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博 士 論 文 概 要 書

論 文 題 目

Analysis and Proposals for Advance of Automobile Air Conditioning System from the Perspective of Energy Saving and Thermal Comfort

車載用パーソナルエアコンの省エネルギー性と快適性側面からの分析と提案

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Automobile has been seen a rapid increase over the past years and has been becoming a necessary transport tool in the modern society. However, the increase of automobiles gives us a lot of problems including the energy shortage. Therefore, with the rapid development of the technology, the energy saving has been taken into account in the design of an automobile. In term of automobile air conditioning system, the low-energy consumption and high comfort has been required increasingly by the consumers. Therefore, this project aims to force the function of air conditioning systems to provide comfortable conditions for the passengers and reduce the energy consumption, especially for electric vehicle. This kind of vehicle has limited electric power when driving on the road so that the air conditioning system should consume power as little as possible. Actually, the traditional air condition system consumes plenty of electric power. When cooling system turns on, the drive distance could be shortened by one third and this number could be a half when the heating system turns on. In order to solve this problem, a new concept of personal air conditioning system is proposed in this study instead of the traditional one. This air conditioning system provides thermal comfort for each passenger individually by set under the chair. By doing this, the waste energy would be reduced at the space of no person in the cabin. In addition, the device of this system is produced by the Peltier module and fan motor that can only need lower electric power so that the saving energy can provide vehicle to drive longer.

However, the design of wind outlets in vehicle cabin plays an important role for this personal air conditioning system. If these outlets are opened the appropriate place the temperature of the cabin can be decreased quickly so that the working time of air conditioner can be cut drastically and the aim to save energy also can be easy to achieve. Hence, the thermal distribution analysis of the automobile cabin provides a useful reference for the development and design of a new air conditioner system and some other associated systems. Using the representative car of Honda Company as the model, thermal properties of the cabin are analyzed by the computational fluid dynamics (CFD) software and a new advanced personal air conditioning system has been provided to replace the traditional one.

Based on that, this thesis is summarized as the following four parts.

1. The heat flow distribution in the sealed cabin of automobile is analyzed. It is well known that the temperature of the sealed cabin tends to become increasingly high along with time, which could conduct the terrible comfortableness when passengers enter into the car after long time parking. Especially in the summer, the temperature of cabin can increase rapidly over 50 degree. The reason why cabin under sunshine is so dangerous can be expressed by the thermal flux motion attributing to the solar radiation. In this study, using the representative car of Honda Company-STEPWGN as a model, a simplified three-dimensional geometry with real dimensions is established to predict the heat flow distribution of cabin when car is parking in the summer sunshine by using the CFD analysis software. The nature convection and radiation heat transfer from environment to cabin are considered and the distribution of transient temperature and velocity at the central and horizontal plane are analyzed respectively. It is shown that the temperature increases by time and there is little temperature difference in the cabin. The highest value is located at the front and both sides cabin after two minutes. The air is essentially stagnant with low velocity and the central compartment has much lower velocity than other regions of cabin.

2. The cooling effect of the traditional air conditioning of automobile is studied numerically and experimentally. The experimental study has taken place in a stable environment. The variation of temperature of different location of cabin is tested and the energy consumption during 15 minutes is measured. The numerical study has analyzed the air flow and heat transfer characteristics inside the cabin during the cooling period. Using the representative car of Honda Company-N box as the model, the analysis enhances heat transfer between the air outlet and inlet of air conditioning. Based on the boundary conditions the same as the experiment, the governing equations are solved by an implicit time marching finite volume numerical scheme. The results are in good agreement with the available experimental and theoretical data in the literature of before. However, under save energy model the traditional air conditioning system cannot make all the

passengers feel comfortable. The rear row of cabin has still higher temperature than front row since it is difficult to carry out the thermal exchange due to the complex structure of inner cabin.

3. A personal air conditioning system is proposed and installed in the chair to instead of the traditional one to provide thermal comfort for the passengers in electric vehicle. Experiment validates that this system can make passengers feel comfortable after four minutes and all the apparatuses can just only consume electric power 338.8 W, which is less than the traditional air conditioning of cabin. However, this system cannot make all the body feel comfortable. Based on the simplified 3-D vehicle model, the thermal properties of cabin under this cooling system are simulated by CFD software. The numerical results have good agreement with the experimental recording. Except the area of chairs, the temperature of cabin has almost no change during 15 minutes. It indicates that this personal air conditioning system cannot be just only set in the chair because it cannot provide enough cooling wind to cut down the heat from ambient.

4. In order to resolve the problem that personal air conditioning system just can be local action, a new modified personal air conditioning system is proposed by adding more four wind outlets in the front of cabin, which have bigger outlets and can provide enough wind for all the passengers. Based on the simplified 3-D vehicle model, a numerical study has analyzed the air flow and heat transfer characteristics of cabin under the cooling action of this new type system during 15 minutes. The simulation results show that the front wind outlets can be well brought into play the role of cooling and put in motion the heat exchange among the air in cabin under the assist of the wind outlets on the chairs. The temperature of cabin can be dropped by about 5 degree under the condition of low energy-consumption. The results of numerical calculation are in good agreement with the anticipation of before and it indicates that this new personal air conditioning system can be used well in the future electronic vehicle