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TECHNOLOGY**
**NUMERICAL SIMULATION BY USING ANOVA ANALYSIS FOR THERMAL
COMFORT IN CAR**

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ABSTRACT

A car will be selected depends upon the majority of occupants. Then on the basis of that factors and levels are decided. Factors are those characteristics which really affects our observation. Levels are the different value for a single characteristic. Main concern of author is to check the pattern of velocity and thermal comfort of the hatchback vehicle in summer condition. Major problem in hatchback cars is less cooling, mainly at the back seat. If the temperature of cabin is higher than a range of comfort, it is not good for occupant's health. It also diminishes the interior of car like dashboard material because of high temperature from a certain limit. So in this thesis, work will perform to optimize the different factors of cabin and control temperature in thermal comfort range. A CAD file will be generated and save in STP format. A Car cabin will generate by taking the dimension of car's cabin only. Vents will also be in position as it is placed originally. After obtaining the parameters on which formers have been worked. Simulation will be accomplished by the help of ANSYS Fluent software. Simulation process is completed by providing the boundary condition in the form of different cases. Model equation will be generated for output parameters.

KEYWORDS: (Anova analysis.).

INTRODUCTION

Thermal comfort^l is defined by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) as —the state of mind that expresses satisfaction with the surrounding environment^l. [17] No of indices are available for the formulation of comfort. But one of the common indices is PMV model. Predicted mean value is expectable to +0.5 to -0.5. Vehicular climate is very transient in nature so it is really a complex task to find thermal comfort because there are mainly six factors which is as follows:

Air temperature

Air temperature of car cabin is different for summer and winter. According to ASHRAE standard 55 it is clear that temperature difference between head and ankle is 3oC. This is allowable temperature for human body to achieve complete thermal comfort. This is opposite of building's. air temperature pattern. In buildings generally temperature is increases from floor to roof. Air temperature in car is generally measure by sensors.

Air velocity

In this study the air flow or air velocity is measured by the help of anemometer. Actually air flow is only a matter of sensation. Means it varies from person to person and it also depends on body part like whether the body part is sensitive or not. Air velocity is generally observed in a range of 0.8- 2.8 m/s.

Mean radiant temperature

Mean radiant temperature is the average temperature of all objects which surrounds the body. When the temperature of object is lesser than surrounding, then MRT is positive and negative in opposite case. MRT can be calculated when the position of object is known and their temperature also should be known.

Human activity

Metabolism is related to the human activity. When any activity is going to be performed then it will change the metabolic rate. Metabolic rate is measured in MET

1MET = 58.15W/m² body surface.

Metabolic rate is always changes according to our activity. For example -

In jogging metabolic rate is 8MET approx.

In sitting metabolic rate is 1MET app.

Air humidity

ASHRAE Standard 55 defines relative humidity as the ratio of the partial pressure of water vapors in a gaseous mixture of air and water vapour to the saturated vapour pressure of water at a prescribed temperature .There is a relation between temperature and humidity is as the temperature is falling down humidity will increase. In vehicle humidity is same at every point. So humidity is measured at one point and it will be same at every point in vehicle cabin.

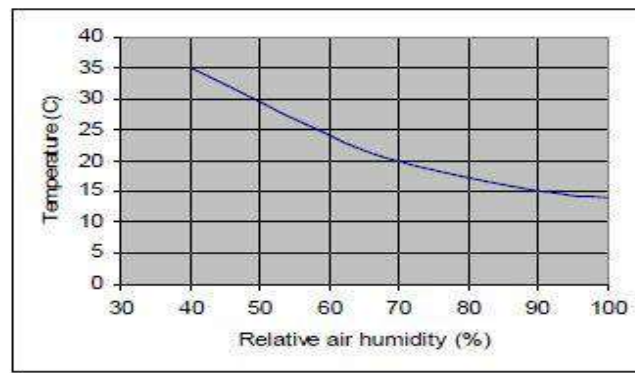


Figure:-Relation between temperature and humidity

Clothing Insulation

Insulation of clothing is also different cloth. Measurement of this parameter is in Clo.

