# Masters by Coursework Project Presentation

**13 June 2014**

**Engineering South Building S111 and S112**

## S111

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<th>Time</th>
<th>Student Name</th>
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<td>Yang Luo</td>
<td>1611: CFD modelling of personalised ventilation system in high-speed railway carriages</td>
<td>Zhao Feng Tian</td>
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**Morning Tea break**

## S112

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Each student has 15 min presentation + 5 min for questions and change over.
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<td>Jiankang Li</td>
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<td>Zhilong Gu</td>
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<td>Rong Pan</td>
<td>1610: CFD modelling of fires in train carriages</td>
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CFD modelling of personalised ventilation system in high-speed railway carriages

Yang Luo

With the increasing use of high-speed railway (HSR) transport, it is important to design effective air distribution systems in the HSR carriages to provide clean air and thermal comfort to passengers. Particularly, passengers are seated closely together in the carriages, making it a perfect environment for transport of the airborne diseases. A personalised ventilation (PV) system may help to reduce the transport of the airborne diseases in HSR carriages and improve the thermal comfort of passengers.

In this study, three PV systems are proposed in conjunction with the conventional ventilation system to improve the performance of total-volume ventilation system. A computational fluid dynamics (CFD) model of an HSR carriage is developed using the CFD package ANSYS/CFX®. To test the performance of the three PV systems, a framework developed by the authors’ group has been used. The performance of ventilation system respect to the thermal comfort and air quality is evaluated based on the results of Predicated Mean Vote (PPD), Predicted Percentile Dissatisfied (PPD), the humidity and Age of Air (AoA) models.

The simulation results show that all three PV systems can improve the thermal comfort and air quality in HSR carriages in terms of better AoA and PPD around passengers.
Demand Controlled Ventilation for HVAC Systems

Yanan Jiang

This project is based on the case of Adelaide Airport Terminal 1 building where the heating, ventilation and air-conditioning (HVAC) system consumes more than half of the total energy. For the purpose of saving energy while maintaining the indoor air quality, demand controlled ventilation (DCV) system was installed. A critical zone is the zone with a great demand of fresh air fraction. Critical zone control is the main part of DCV system. The existing system has several problems: low indoor air quality and energy efficiency, delay of CO₂ concentration detection and only single critical zone control. To solve these problems, the control algorithm of an air handling unit serving 4 different zones is researched. Multiple critical zone control has been achieved. By using the predicted CO₂ concentration strategy, the delay of the CO₂ concentration detection has been reduced so that the performance of the multiple critical zone control has been improved. The temperature set point reset strategy is designed to control the temperature in different zones. The results demonstrate that the proposed multiple critical zone control strategy can automatically identify critical zones and improve indoor air quality in each zone. The temperature set point reset strategy is able to adjust temperature in each zone to reduce the energy consumption of the cooling or heating process. In the seminar, I will show the models and results of the multiple critical zone control combined with temperature set point reset strategy and CO₂ concentration prediction strategy.
Intelligent C2, Navigation and Avionics of Maritime UAV Drone Robot for Oceanic Application: A Feasibility study

Gurdeep Singh

In recent times, research about UAVs has been conducted by various institutions globally. Students from the ‘University of Adelaide’ in previous years, have also been involved in successfully design and build UAVs with various maritime capabilities such as carrying payload for sonobuoy deployment as well as carrying on-board camera while in flight. Initially in most mission scenarios the command control and navigation of the UAV was conducted manually by human operator(s) (pilot) using radio transmitter.

The purpose of this project is to conduct the feasibility study to investigate the techniques to assist the UAV autonomously achieve accurate landing on a fixed or a moving target on the ground and furthermore on Oceanic environment.

The UAV test-bed used in this project has four rotors (quad-copter) and is capable to achieve vertical take-off from any platform. The quadcopter is a six degree of freedom system. To study and investigate the method of controlling of the quadcopter, a critical literature survey was conducted involving quadcopter dynamics and kinematics to understand the maneuvers of the UAV test-bed. Furthermore, simulation for object detection and target tracking techniques were conducted in ‘Matlab’ using on-board camera. Quadcopter was equipped with sensors i.e. compass, accelerometer, altimeter, pressure-sensor, GPS, sonar sensors and vision sensor (camera). Various landing techniques for manual flight and autonomous flight were tested for accuracy of landing on target.

