A Review on Effect of Heating through Different Duct Location inside the Car Cabin

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Abstract*-Everyday people spend much time in vehicles. Either riding or driving has become a part of our life. The last fifteen years have seen many developments in automotive glazing theory and technology. Current issues include such diverse concerns as weight reduction, safety, comfort, aesthetics, cost, recycling potential, standards and regulations, the characteristics of windshields versus side and rear glass, and the implementation of multiple functions into the glass. A comfortable thermal sensation brought on occupants contributes a lot to our life and work. On the contrast, a bad and uncomfortable thermal environment may get human ill and even risk their life. In this paper takes the interest of some real feelings about thermal comfort while riding or driving. And out of consideration for a better vehicular thermal environment this paper by using the method of literature review, trying to give readers a basic description about "what the thermal comfort in vehicles is and how to achieve a thermal comfort level.

Keyword: -Car model, thermal comfort, HVAC system, CFD etc.

I. INTRODUCTION

The agreed-upon definition of thermal comfort is "that condition of mind which expresses satisfaction with the environment" (ASHRAE 55, 1992; ISO 7730, 1994). As

Parsons (1993) points out in a chapter on the subject, this definition emphasizes the fact that thermal comfort is first and foremost a psychological phenomenon. As such, it is a classic example of the mind/body problem (i.e., how do the environmental and physiological correlates of thermal comfort translate into a cognitive evaluation?). Though this question is interesting in and of itself, most of the scientific enquiry on thermal comfort has been in applied areas, with emphasis on finding practical solutions to common problems. The objective of research has been twofold: to find an operational definition of thermal comfort that is based on quantitative measures (i.e., the environmental parameters and physiological conditions that correlate with psychological comfort), and to build models of thermal comfort that are based on that operational definition. Instead of "Why do people feel comfortable or uncomfortable?", the question has become "What environments will produce thermal comfort?" More specifically, because of variance among individuals, what environments will produce thermal comfort for the highest possible percentage of a given group of people?

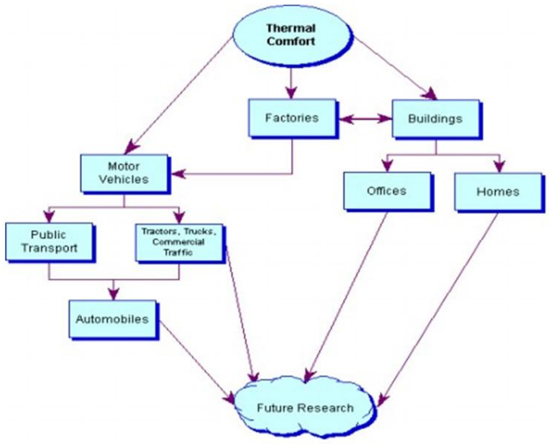

Fig 1: The historical trend in thermal comfort research.

A. HVAC System

Nowadays air conditioning system as basic standard equipment of automotive climate control has been installed in all automobile. The demand for more comfortable and luxury vehicular thermal environment has led to a promotion in vehicles thermal control. Heating, ventilating, and air conditioning system was first introduced in the early 1960s and now is available in most high-end vehicles. It is based on inventions and discoveries made by Nikolay Lvov, Michael Faraday, Willis Carrier, Reuben Trane, James Joule, William Rankine, Sadi Carnot, and many others

HVAC system is a technology of climate control in indoor building and vehicular thermal environment. It is designed for provide constant fresh air and controlling the interior temperature by cooling or heating, meanwhile meet the comfort demand of the occupants. It also plays a significant role in interior safety by clearing the fog, mist and moisture from the windshield and window. It includes three functions, namely heating, ventilation and air conditioning. These three function are interrelated and work together to provide the occupants a comfortable temperature and good air quality no matter in summer or in winter. Thermal comfort could be obtained by relying on the perfect performance of HVAC system.