1 Clo = 0.155 m² oC/W

To find the total insulation we will add Clo values of all.

MODELING

Finite volume method

In FVM, domain is discretizing only on volume basis. Volume should be same for each element in whole domain. In simulation, for every finite volume governing equation is to be applied and equations will numerically solve. Mainly three governing equation is applied for numerical analysis in simulation which are conservation of mass, momentum and energy.

FVM has an advantage over FEM and FDM is that this can be applied on unstructured mess. FVM are of two types, it deals with two methods.

First one is =cell centered and another one is =vertex centered* or =nodal point*.

Cell-Centered Methods

The dependent variable Q in equation is to be solved for at node 5 which is located at the center of the element, and hence the scheme is referd to as a cell-centered scheme.



Figure :- Diagram of cell centered methods

Vertex Centered Method

In this approach the dependent variable C is evaluated at the vertices like m, j etc. So this approach is known as vertex centered scheme.

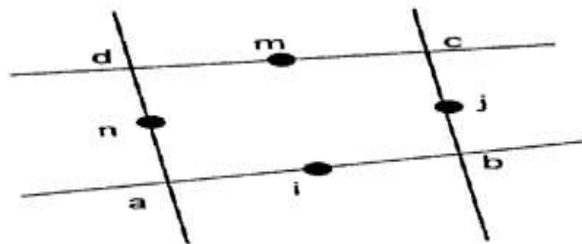


Figure :- Diagram of vertex centered method

METHODOLOGY

Next step is to provide boundary condition to domain. Boundary condition plays an important role in obtaining accurate result for example inlet/outlet, free stream temperature, convection, initial temperature etc. In our study, car is considered south facing because radiation effects also have to examine. Simulation was performed for one hour. A Result contains various plots, contours and data which we will get from transient simulation. In our paper, ANSYS FLUENT software is used for the simulation purpose. In fluent, first step is that we have design domain of car cabin in design modular software or you have choice to import the file in Fluent.

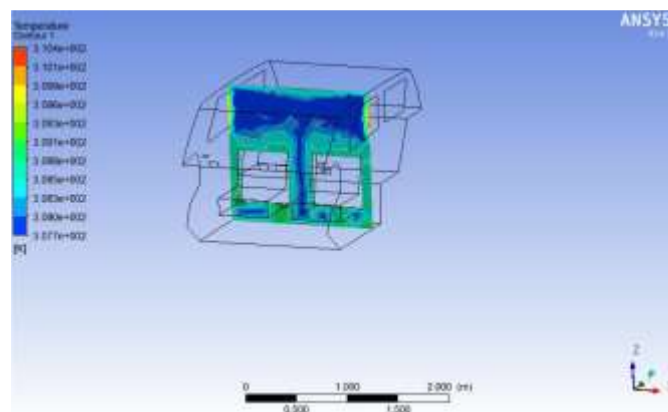


Figure :-Temperature contour

To perform any research or study on any topic literature review is essential so that we will get variable that we have to use or how much variables have been used till now. To do that problem statement or objective must be clear to the researcher.

After getting the main influencing variable, design of experiment technique was applied to find the orthogonal array. Orthogonal array is that which has sampling cases for our selected parameter. Orthogonal array was developed by Taguchi method. The cases were simulated in ANSYS Fluent.

ANOVA Analysis

Results got from simulation is now used to get some significance with input parameter ANOVA is used to know that which case is best and which the worse. ANOVA also helps in finding the more crucial factor among the chosen and which level is best for particular factor.