The investigation conducted in this research proves that it is feasible to attain accurate landing by using a viable GPS (Global position system) such as differential GPS to achieve an accuracy of about 4 cm horizontally. In addition to this more robust algorithm for object detection and tracking would further minimise the horizontal error from the landing target.

The main aim of this seminar presentation is to discuss on methods of manual and autonomous manoeuvring of UAV in conjunction with visual servoing techniques to assist in achieving accurate landing on the target.
Firework ignition control system

Chen Zhao

This project originated from discussions with an executive member of a leading Australian fireworks manufacturer Foti Fireworks, about the manufacturing processes accompanying their business model. Foti Fireworks has an extensive history spanning over 50 years, and their manufacturing methods were a reflection of this. At a time of business expansion, it becomes apparent that they needed to consider more efficient testing processes. Until now, all the igniter testing is manual work. The aim of this project is to research the automatic control system to the resistance of igniter heads. In my seminar, I will be discussing the research of the control system which can achieve the auto-test of igniter resistance, separate the igniter in different container base on different quality. In addition, I will introduce the background and gaps of this project, objectives that the control system should achieve, working theory of the control system and simulation of the system working process. The problems which were encountered on the way and further work will also be mentioned. These topics will be discussed in detail to give an insight to the design process for this project.
Optimisation of chillers operation

Ping Dai

Chillers consume a large amount of electric energy every year. In the Adelaide airport, there are three chillers to keep the inside room temperature comfortable for passengers, but this results in a large energy consumption. The current chillers control method in Adelaide airport is not efficient as the three centrifugal chillers are not always work with high efficient. It wastes a large amount of electric energy. The aim of this project is that optimize the three chillers operation, hence save energy for Adelaide airport.

In this report, an artificial neural network model of chillers is built based on the previous cooling load, zone temperature and outdoor temperature to predict cooling load in the next 10 minutes. COP curves of three chillers are drew to find efficient region of each chiller. Then, Chillers operation is optimized according to the prediction cooling load and COP curves. Experiment study is applied to test the artificial neural network model and the optimal scheme.
Designing robust structured materials based on analysis of rigid biological systems

Alexey Deev

Objectives
This project is aimed to conduct an experimental investigation to study the structure of a rigid biological object by using micro-CT scanning and the analysis of its mechanical behaviour by Finite Element Method. The ovine tooth was chosen to be the studied object as it simultaneously possesses properties such as high hardness, high toughness and high wearing resistance. Also there is a lack of research on hypsodont type of teeth (the category to which ovine teeth belongs to). The additional aim of the project was to find a sequential transformation methodology to convert the micro-CT dataset into a FE model.

Methods
Initially three ovine teeth (incisor, premolar and molar) were extracted and scanned using XRadia Micro XCT-400 scanner. 2-D images of all scanned objects were obtained as a result of the micro-CT dataset acquisition. These 2-D images are then input into the Avizo Fire software to obtain 3D images of the teeth and generate its 3-D surfaces for each substance through a segmentation process. These results for the molar were then transferred into CAD software application (CATYA) to create the solid model of the tooth. The solid CAD model was transferred into FE software application (ANSYS) to create the FE model and generate volumetric mesh. One of the variations of the possible masticatory loads was applied to the FE model to calculate the stress and strain distributions.

Results
The analysis of stress distribution proved that the ovine tooth mechanically behaves like a rigid structure. It also confirmed the existence of the mechanism that prevents possible crack propagation inside of the tooth. The FE submodel was created to examine the area with the highest level of stress. The obtained submodel stress patterns confirmed the stress distribution calculated for the whole FE model and also allowed to examine much more detailed submodel stress distribution. Additionally this analysis formed a methodology that allows to facilitate the creation of detailed FE models of complex objects with irregular geometric properties and many substructures or materials.
Three billion people use cookstoves across the globe for cooking, cleaning and heating. These cookstoves use biomass, which although renewable, produces harmful emissions. The emissions produced include those from complete combustion; nitric oxides (NO₂) and carbon dioxide (CO₂) as well as those from incomplete combustion; carbon monoxide (CO), volatile organic compounds (VOC) and fine particles (PM₂.5-10). It is the exposure to such emissions which cause between 2 and 4 million deaths every year. These deaths can be prevented by using improved cookstoves that reduce harmful emissions and increase fuel efficiency. In addition to health issues, there are many environmental issues such as deforestation and anthropogenic climate change which result from the use of these cookstoves. However, the application of scientific knowledge to support the development of improved cookstoves has previously been limited. The aim of the current project is to experimentally investigate and thus further the understanding of wood combustion in a typical cookstove.

