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REVIEW ON AC DUCT PERFORMANCE BASED ON CAE TOOL (ANSYS)

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Abstract

Air Conditioning ducts are the actual transporters of conditioned air from one location to another location. Hence the performance of ducts is the important issue in systems. Some of the ducts are circular in cross sections, while some are of rectangular cross section. both are versatile used. But the performance testing methodologies are rare, out of them CAE tool method is most efficient and active method. Behavior of fluid can be understood with this tools easily.

Most of the researchers have focused on manual performance testing, whereas the CAE tools are also most effective and active method available. It does not mean that complete negligence accorded with CAE tool method. Some of the researchers have concentrated on CAE tools too.

The importance of CAE tools for AC duct performance testing found reliable in most of the review study. We can consider CAE tools are a cheap and active method available now a days for performance testing of AC duct. In this paper literature available on AC duct performance and other parameters are reviewed and further conclusion were drawn.

Keywords: CAE Tools, Performance testing, fluid, AC duct

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1. INTRODUCTION TO AC DUCT.

Ducts are conduits or passages used in heating, ventilation, and air conditioning (HVAC) to deliver and remove air. The needed airflows include, for example, supply air, return air, and exhaust air. Ducts commonly also deliver ventilation air as part of the supply air. As such, air ducts are one method of ensuring acceptable indoor air quality as well as thermal comfort.

A duct system is also called ductwork. Planning (laying out), sizing, optimizing, detailing, and finding the pressure losses through a duct system is called duct design.

AC ducts are one of the most important systems at home, and if the ducts are poorly sealed or insulated they are likely contributing to higher energy bills.

AC duct system is a branching network of tubes in the walls, floors, and ceilings; it carries the air from your home's furnace and central air conditioner to each room. Ducts that leak heated air into unheated spaces can add hundreds of maximum heating and cooling bills, but we can reduce that loss by sealing and insulating your ducts. Hence the performance and efficiency can be improved with this process. Quality of outlet air is also improves. hence it is one of the important task.

1.1 Types of Duct.

a) Flexible Ductwork

Flexible ducts are typically tube-shaped, made of a wire coil covered with a bendable, durable plastic, and surrounded by insulation. This kind of ducting is best in tricky spaces where rigid ducts are just not possible to install, or used to attach non-flexible ductwork to an air supply outlet. Like most central air conditioning parts, flexible ducts have specific installation requirements. For example, flexible ductwork needs to be secured and supported properly, ensuring little sagging or snaking. Kinks, bends, and turns also need to be minimized – these reduce air flow and could hamper the efficiency and effectiveness of the air conditioner. The advantages of flexible ducts are that they are fairly quick and easy to install, and often cost less than rigid ductwork.

b) Rigid Ductwork

They come in a variety of materials and sizes, and can be either cylindrical or rectangular. They are also often insulated. They are hardy, enduring, and reliable. The most common types of rigid ductwork are:

Sheet metal ducts. Galvanized steel and aluminum are the most common materials for sheet metal ducts. Aluminum in particular is relatively light and easy to install.

Fiberglass lined ducts. These are sheet metal ducts (like those described above) that have internal or external fiberglass lining. This type of duct is common in office and commercial buildings, as it dampens the sound of the air conditioner unit.

Fiberboard ducts. Fiberboard is made from fiberglass strands that have been compressed and bonded with a resin, and then covered with a sheet of foil laminate to protect them from moisture. This type of duct is good for cooling and heating systems because it is well insulated by itself.

1.2 Materials for AC duct.

- Galvanized stee
- Aluminium (Al)
- Polyurethane and phenolic insulation panels (pre-insulated air ducts)
- Fiberglass duct board (preinsulated non-metallic ductwork)

2. LITERATURE SURVEY

Following literatures are reviewed for study of AC duct.

