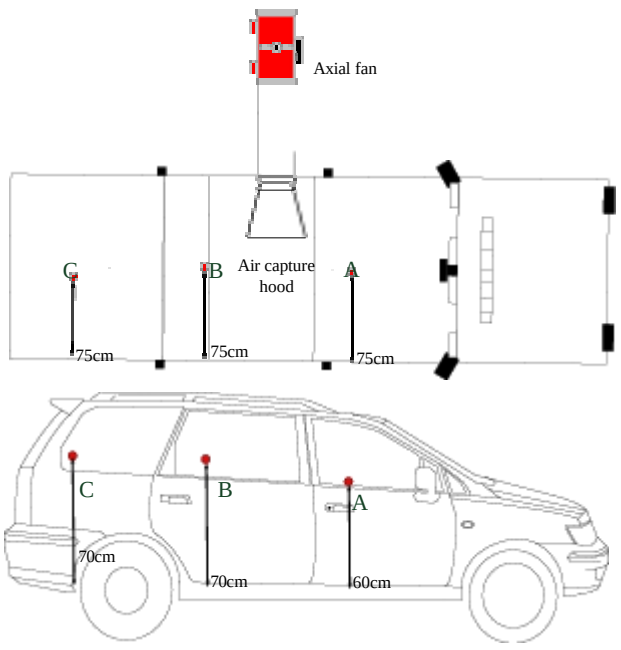
Research Highlights

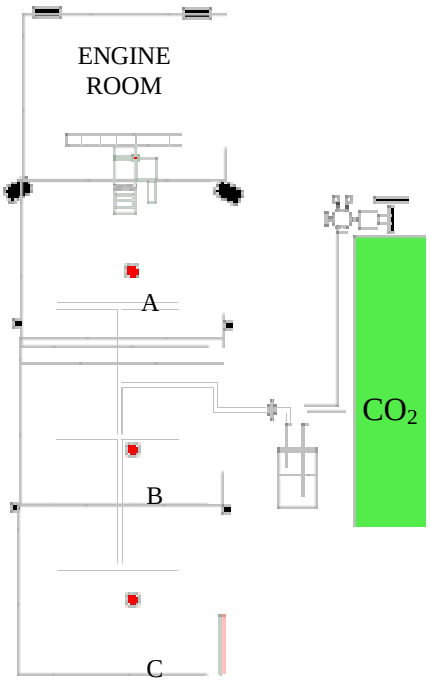
Prof. Tong-Bou Chang

JOURNAL: Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering

TOPIC: An experimental method for evaluating vehicle cabin airtightness and ventilation performance

ABSTRACT: An experimental method is proposed for evaluating the airtightness of a vehicle cabin and the ventilation effects of three components ofthe vehicle ventilation system. The measurement results are used to derive a theoretical equation to predict the total air infiltration rate of the cabin as a function of the pressure difference between the cabin interior and exterior, respectively. The validity of the predictive equation is demonstrated by means of fan pressurization experiments performed with the vehicle air-conditioning system set in the fresh air mode. It is shown that the prediction results for the total ventilation rate deviate from the experimental results by less than 10%. The infiltration ventilation effect of natural diffusion in the vehicle cabin is measured using the CO_2 tracer gas method. The ACH (air exchange rate) of the cabin is found to be 0.816 in the recirculation air mode and 3.554 in the fresh air mode.