Experiments were conducted in a furnace analogous to a Top-Lit, Up-Draft (TLUD) cookstove. The furnace and TLUD stoves are lit from above and use induced primary air to pyrolyse the fuel. These volatile gases mix with the secondary air to create a flame with fewer harmful emissions than that from primitive cookstoves. In addition, once extinguished, the remaining solid fuel can be used as biochar.

The suitability of the research furnace as an analogy to the real world biomass cookstove was a main aim to be investigated. This involved assessing the emissions produced in the combustion of wood as a fuel through systematic experimentation. This systematic experimentation included varying the primary and secondary air ratios to understand the optimum level of emissions and efficiency. A simulation of the furnace in the real world was then carried out by using the natural draught alone, which enabled a comparison and showed whether the research furnace was a suitable analogy to the real world biomass cookstove.

Measurements taken during the experiments include the emissions produced, the outer temperature of the furnace chamber and the water temperature. A Testo™ gas analyser was used to record the emissions, an infrared thermometer operated manually was used to record the outer temperature of the furnace chamber and a K-type thermocouple was used to record the water temperature.

Varying the secondary air and primary air flow rate showed very consistent results. Although consistent results were gained, results indicate that the higher the secondary air flow rate, the higher the O₂ emissions, lower CO and CO₂ emissions and a slightly prolonged time for 2 litres of water to boil. However, allowing just the natural draught to combust the fuel, the emissions and water boiling efficiency did not match those produced through the fan-forced approach. This concludes that the research furnace is not a suitable analogy to the real world biomass cookstove in its present state but would be suitable for larger industry based combustion needs in the third world. This therefore indicates that future work aiming to gain a further understanding behind wood burning in cookstoves is required.
Energy Assessment of High-rise Building – A Case Study in Shanghai

Ji Wang

With the rapid growth and improvement of living standards, China’s building energy consumption has kept rising in recent years. The Hechuang building in Shanghai is a business office building, which would be the objective of this study for an energy assessment. This assessment focuses on the electricity consumption evaluation as well as analysis of water and gas usage in 2012. The electricity consumption is divided into three parts, which are public area consumption (accounts for about 39% of total electricity usage), office area consumption (about 40% of total) and commercial area consumption (about 20% of total), while 1% is for the error. There are three major electricity consumers in the buildings which are Air-conditioning system, Lights and Lifts. Among them, air-conditioning system accounts for up to 50% of the public electricity usage and around 34% of the total electricity usage.

The type of the air-conditioning system used in the Hechuang building is Sanyo DG-53GHT double-effect Water-Lithium Bromide Absorbed chiller-heaters, gas firing with cooling capacities of 2461 kW and heating capacity of 2059 kW. The calculated cooling load of building using the CAMEL software is around 2514 kW, which shows the air-conditioning system used in the Hechuang Building is proper in terms of the size/capacity.

The lights consumption in 2012 is around 352800 kWh, which accounts for about 18% of the public electricity usage and 7% of the total electricity consumption. In order to reduce the energy consumption of lights to 5% of total consumption, which was set by the building management department, the study recommends the technology of audio-control should be applied to some lights.

The electricity consumed by the lifts in 2012 is around 60450 kWh, which accounts for around 5% of the public electricity usage and 1.2% of the total electricity consumption. According to study, it is suggested that only running 4 lifts (2 for high levels, 2 for low levels) during the off-peak period (6:30 pm to 11:00 pm). The lifts are out of use from 11:00 pm to 8:00 am.

