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NUMERICAL SIMULATION AND OPTIMIZATION FOR THERMAL COMFORT IN CAR

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ABSTRACT

To find the most manipulating factors in this paper, steps are to be followed to get the substantial results. A quality review has been performed in this paper so that researcher gets the clue about related parameters, boundary condition which was used in previous papers or by former researchers. By the time review will complete, outline is form about all the researches like about their outcomes, shortcomings of study and about future scope in every work. After this work will be start in the direction to give better solution. A car will be selected depends upon the majority of occupants. 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. 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. 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. Digital Anemometer or wind meter is a small in size easy to use device.

KEYWORDS: (Taguchi method, Anova analysis.).

INTRODUCTION

Today vehicles are like our necessity in life. Most of the people of metro cities spend minimum 2-4 hour daily in their car. So people want better thermal comfort. Nowadays companies start focusing on customer choice. Vehicular cabin climate is adjusted by making changes in dry bulb temperature. It depends upon person that in which range person feels thermally comfort. This temperature range is always deviate from person to person. Every person has different metabolic rate so range of thermal comfort diverges person to person and it also depend upon clothing of people. If more powerful air-conditioner is applied then it affects the car performance means it lessen the average of vehicle. Air-conditioner will be applied in a limit.

Thermal comfort is depending upon capacity of air conditioner, air velocity in car cabin, Air temperature, humidity and air flow distribution. So, first thing is capacity of air conditioner that will not be altered to higher value because AC is one and the only thing which consumes more power than other equipment. If large air conditioner is applied it will not be economical also. This is not the optimal solution for increasing thermal comfort. Air temperature can be decreased to improve thermal comfort but in this case size or capacity of air-conditioner will increase, ultimately this will increase cost. Humidity is that factor which has more weightage in vehicular climate. It was shown by Ali Alahmer [4] that by changing the relative humidity in summer or winter, thermal comfort range can obtain faster. Joel M. Devonshire [16] shows that by applying IRR (infrared reflective film) you can also decrease energy consumption of air conditioner. Last parameter is air flow distribution in which the pattern of air flow will be analyzed. In hatchback cars always there is a complaint of uneven cooling means cooling at front seat is good but very less cooling at back seat. Generally after an hour you feel some cooling at back. So there is need of optimal solution which is not too costly and also economic with respect to kilometer per liter. In this study of air pattern conclusion can be drawn that if there

is any A.C. vent will also present for back seat. Thermal comfort is also relying on Glass transmissivity of window glass in car cabin.

Measuring Instruments
Digital Anemometer or wind meter is a small in size easy to use device. Anemometer consists of digital meter and vane wheel which is used to measure flow of any fluid generally air or gases. Vanes of vane will move proportional to the air which is flowing in front of vane wheel. It is also helpful in measuring temperature. Proximity switch is used in this device to sense velocity and the rotational direction of velocity. To construct a car cabin CAD file, accurate measurement has been taken. Measuring tape has used for measurement, care must be taken while measuring so that inside volume of car cabin as a result of that simulations will be accurate.

Taguchi Method
After the Second World War, the allied forces found that the quality of the Japanese telephone system was extremely poor and totally unsuitable for long-term communication purposes. To improve the system the allied command recommended establishing research facilities in order to develop a new communication system. The Japanese founded the Electrical Communication Laboratories (ECL) with Dr. Genichi Taguchi in charge of improving the R&D productivity and enhancing product quality. He observed that a great deal of time and money was expended on engineering experimentation and testing. Little emphasis was given to the process of creative brainstorming to minimize the expenditure of resources. He noticed that poor quality cannot be improved by the process of inspection, screening and salvaging. No amount of inspection can put quality back into the product. Therefore, he believed that quality concepts should be based upon, and developed around, the philosophy of prevention. The concept is Quality should be designed into the product and not inspected into it.

Taguchi viewed quality improvement as an ongoing effort. He continually strived to reduce the variation around the target value. The first step towards improving quality is to achieve the population distribution as close to the target value as possible. To accomplish this, Taguchi designed experiments using especially constructed tables known as ―Orthogonal Arrays‖ (OA). The use of these tables makes the design of experiments very easy and consistent.
The Taguchi Method is applied in four steps.

1. Brainstorm the quality characteristics and design parameters important to the product/process.
2. Design and conduct the experiments.
3. Analyze the results to determine the optimum conditions.
4. Run a confirmatory test using the optimum conditions.

Since we are knowledgeable enough to be designing the system in the first place, we generally will have some understanding of the fundamental processes inherent in that system. Basically, we use this knowledge to make our experiments more efficient. We can skip all the extra effort that might have gone in to investigating interactions. Without going into the details, it has been shown that this can decrease the level of effort by a factor of ten or twenty and sometimes much more. Another distinction of Taguchi methods is the recognition that there are variables that are under our control and variables that are not under our control. In Taguchi terms, these are called Control Factors and Noise Factors, respectively. Taguchi started to develop new methods to optimize the process of engineering experimentation. He believed that the best way to improve quality was to design and build it into the product. He developed the techniques which are now known as Taguchi Methods. The Taguchi method (Tm) is a powerful problem solving technique for improving process performance, yield and 8 Productivity. It reduces scrap rates, rework costs and manufacturing costs due to excessive variability in processes.The process of performing a Taguchi experiment follows a number of distinct steps:-
Step1: Formulation of the problem – the success of any experiment is dependent on a full understanding of the nature of the problem.
Step 2: Identification of the output performance characteristics most relevant to the problem.
Step 3: Identification of control factors, noise factors and signal factors (if any).Control factors are those which can be controlled under normal production conditions. Noise factors are those which are either too difficult or too expensive to control under normal production conditions. Signal factors are those which affect the mean performance of the process.
Step 4: Selection of factor and levels.