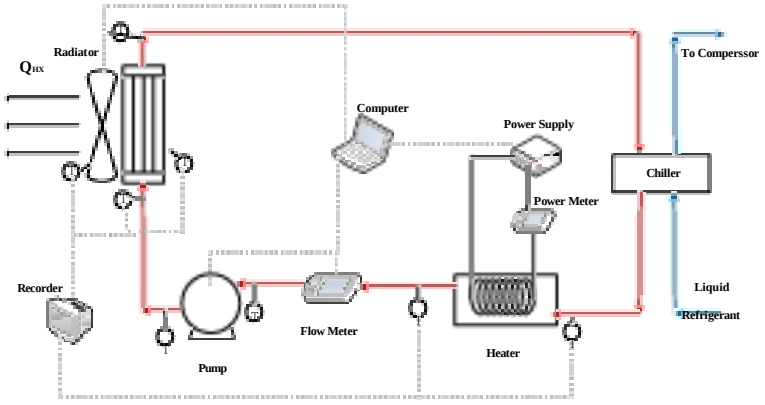
Research Highlights

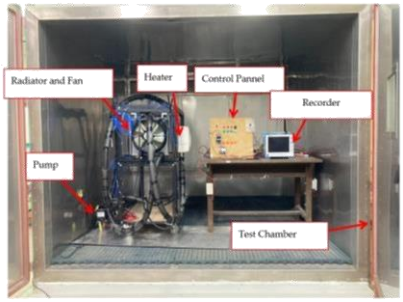
Prof. Tong-Bou Chang

JOURNAL: Sustainability

TOPIC: Development of energy-saving battery pre-cooling system for electric vehicles

ABSTRACT: The performance, lifetime, and safety of electric vehicle batteries are strongly dependent on their temperature. Consequently, effective and energy -saving battery cooling systems are required. This study proposes a secondary -loop liquid pre-cooling system which extracts heat energy from the battery and uses a fin -and-tube heat exchanger to dissipate this energy to the ambient surroundings. The liquid then passes through a chiller to complete the cooling loop. The air-conditioning system is also used to cool the battery only if the temperature of the cooling water exceeds the maximum permissible temperature. The cooling load of the air -conditioning system is thus greatly reduced. The feasibility of the proposed cooling system is demonstrated experimentally under four simulated seasonal environmental conditions, namely high summer (35 °C), mean summer (30 °C), spring and fall (20 °C), and winter (7 °C). The results show that the pre-cooling system can dissipate 1000 W of battery heat in high summer, 2000 W in low summer, 3167 W in spring and fall, and more than 4000 W in winter. In other words, the pre-cooling system greatly reduces the cooling load of the air -conditioning system, and hence significantly reduces its energy consumption.





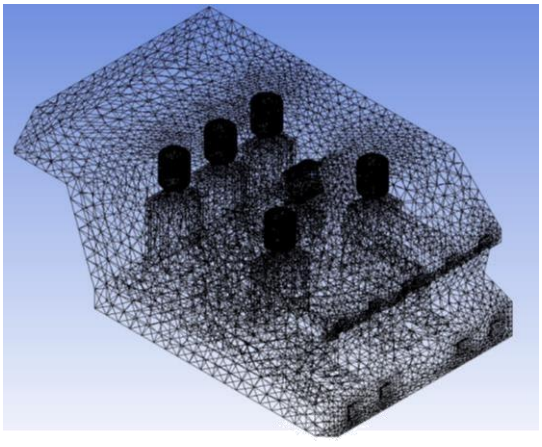
Research Highlights

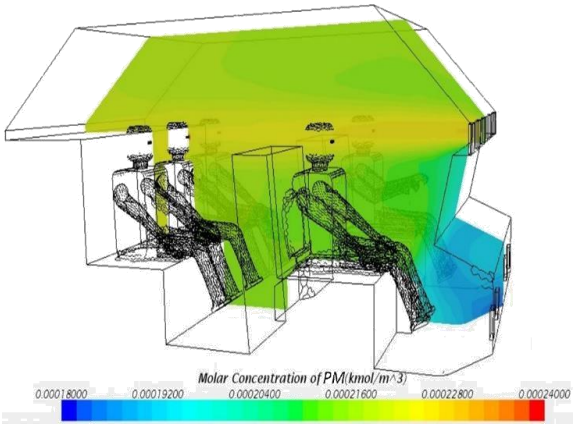
Prof. Tong-Bou Chang

JOURNAL: Atmospheric Environment

TOPIC: CFD Simulations of Effects of Recirculation Mode and Fresh Air Mode on Vehicle Cabin Indoor Air Quality