Besides, the water and gas usage in 2012 is around 75450 m³ and 1,336,400 m³ respectively. Compared with the previous two years, both the gas and water consumption in 2012 increases by approximate 7%.
Wave Surface Glider (WSG) Robot Design, Development and Operation: Feasibility Study

Mohammadreza Salari

A Wave Surface Glider (WSG) Robot is an Unmanned Surface Vehicle (USV), which has the capability of roaming in the ocean and executing numerous marine missions such as patrolling, station keeping and ocean data gathering for a predetermined area of the ocean while consuming only ocean waves and solar energy to function.

In this research project, WSG robot test-bed, which is manufactured by School of Mechanical Engineering of the University of Adelaide, has been investigated dynamically. This seminar discusses the works done on dynamic modelling of this marine vehicle and a new approach to model WSG robot with the help of fluid analysis results of its structure.

Recently, the maritime surface-vehicle has been challenged for a real-time ocean trial and the results have been obtained, analysed and compared with similar international works as well as simulation results. At the end, a number of adjustments have been proposed and taken into consideration for further development of this robot which would be presented and discussed at the seminar.

Surface Wave Glider Robot – Oceanic Case Study
A feasibility study of design, development and operation of Submersible Tube Launched UAV Robot

Gholamali Mansouri Pake

In the past decades, UAV-systems have become useful for a number of applications including, security, farming, search and rescue missions, safety and surveillance within critical areas or vulnerable disaster locations (e.g. Nuclear disasters, Earthquake and Tornado sites). In addition, the major mission of the UAVs within maritime environment is to determine information to support operators on critical situations. The goal of this research project is to conduct a feasibility study on the design, dynamics, development and operation of a submersible tube launched Unmanned Aerial Vehicle (UAV) with launching capability which could be launched from an unmanned underwater robot or a submarine to begin its’ mission(s) and to be able to achieve a desired maritime-air mission scenario.

The seminar would explain the investigation towards the integration of the body design concepts, deployable wings mechanisms, wing’s shapes and material selection of such UAVs that have been studied. Throughout this study, a wide range of extensive international literature survey has been conducted to improve the knowledge about previous studies which have been done by other researchers in this area whilst evaluating possible gaps between their efforts and outcomes. Additionally, the design and development of a new UAV have been investigated while considering its launching mechanism, control system and application of the maritime-UAV on ocean-air scenarios.

In addition, a series of computational results and experimental data (if applicable) would be compared and explanations would be given on the optimization of the UAV’s structural dynamic (shape and wings cross-sections, etc.) to support the viability of the robot.
A Feasibility study on Automated Ocean Energy Recovery System for Oceanic Applications

Mahyar Heidari

This research project is focused on study of Oceanic energies as well as investigating towards the methods of harnessing those energies. A new automated Oceanic energy recovery system will be suggested that provides enough electricity for underwater sensors working within an Oceanic facility. On the other hand a research was conducted by Maritime Division (MD) which led to the design of a mechanism that has already been manufactured and under real-time laboratory trials. The gaps of this system are investigated in order to develop a viable design for Ocean dynamic situation(s). That is also included with achieving a higher efficiency of performance for the mechanism.

The main objective of this talk is to discuss on the research investigation towards Point Absorber (PA) type and dynamic classification of the Wave Energy Converters (WEC). In this case, motions of wave have been analysed and the behaviour of a buoy on the surface of the ocean investigated in Computational Fluid Dynamics (CFD), which resulted in a set of data, which were used further as the input of hydraulic software. The result simulates the hydraulic circuit of the original design of the PA developed by the MD. The outlet of the software then was compared to the data collected from the working real-time mechanism in the lab. After a series of research investigation a number of alterations are suggested to increase the efficiency of the current mechanism. Modified circuit then is analysed in the software and efficiency is compared to the current mechanism.

Furthermore a new mechanism for a PA is suggested as future work which is optimized not only in the size and weight but also considerably in efficiency.

Photos taken from the web site of Northwest National Marine Renewable Energy Center
A Feasibility study of New-version of Micro-Sonobuoy Deployment by UAVs

Jiankang Li

The main purpose of this research study is to undertake necessary work to investigate the feasibility of developing a new version of micro-communication sonobuoy deployable via UAVs, so that it can be safely deployed into surface water and work as a relay between underwater and above water communication.