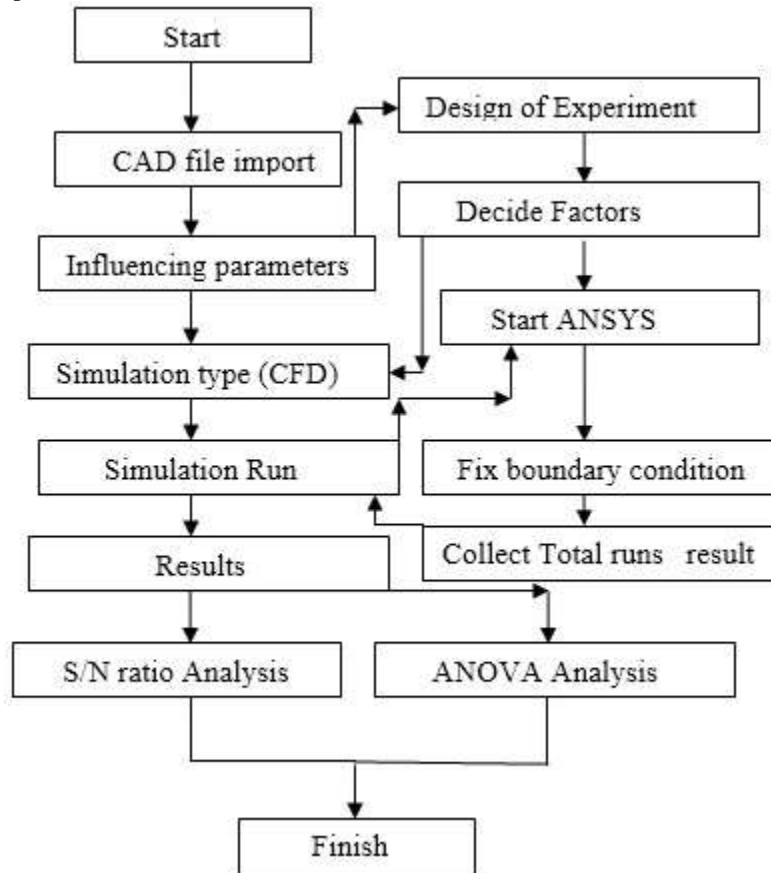


Figure :-Simulation flow chart

Factors	Levels		
1.Air velocity	<u>1.5</u>	<u>2</u>	<u>2.5</u>
2.Air temperature	<u>18</u>	<u>20</u>	<u>22</u>
3.Vane angle	<u>-6</u>	<u>0</u>	<u>+6</u>
4.Glass transmissivity	<u>0.5</u>	<u>0.7</u>	<u>0.9</u>
5.Inlet position	<u>1</u>	<u>2</u>	<u>3</u>

Table :- Table of Factors and level:

Air velocity factor has three values of velocity of Air-conditioner vents of car cabin. Values of air velocity are in m/s. Temperature of air is opted in three levels in oC. Vane angle are also adjusted in three condition, in first case all front

vents are aiming air on front seats only specifically on the passenger chest. In Second case no direction is given to vent's grill and third case is just opposite of first.

CONCLUSION AND FUTURE SCOPE

Objective of this paper is to increase thermal comfort of hatchback car cabin. Thermal comfort can be change by various parameters such as air velocity, air temperature, humidity and many more. Taguchi method is used to form an orthogonal array from different factors and levels. So Taguchi gives 27 cases. By the help of experimental design no of cases were obtain than with the help regression relation between parameter found.

Ranking of input parameter:

Level	A	B	C	D	E
1	-4.647	-4.611	-4.554	-4.620	-4.593
2	-4.633	-4.607	-4.652	-4.622	-4.545
3	-4.569	-4.632	-4.643	-4.607	-4.711
Delta	0.077	0.025	0.098	0.015	0.165
rank	3	5	2	5	1

Table :- Ranking of parameters

From the above table it is concluded that Factor E is the most manipulating factor. After than C is the main factor that means the vane angle. To achieve better thermal comfort these factor plays important role.

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