conference, we will present and discuss temperature and velocity fields, streamline visualizations, heat removal efficiencies as well as the above-mentioned comfort indices for various ventilation configurations. First results proved the energetic advantages of displacement ventilation compared with state-of-the-art mixing ventilation. Further, different locations and dimensions of the micro-jet and trickle-ceiling air inlets resulted in locally different flow fields. Here, promising locations providing a good overall comfort with high horizontal temperature homogeneity were detected.

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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Impact of Turbulence on the Thermal Comfort of Passengers in Car Cabins

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People spend a considerable amount of their time in vehicles. Hence, thermal comfort is an important argument in terms of the competitive edge. Most studies characterize thermal comfort in car cabins based on EN14505 [ENISO14505] originating from the evaluation of thermal comfort for low-velocity ventilation of rooms and buildings. However, the ventilation in cars is typically realized by means of high-momentum air flow through air outlets on the dashboard. In addition, the temperature sensation differs between cars and buildings due to e.g. the activity level or the environment. The aim of this study is to verify the impact of draft on the thermal comfort of passengers.

The measurements are performed within a temperature-controlled environment housing a generic single-person car cabin. The latter features two air inlets with adjustable turbulence intensity and an air flow directed at the chest of a thermal manikin (TM) with a heat release of 75 W. The TM's surface temperature (T_S) is recorded by means of infrared (IR) thermometry for various combinations of inlet and ambient temperature, air velocity near the TM's chest, and low (LT) and high turbulence intensities (HT). Based on [ENISO14505], the equivalent temperature (T_{EQ}) of the different body parts is determined as objective criterion and rated accordingly.

A sample result for an inlet and ambient temperature of 23°C and a velocity of 1.25 m/s near the chest is depicted in Figure 1 with (A) representing the T_S of the TM for LT. T_{EQ} for the LT scenario is shown in (B) and for HT in (C). For LT, significantly higher values for T_{EQ} are obtained compared to HT. Here, the higher turbulence of the jet hitting the TM's surface leads to an increase in the heat transfer and as a consequence to lower T_S. At the conference, we are going to present the impact of draft on the thermal comfort as a function of air velocity, temperature and radiation.

Influence of ventilation on particle deposition around cabin supply air nozzles

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Enhanced soiling around multi-slot air diffusers due to particle deposition is frequently observed in commercial airplanes. The dirty black soiling is very unsightly and influences the passengers' perception of cabin air quality. This study conducted experimental measurements and large eddy simulations with Lagrangian tracking for the distribution of particle deposition around a multi-slot diffuser. This investigation first used a relatively simple case of indoor particle deposition to compare the LES-Lagrangian model with the RANS-Lagrangian model with near-wall turbulence kinetic energy correction. The comparison shows that the LES-Lagrangian model was more robust than the RANS-Lagrangian model in predicting particle deposition indoors. The superior LES-Lagrangian model was then applied in predicting the particle deposition distribution around a multi-slot diffuser. This investigation also conducted detailed measurements of the distribution of particle deposition around the multi-slot diffuser in a laboratory chamber using a wiping method on a resolution of 3×20 mm^2. The measurement accuracy of the wiping method was within 20%. The particle deposition distribution predicted by the LES-Lagrangian model was compared with the experimental data to validate the model. The results indicated that the LES-Lagrangian model correctly predicted the order of magnitude of the particle deposition velocity distribution around the multi-slot diffuser.

Model based real time assessment of local thermal sensation and comfort for vehicle cabins under transient and inhomogeneous climate conditions

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Certain indoor environments such as vehicle cabins are subject to highly transient and inhomogeneous climate conditions. Typically high vertical air temperature gradients, asymmetric radiant temperatures and high air velocities characterize these environments. In order to provide individualized comfort for humans through designated actors such as air outlets or heated/cooled surfaces, information about local sensation and comfort is required.