The micro-communication sonobuoy system is divided into three subsystems including sonobuoy canister (with excellent sensitivity in a dynamic sea state), dynamic deployment system and communications systems (both above and underwater). As for the sonobuoy canister, research on material selection and impacting pressure of micro-communication sonobuoy on surface water after deployment from UAV robot were carried out. In this research study, calculation and selection of parachute for deployment system was investigated. With respect to communication system, an extensive selection survey was conducted to select a suitable radio frequency (RF) module, antenna, microcontroller, GPS, power supply system. In addition, the literature survey on the design of low-cost acoustic modem was carried out as well.

The simulation results on a deployed micro-sonobuoy shows the impacting pressure acting on the micro-communication can reach to a very high value, and this high impacting pressure value can be used for material selection of micro-communication sonobuoy canister. The literature survey on the selection of electronic components indicates that the GPS, RF module and a suitable power supply system under the limitation on physical size and weight of micro-communication sonobuoy. Furthermore, results of underwater acoustic modem literature survey show that the communication range can be increased by a higher power input and with modified amplifier. Furthermore, the new transducer design and noise filtering technology have potentials in increasing the quality and communication range of underwater acoustic modem.

The work done in this research-study shows that it is feasible to develop the new micro-communication sonobuoy incorporating GPS, RF module, microcontroller, power supply system and underwater acoustic modem by considering its limited space improvements as well as total weight requirement and budget.
Vibration isolators for crushers

Jiarui Xu

This project is the research of crusher vibration isolators. Vibration is a very common phenomenon in our life especially in mechanical engineering. However, most of vibrations have negative effects on engineering applications which may reduce efficiency of outcomes, damage or shorten the lifetime of machines and their surrounding structures, waste energy or generate seriously noise. Crusher is a machine designed to crush large rocks into smaller rocks or gravel. This project, vibration isolators for crushers, is a continuous project between the University of Adelaide and Boral Quarries. At Boral Quarries Para Hill site, the crusher has been connected with the foundation by four bolts and nuts. But when the crusher works, it will produce huge vibrations which can damage crusher and its supporting structures. In this project, the aim is to isolate or reduce the vibrations of the crusher. This will avoid mechanical failures and increase the lifetime for both crusher and its supporting structures. By using vibration isolator, the vibrations of the crusher can be reduced effectively. However, the existing isolators cannot be used directly for the crusher in Boral Quarries. Therefore, it is necessary to analyse the vibration of crusher system and design a new isolator system in order to meet the demand of vibration reduction for Boral Quarries. To achieve this goal, the vibration isolator which has been determined by previous project is analysed by theoretical calculation and simulation firstly. After that, the different types of isolators and accessories will be designed. When all the new parts are assembled, the isolator system is analysed by simulation in ANSYS Workbench including modal analysis and harmonic response analysis. Furthermore, the vibration isolator is modeled and simulated in Simulink in order to verify the efficiency. In our seminar, we will be discussing the results about theoretical calculation and simulation of vibration isolator and different isolator systems. These topics will be discussed in detail to give an insight to the research and analysis process for this project. The problems that were encountered during the project will also be discussed.
Mechanical Testing of Turning Devices

Chi Zhang

The project deals mainly with the research of a new equipment for turning devices’ fatigue testing. In modern industry, mechanical parts are tested in terms of rotation to ensure their quality and reliability. Some turning devices, however, have to work between -30 °C and 70 °C rather than ambient temperature. Such devices need to be tested under similar conditions. This project specifies the research on how to make the selection of an appropriate environment chamber and how to combine the mechanical turning together with it. Hence, the research is separated into two main sections: the chamber section and the mechanical section. In the chamber section, an 80L temperature test chamber has been selected with the comparison. While in the mechanical section, a step motor controlled by an STC 51 MCU was finally chosen as the turning driving force. It offers a programmable rotation between certain degrees which would suit for different turning tests. What the difficulty this research was faced with was how to install the step motor and the control panel onto the chamber without much heat loss. It is possible to cut up part of the window on the chamber door and replace it with a phenolic foam plate of low thermal conductivity. A contact hole was drilled to let the motor shaft coming inside to drive and ensure less impact on the chamber. In addition to the normal design steps, a real model was made to verify the final prototype. This will be discussed the future possible manufacture of the testing equipment.
A Feasibility study of Intelligent Attitude Control & Communication of a new version of Small-Satellite for Ocean Robotics Application

Arpit Saxena

The ever-increasing demand on expanding data communication infrastructures and rapid data transfer rates has made satellites to play an inevitable part in the contemporary age of technology. Small satellites are inexpensive, both to manufacture and launch and hence the concept is widely acclaimed.