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Step 5: Design of an appropriate orthogonal array (OA).
Step 6: Preparation of the experiment.
Step 7: Running of the experiment with appropriate data collection.
Step 8: Statistical analysis and interpretation of experimental results.
Step 9: Undertaking a confirmatory run of the experiment

MODELING

Cad Modeling

CAD file is generated with the help of inventor software and save in STP format for further use in Fluent.

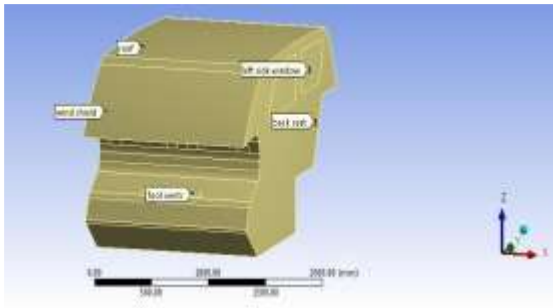

Figure:- CAD file of swift car

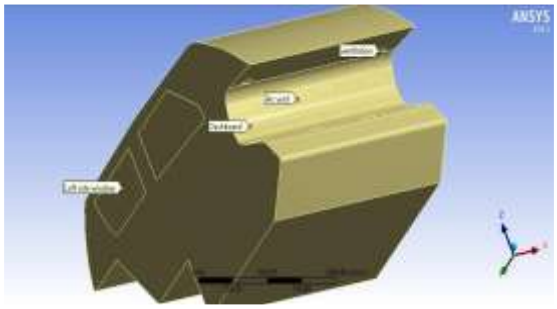

Figure :- CAD file of swift car

Cfd Modeling

Computational fluid dynamics (CFD) is the science of predicting fluid flow, heat transfer, mass transfer, chemical reactions, and related phenomena by solving the mathematical equations which govern these processes using a numerical process. In this thesis, fluent is use and it is based on FVM. FVM is generally use for fluid and complex problem. FEM is method in which whole domain is divided in small element of finite size so that complex domain can be solved. CFD domain of car cabin that is used in this thesis is of Maruti Swift. Schematic diagram of domain is shown as under:

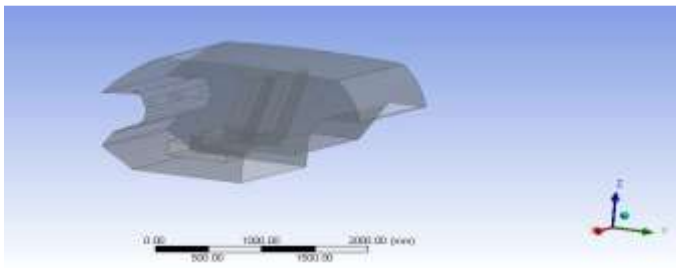

Figure:- Schematic diagram of domain

This domain has four front vents, two is for foot. These vents are for air-conditioner or for the heater. Two outlet vents is also available for ventilation. In this domain various combination of air velocity and air temperature has been simulated. A numerical analysis has been executed over this domain by changing the different boundary conditions for two ventilation vents (outlet vents) and six AC vents (inlet vents). Sampling method has been used i.e. Taguchi method. Detection of significant relation between input and output parameter analysis of variance was used.

METHODOLOGY

In our thesis, 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 shows the CAD file of cabin.Then meshing process will start means discretization of whole domain in small definite volume. Mesh quality must be good to get good results from simulation because as no of cells increases governing equation are applied on more cell than before. So, resolution of result is good if meshing is good. In meshing process we have also used face sizing for four vents present in cabin. To get good results you have to remember that the smallest element in domain must be divided minimum by three to four times.

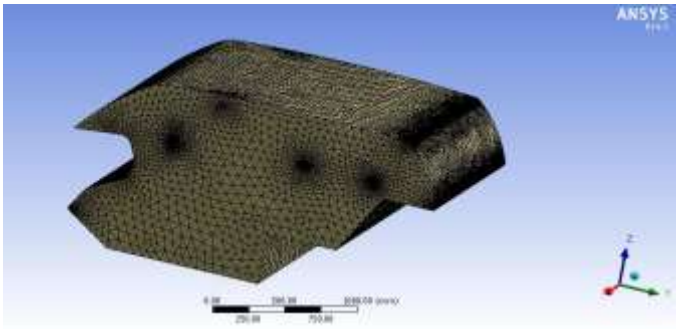

Figure:- Meshing in domain

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.

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