II. LITERATURE REVIEW

Ajay Giri (2017) said the temperature of passenger compartment gets increased very high during summer, if a car is parked in open atmosphere for long duration. It is very uncomfortable for the passengers and driver during start of the driving. This may be fatal to life also when a child is left inside during parking due to some reason because of heat accumulation and ventilation problem. In this study, a 2-D numerical analysis of passenger compartment of a small ALTO™ car is carried out considering an inlet vent in between roof and front windshield while an outlet vent in goods cabin. Governing equations for velocity and temperature are solved numerically with CFD software (Ansys Fluent V.14.0) with SIMPLEC algorithm to find velocity and temperature distributions. A two dimensional incompressible, laminar, steady flow analysis with Boussinesq's approximation is carried out with varying inlet velocities and constant ambient temperature.

Ibrahim Reda (2017) said that the Thermal comfort in vehicle cabin can affect drivers and passenger's health, performance and comfort. Due to spatial and temporal variation of state variables and boundary conditions in the vehicle cabin, the heating, ventilating and airconditioning (HVAC) does not have to be designed to provide a uniform environment, especially because of individual differences regarding to physiological and psychological response, clothing insulation, activity, air temperature and air movement preference, etc. The main objective of this research is to study the air flow regimes and thermal comfort in vehicle cabin using computational fluid dynamics (CFD) software.

Michael Schmitt (2017) explains a thermal management concept for future intercity and long-distance vehicles is described in which the waste heat from a fuel cell system was being used for heating the cabin inlet air. To this end, various waste heat utilization concepts are created with different location of heat-exchanges and PTC-heaters and then modeled in the simulation environment Modelica/Dymola. From the obtained simulation results, a suitable waste heat utilization concept is examined in the entire vehicle.

Latiff et al. (2014) managed to lower the cabin temperature down to just 40 to 50°C by applying water mist and ventilation together. The temperature is controlled automatically by microcontroller and activated at a certain temperature. Speed of the blower is varied to study the response of temperature inside vehicle cabin. The study, however, did not measure the power consumption of the system as it is solely powered by the car battery. The excessive usage of electric source from the car battery could lead to dead battery or shorter battery life.

Sevilgen and Kilic (2013) conducted a three-dimensional transient cooling analysis of an automobile compartment under solar radiation with a virtual manikin. In the numerical simulations, the velocity and temperature distributions in the passenger compartment, as well as around the human body surfaces, were computed during transient cooling These results indicated that non- uniform temperature distributions were adopted, especially during the first 10 min of cooling. However, thermal comfort is substantially affected by solar radiation, glazing, the size of the vehicle, the clothing of the passengers, the number of passenger in the vehicle cabin, and physiological and psychological factors

Alok Singh, Sandeep Kumar. (2012). An air conditioning system must maintain an acceptable thermal comfort inside the cabin despite these changes. However, an air conditioning system inevitably uses energy, which increases automobile fuel consumption. This energy must be minimized. Therefore, an effective control procedure is needed to resolve the contradictions of low energy consumption and a pleasant driving climate for passenger as well as driver.

Jasni et al. (2012) conclude his research with air ventilation at windows, the ambient air inside vehicle cabin can be reduced up to 5.8%. The method, however, did not manage to reduce the interior surfaces' temperatures.

Chen et al. (2012) validated the predictive capability of a recently developed physiology based thermal comfort modeling tool in a realistic thermal environment of a vehicle passenger compartment. Human subject test data for thermal sensation and comfort was obtained in a climatic wind tunnel for a cross-over vehicle in a relatively warm thermal environment including solar load. A CFD/thermal model that simulates the vehicle operating conditions in the tunnel, is used to provide the necessary inputs required by the stand-alone thermal comfort tool. Comparison of the local and the overall thermal sensation and comfort levels between the human subject test and the tool's predictions shows a reasonably good agreement. The next step is to use this modeling technique in designing and developing energy-efficient HVAC systems without compromising thermal comfort of the vehicle occupants.

