QUB PhD Project Proposal

2018-2019

Title: Modelling and development of efficient ventilation strategies to optimise bus passengers' thermal comfort whilst minimising energy consumption

Project Description:
Commuters in the UK spend on average 75 minutes a day of their lives inside buses, trains or cars; it is thus vital that the conditions in mass transport systems are safe, healthy and comfortable. Ventilation, which is the supply of fresh air and the removal of stale air in an indoor space, is a key component to provide satisfactory indoor environmental quality (IEQ) in term of both thermal comfort and air quality. The effective design and/or assessment of the ventilation system for the mass transport system is therefore of paramount importance to guarantee satisfactory standards of thermal comfort and air quality.
Novel and optimised strategies need to be implemented in order to guarantee an adequate level of thermal comfort and air quality reducing at the same time the energy consumption. Recent literature for example, has stressed the importance of local thermal comfort, in addition to general thermal comfort. Addressing the local thermal comfort concept that focuses on specific body parts instead of general thermal comfort opens the potential to develop occupant-responsive or 'personal' environmental control systems. These systems can focus on localized heating and cooling of the occupants themselves, rather than conditioning the entire space, and include task-ambient, radiant and naturally ventilated systems. More importantly these systems can be highly energy-efficient in maintaining thermal comfort compared to traditional approaches.
This research project aims firstly to develop an understanding of the HVAC system utilised in buses. The development of surrogate 1D models of the entire system will allow to achieve a better understanding of the system itself and the possibility of its optimisation.
Secondly, thermal comfort conditions in city buses during typical operating conditions will be investigated. This investigation will be achieved through the development of detail fluid thermal models (CFD) and actual experimental data. CFD models and reduced order models will consequently be utilised to develop innovative strategies either for the redesign of the ventilation system in buses and/or for the optimisation of passengers' thermal comfort to minimise energy consumption during operating conditions.

Project objectives

- To understand and optimise the operation of HVAC system in buses for both current and future driveline technologies. This objective will be achieved through the development of reduced order model, in modelica language, of the entire HVAC system. The model will be validated with in vivo experimental data.
- To understand passengers' thermal comfort conditions in city buses during typical operational periods (summer, winter, rush hours). This will be achieved through the gathering of real time experimental data and the development of detailed numerical models (CFD).
- To develop accurate, reliable and efficient models (CFD and Reduced Order Models) to facilitate the redesign of the ventilation system to optimise thermal comfort in city buses reducing energy consumption.
- To set and achieve suitable targets for energy consumption relative to the temperature difference between internal and external conditions.

Project methodology

The project will be conducted in the William Wright Technology Centre in Queen's University Belfast.

There are five core objectives associated with the project:

1. Model development of HVAC system in buses
2. Gathering of live experimental data in buses (temperature, humidity and air velocity) and carry out analysis of uncertainty for CFD validation purposes
3. Numerical investigation of thermal comfort in city buses during operational conditions
4. Development of numerical models (CFD and ROM) for fast and reliable redesign of the ventilation system.
5. Development of ROM (Modelica type) for Multiphysics energy efficient analysis.

Project impact

- Scientific impact
    - To extend knowledge in the field of thermal comfort modelling focusing on the challenges provided by mass transport systems.
    - To develop knowledge of Reduced order models and their applicability for energy efficient strategies in buses
- Commercial impact
    - Commercial viability of the design of new buses' ventilation systems to improve passengers' comfort experience and reduce energy consumption with a cost-effective, adaptable, modular design.
- Researcher impact
    - To increase the Student and the William Wright Technology Centre national and international visibility through dissemination (conferences and journals) and strategic partnership.

Key Transferable Skills that will be developed during the PhD:

At the end of the doctorate the candidate is expected to have developed generic and transferable skills in time management, problem solving, report writing and oral presentations. It also expected to develop a considerable skillset in the thermo-fluid area and in numerical code programming with specific emphasis on Modelica, C++ and python and in the utilisation of OpenFoam CFD software.

First/Lead Supervisor and their contact details	**Dr Marco Geron (m.geron@qub.ac.uk)**
Second Supervisor and their contact details:	**Prof Roy Doulas (R.Douglas@qub.ac.uk)**
Top up available for this project?	The studentship covers the full university fees and includes an income of up to £18,500 per annum (This includes a top-up to the basic stipend which will only be awarded on the recommendation of the interview panel).