ABSTRACT: Drivers in hot and humid countries tend to operate the vehicle air conditioner system in the recirculation mode when driving. However, this causes the concentration of carbon dioxide (CO_2) in the cabin to rise sharply, potentially resulting in dizziness, drowsiness a nd other traffic safety hazards. In the fresh air mode, suspended particles and contaminants are introduced into the cabin along with the outside air, posing further health risks to the occupants. Thus, it is important to evaluate the optimal ventilation strategy for vehicle cabins. Accordingly, the present study performs computational fluid dynamics (CFD) simulations to investigate the indoor air quality (IAQ) in the cabin of a compact passenger vehicle under various ventilation / circulation modes. The validity of the CFD model is confirmed by comparing the simulation results for the IAQ in the cabin with the experimental data reported in the literatureAn air-conditioning ventilation strategy is proposed for maintaining the CO_2 concentration in the cabinbetween 1000 ppm and 2000 ppm. The feasibility of the proposed strategy is investigated for various numbers of occupants in the cabin (1, 2, and 5 people) and air filters with different filtration efficiencies of 20%, 40%, and 80%, respectively. The results show that as the number of people in the cabin increases, the frequency at which switching between the two ventilation modes is required increases. Moreover, the relative proportion of time for which the fresh air mode is needed also increases. The conc entration of suspended particles in the vehicle cabin increases as the duration of the fresh air mode increases. However, the particle concentration reduces significantly as the filtration efficiency of the air filter is increased.





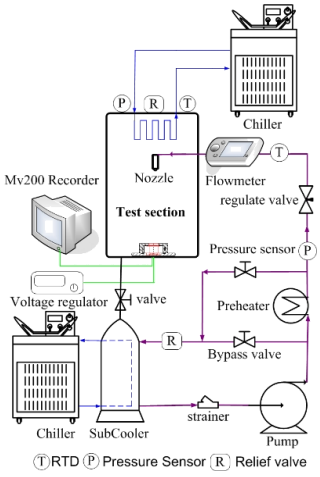
Research Highlights

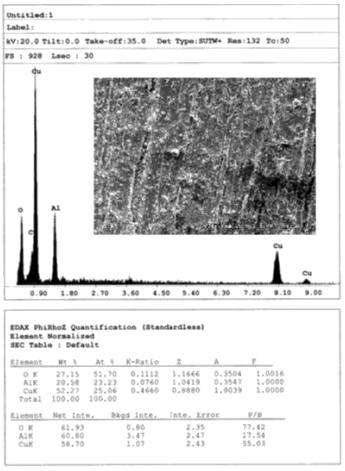
Prof. Tong-Bou Chang

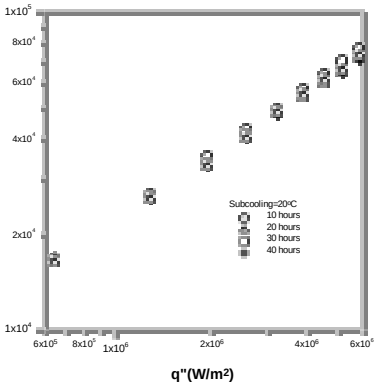
JOURNAL: Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering

TOPIC: Experimental Investigation into Spray Cooling Heat Transfer Performance of Al_2O_3-water Nanofluid with Different Subcooling Degrees

ABSTRACT: This study investigated the spray cooling heat transfer performance of Al2O3 -water nanofluid given four different subcooling degrees (0°C, 10 °C, 20 °C and 30 °C). The results showed that the subcooled nanofluids were ranked in order of a reducing spray cooling heat transfer performance as follows: 2 0 °C, 1 0 °C, 0 °C and 3 0 °C. On average, the heat transfer coefficient obtained using the nanofluid with 20°C subcooling was around 8.3 %, 8.6 % and 15.6 % higher than that obtained with 10 °C, 0 °C and 30 °C subcooling, respectively. However, the heat transfer performance decreased with an increasing spray operating time.The scanning electron microscopy observations showed that the reduction in the heat transfer coefficient was the result of a gradual increase in the thickness of the nano-adsorption layer on the heated surface as the spray operating time increased.