III. OBJECTIVE

The main objective of the paper is through the literature review of basic thermal comfort theory and HVAC system in vehicles such as car to find out how thermal comfort could be affected. At the beginning introduce the basic background of thermal comfort in vehicles. In the second part thermal models, thermal factors in cars and thermal comfort research will be given. In the third part HVAC system and HVAC problems in cars will be described. At the end give the discussion and conclusion of the research and foreground of the future.

IV. METHODOLOGY

A. Modeling

Modeling generally refers to a process in design which employs mathematical representation of model for 3D Surface of a model. There are various tools used for the modeling purpose in design industry, CATIA V5 R20 which is one of them can be used for the modeling of this research work.

B. Finite Element Analysis

The finite element analysis is a numerical method for solving problems of engineering. It is traditionally a branch of Solid Mechanics. Most common areas of interest are Heat Transfer, Structural Analysis, and Mass Transport. For the designed it is a must to compare the performance is used as CFD tool. ANSYS 15 is software used for solving a number of mathematical problems.

The results which are obtained by post analysis procedure depend on the mesh size. ANSYS Workbench provides potent, practical applications which simplifies the process of mesh generation, decreases the design cycle time, reduces the number of prototype production and testing, thus helps providing an optimum design.

The Process of Analysis is divided in following steps;

1. Pre-Processing

2. Solver

3. Post-Processing

C. Theoretical Formula For Thermal Comfort

Based on ASHRAE Standard 55, thermal comfort is defined as “that state of mind which expresses satisfaction with the thermal environment”. Thermal comfort reflects human being’s subjective sensation to surrounding thermal environment. In ASHRAE handbook of fundamentals, the heat balance equation（1） is described as:

$S = M \pm W \pm R \pm C \pm K — E — RES$ [W/m2] (1)

S – Rate of heat storage

M – Rate of metabolic heat production

W – Rate of mechanical work accomplished

R – Rate of heat exchange by radiation

C–Rate of heat exchange by convection

K– Rate of heat exchange by conduction

E – Rate of heat exchange by evaporation

RES – rate of heat exchange by respiration

From the equation we could see, the thermal comfort of human body is affected by environmental factors and personal factors. Air temperature, mean radiant temperature, air velocity and relative humidity compose the environmental factors and human body metabolic rate and cloth insulation compose the personal factors.

People produce heat during metabolism, and then heat will be exchanged with the surrounding by conduction, convection, radiation and evaporation. When the heat produced balance with heat loss, people feel comfortable and then body temperature keep at 36.5 degree. However with these factors changing, the balance happens to incline. As consequence the body temperature changes as well.

The early thermal comfort index was established based on empirical dates, statistic survey and people’s vote, but these results had its limitations. In order to find the more comprehensive thermal comfort index, Fanger stated the thermal comfort equation.

F (M, Icl, v, tmrt, ta, Pa) = 0 (2)

Where

M = metabolic rate, met

Icl = cloth index,

v = air velocity, m/s

tmrt = mean radiant temperature,

ta = ambient air temperature

Pa = vapour pressure of water in ambient air

V. RESULT

Through the basic introduction of thermal comfort theory we’ve known that thermal comfort is controlled by heat balance equation. This equation is affected by many factors which including environment factors, personal factors and some other factors as mentioned above. Any variation of these factors will influence the thermal sensation of occupants.

VI. COUNCLUSION

The present work gives a basic understanding of thermal comfort research and HVAC systems in cars. Thermal comfort is affected by six factors: air temperature, air velocity, relative humidity, mean radiation, human activity and clothing insulation. Through the measurements and analysis of thermal factors, give the defined value where thermal comfort could be reached. Meanwhile with quantitative analysis like air distribution, air quality with numerical model, could find the better way to improve the design of HVAC system. And finally get a perfect-deigned HVAC system which could bring the occupants a comfortable thermal sensation. In the future more research should be done on improving efficiency of HVAC system with the fuel economy and decreasing the local discomfort level. At the same time more standard should be set to regulate the climate control system in vehicles. More attention should be drawn on thermal comfort in transportation system.

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