The purpose of this research project is to perform a feasibility study to investigate the 1.5 Unit Cubic Satellite demonstrating deployable characteristics as well as its intelligent attitude control exhibiting a controllable maneuvering capability in the orbit to orient itself precisely using only electromagnetic actuation.

The need for a high power, self-maintaining source for continuous data transfer as well as continuous correction of the satellite’s orientation, has led to the idea of having deployable solar arrays, giving the flexibility of having increased number of solar panels and thus more power. Satellites exhibit random motions. The most inexpensive and lightweight method to gain a precise control over the satellite’s motion is to use electromagnetic force generated using magnetorquers. In this research investigation, a conceptual design showing the deployment of solar arrays was modeled and the intelligent attitude control for the same design was simulated using MATLAB. The orbital parameters were calculated as well as other necessary calculations for the control of the attitude and the results were used in a simulation of the satellite’s attitude control.

The feasibility study concludes that the attitude control of satellites is possible using only the geomagnetic field of earth. This seminar would discuss the method of achieving this goal.
Vision-based bottle alignment system

Peixin Zhang

The project of Vision-based bottle alignment system has required the research and development of a sub-system, an image processing system, based on an automatic alignment system which is for the use of a wine bottle labelling mechanism. This project aims to optimize an image processing system that links to the automatic alignment system for identifying the start position for mechanical bottle labelling and print accurate alignment of labelling on bottle. In addition, a successful automatic alignment system also reduces human errors. This image processing system takes information from the camera and decipher it in matrix by using MATLAB software. Additionally, the image processing system determines correct start position of labelling on bottle and communicate the information to the control system which is another sub-system of the automatic alignment system. The system of automatic alignment can provide unique and high standard labels for the wine bottles. In the presentation, at first introduce the background of hand printing system and automatic alignment system which are based on the earlier research. And after that, the aims, objectives and significance of this project will be explained in detail. Additionally, the methodology and the experiment will be illustrated. At the end of the presentation, the discuss about image optimization and image processing methods in MATLAB software, results and further work will be mentioned as the conclusion of this project.
Modelling HVAC System of Vehicles

Zhilong Gu

In passenger cars, the air distribution system plays an important role in providing a healthy and comfortable environment for driver and passengers. In this study, a novel air distribution design for passenger cars is proposed in order to improve air quality, particularly to avoid the transport of airborne particles that can transmit airborne diseases such as influenza and Severe Acute Respiratory Syndrome (SARS).

A three-dimensional Computational Fluid Dynamics (CFD) model of a sedan has been developed using a commercial CFD package, ANSYS/CFX. The proposed HVAC system including air curtains mounted on the roof of the cabin and an exhaust in the back seats area are tested in the CFD model. The air curtains are designed to isolate the air zone of the driver from the passengers in the front and back seats. A framework has been developed to assess the performance of the novel air distribution system design. The CFD results show that the novel air curtains can effectively prevent the airborne particles from transporting inside the car, particularly to the driver. It is also found that the thermal comfort of the drivers can be improved through the use of the novel air distribution system.
CFD modelling of fires in train carriages

Rong Pan

Trains are one of the most important transportation methods since they can transport passengers efficiently and economically. The increasing numbers of accidents in train carriages due to fires have seriously threatened passengers as fire and smoke can spread very fast in the enclosed carriage space. Therefore, it is very important to predict the fire spread in train carriage for better design of train fire systems.

In this study, a computational fluid dynamics (CFD) model of a train carriage has been developed to simulate fires in train carriages. Two kinds of fire models, namely, the volumetric heat source (VHS) model and the reaction model, are tested in a small-scale train compartment case by comparing the predicted temperature files against the available measurements in literature. The agreement of the prediction and measurement are good. Both models are later used to simulate fires in a full scale train carriage. Three operation schemes of the ventilation systems are tested in the full scale fire model.