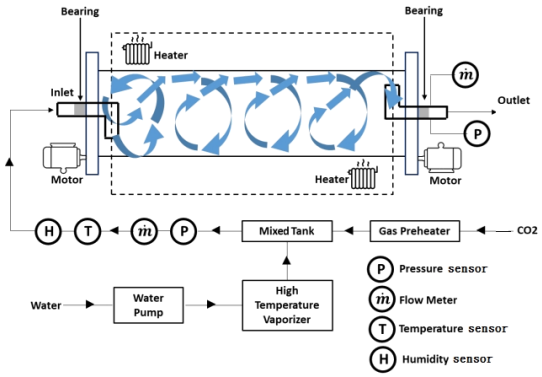
Research Highlights

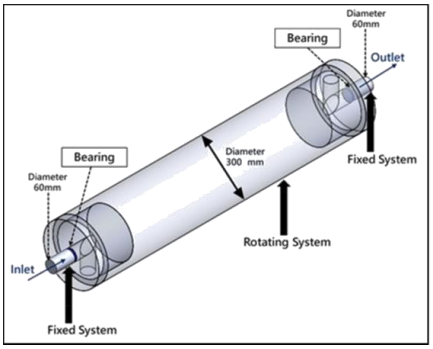
Prof. Tong-Bou Chang

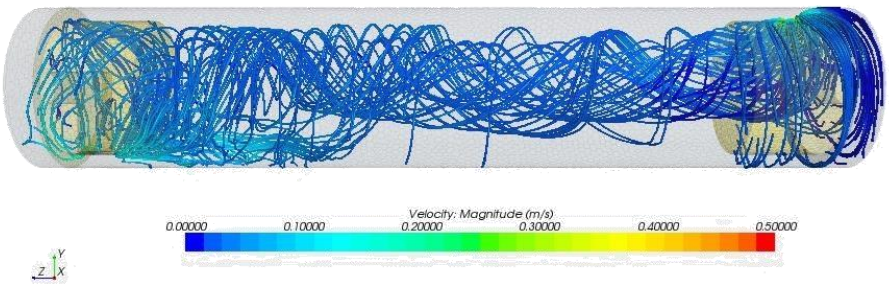
JOURNAL: Sustainability

TOPIC: Optimization of Cyclone-Type Rotary Kiln Reactor for Carbonation of BOF Slag

ABSTRACT: Mineral carbonation of the basic oxygen furnace (BOF) slag produced in the steel-making process not only provides an effective approach for carbon dioxide storage, but also stabilizes the slag such that it can be reused as a construction material. Generally speaking, carbonation performance improves as the time for which the carbon dioxide resides within the reactor increases. This research proposes a method to increase the residence time of carbon dioxide in the cyclone converter slag cabonization kiln by adjusting the inclination angle and length of the feed pipe. Therefore, it has the same effect of increasing the flow path length of the cyclone in the reactor. The optimal values of the inclination angle and length of the gas inlet tube are determined using the robust Taguchi design method. Computational fluid dynamics simulation results show that the optimized reactor design increases the average residence time of carbon dioxide gas by 60.4%, compared with the original rotating reactor design with a straight (non-cyclonic) flow path. Moreover, the experimental results show that the optimized design increases the carbon dioxide storage capacity from 12.15 g per kilogram of BOF slag in the original rotary kiln reactor to 16.00 g in the re-designed reactor.







Research Highlights

Prof. Tong-Bou Chang

JOURNAL: Energies

TOPIC: High-Efficiency HVAC System with Defog/Dehumidification Function for Electric Vehicles

ABSTRACT: Electric vehicles (EVs) generally use an electric heating system to provide heat. However, the heating system consumes a large amount of energy, and therefore reduces the mileage of the vehicle. The energy consumption can be reduced by replacing the electric heating system with a heat pump air conditioning system. Such systems achieve an effective heating of the vehicle interior, but do not provide a defog or dehumidification function. Consequently, the inside surface of the windshield tends to fog in cold weather; leading to poor driver visibility and an impaired road safety. Accordingly, the present study proposes a novel high -efficiency heating, ventilation and air conditioning (HVAC) system with both heating and defog/dehumidification functions for electric vehicles. The effectiveness of the proposed system is investigated experimentally using a simulated cabin placed in a temperature and humidity-controlled test chamber. The experimental results confirm that the HVAC system achieves the required cooling, heating and defog/dehumidification functions and meets the corresponding standards. Moreover, the application of HVAC in EVs could lead to significant electrical power saving effect.