In this publication, a method for real-time coupling of a sensor manikin with a comfort model is presented. We use a self-constructed sensor manikin with air temperature sensors for 16 individual body segments, 4 globe temperature sensors and 4 air velocity sensors to measure environmental conditions. Additionally, relative humidity is monitored in one position of the setup. The sensors are attached to a computer based controller which enables real-time communication with simulation software through the Automation Device Specification (ADS) interface. For the assessment of thermal sensation, we use the NOODEL – 33 Node Comfort model. Each of the 16 body segments of the model is allocated to one of the air temperature sensors. Groups of body segments are allocated to the velocity and globe temperature sensors according to their physical distance to the sensor. The comfort model determines local as well as global thermal sensation and comfort in 2.5-second time intervals based on the measured values.

With results of a pilot study conducted in a vehicle cabin mockup inside a climate chamber the method is validated for cold ambient conditions. A group of 12 test subjects evaluated thermal sensation and thermal comfort in a test scenario with dynamic climate conditions. The simulation results of the comfort model show good agreement with the subjective ratings for the upper body. Deviations are lower than one scale unit even under transient conditions. For body parts at the lower body, higher deviations occur and the overall amplitude of dynamic transitions is attenuated significantly in comparison to the subjective ratings. With further improvement of the comfort model calibration, the method can be used for development of enhanced comfort driven control strategies for HVAC systems in transient and inhomogeneous environments.

Influence of geometrical air vent parameters on the resulting jet stream for passenger car cabins

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This study is intended to support the development of novel air vent outlet approaches for passenger car cabins. The operating principle of the airflow deflection of the new air vent works without any visible adjustment elements to generate a higher degree of freedom regarding the interior design. In order to assess the correlation between the air vent geometry and the resulting jet stream, a parametrization of the outlet design is established. To evaluate the different jet streams, the resulting velocity fields are determined using computational fluid dynamics (CFD). The examined qualitative and quantitative airflow characteristics form the basis for determining the evaluation criteria for various novel air vents. The analysis of the full parameter space with various geometrical vent configurations, for instance outlet height and nozzle surface alignment, is implemented by using a model order reduction technique. Based on a parameter space sampling with a Design of Experiments (DoE), the velocity field and the main flow characteristics for the different parameter combinations are predicted using Proper Orthogonal Decomposition + Interpolation (POD+I) and Kriging, respectively. With this adapted approach, various air outlet geometries are analysed in order to determine optimised geometrical parameter values for each evaluation criterion.

IMPACTS OF PANDEMIA COVID-19 ON THE ENVIRONMENTAL QUALITY OF CIVIL AVIATION SECTOR

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The spread of the COVID-19 pandemic, caused by the SARS-CoV-2 virus or New Coronavírus, occurs by the dissemination of viral infections forcing the need for actions to control the virus. How to wash your hands and not take them to the eyes, mouth and nose, the social isolation and/or quarantine and there is urgency in testing medications and vaccines. COVID-19 caused a pandemic that impacts the health system in biomedical and epidemiological order on global scale, as well as social, economic, political and cultural impacts and their repercussions. One of the measures taken by the governors to contain the dissemination of the virus was the closure of airports, ports and land borders, keeping only essential repatriation flights, support for health professionals, political and military cruises to transport health materials.

The new coronavirus pandemic and the temporary airport closure directly affected the civil aviation sector due to the commitment of airlines with the environmental quality of airports and planes. The concern about the agglomeration of people in public spaces causes the need for ventilation control to reduce the contagion and maintain hygiene in airports and planes. The sum of these factors brought, as a consequence, a resumption of decisions about how to adopt postures to control the contagion. Based on this analysis it turns out that ventilation is the fundamental factor to control the contamination of the COVID-19 pandemic. In the civil aviation sector for passengers transport on plane and airport the following related aspects are presented: 1) determine the air conditioning system coefficients in commercial airplanes for passenger transport using CFD (Computational Fluid Dynamics) to check airflow; 2) present new hygiene technologies for plane and airport and 3) use geoprocessing as a relation among the geographical space of airport location, the plane and the passenger for contagion control.

Keywords: pandemic, COVID-19, airplane cabin, environmental quality, geoprocessing and health