2.1 Survey/ Review

Arlan Burdick have written in his advance strategy guidelines for AC duct design, "This strategy guideline discusses the information needed to design the air distribution system to deliver the proper amount of conditioned air to a space. Heating and cooling loads are dependent upon the building location, sighting, and the construction of the house, whereas the equipment selection and the air distribution design are dependent upon the loads and each other. [1]

A. Bejan1 and C. L. Tien2: This technical note develops an analytical result for heat transfer by laminar free convection in a long horizontal parallel-plate channel connecting two reservoirs containing the same fluid but kept at different temperatures. The analysis is based on the integral method. The Nusselt number result is presented in chart form in terms of the Rayleigh number based on height, Ra, and the height/length aspect ratio, h/L. Elsewhere in this issue have discussed the free convection heat transfer mechanism in a rectangular horizontal enclosure with the long boundaries insulated and the two vertical end-walls maintained at different temperatures. The purpose of this brief technical note is to cast some light on a related phenomenon which occurs in a slightly different geometry, namely, a long horizontal duct connecting two reservoirs which contain the same fluid but are at different temperatures. [2]

R. Bontempo∗, M. Manna: This paper completes the work presented in the companion paper [Bontempo et al., Appl. Ocean Res., 58(2016) 322–330] by presenting the investigation of the flow around a propeller ducted with a so-calledaccelerating duct. To this aim, both the axial momentum theory and a nonlinear actuator disk methodare used. The straightforward application of the first approach reveals that if the duct and rotor thrustsare concordant, then a beneficial effect on the propulsive efficiency can be readily obtained by enclosinga propeller in an accelerating duct. When the more advanced nonliner actuator disk method is appliedto verify the outcomes of the axial momentum theory additional information on the performance of the device are obtained. [3]

Riccardo Mereu: A preliminary numerical study of the fluid dynamic behavior of flat and ribbed square duct is presented. Fluid dynamics of two configurations is analyzed via Reynolds Averaged Navier Stokes (RANS) modeling in order to underline the main characteristics of each configuration and to give some information at global and local level. This kind of modeling is used as base for setting up a more detailed analysis such as Direct Numerical Simulation (DNS). Flat and ribbed square duct with a Reynolds number based on bulk velocity and hydraulic diameter of 10320 (Re□=600 for the flat configuration) are analyzed and the results of the flat configuration are compared with available results obtained via DNS approach. The ribbed square duct is characterized by a two-pass configuration (aligned ribs in the top and bottom walls), with the duct height about six times the height of the obstacles for a blockage ratio of about 30%. Finally a pitch ratio (rib spacing to rib height) of 10 is used in order to obtain a k-type roughness permitting the flow to reattach before the next obstacle. [4]

Bradley S. Hurak: In his study, a computational fluid dynamic analysis was performed to investigate the effect of the physical configuration of inlet and outlet vents on the temperature and flow patterns inside a room modeled for simplicity as a two dimensional enclosure. It was determined that for use in both heating and cooling of a room, a low or floor located inlet vent coupled with an outlet that is positioned on the upper half of a wall yields the most desirable results in reaching, or nearly reaching, comfort conditions in the shortest amount of time. However, if either heating or cooling is expected to be the primary energy consumption, it may be advantageous to deviate from this configuration. [5]

W. S. Tseng: In his study the secondary flow in the duct is visualized and the steady and transient thermal characteristics of the flow are examined by measuring the spanwise distributions of the time-average temperature. The effects of the Reynolds and Grashof numbers on the vortex flow structure are studied in detail. Moreover, the spanwise-averaged Nusselt numbers for the horizontal rectangular and tapering ducts are also measured and compared. Furthermore, the time records of the air temperature are obtained to further detect the temporal stability of the flow. [6]

Charisis G. Vrellas: The purpose of his study is to describe and categorize calculation methods for conducting a complete air conditioning study. More specifically, his paper is a general review of cooling loads calculation methods, psychrometric calculations for installing a central air conditioning unit, ways of fan coil units connection and air duct calculation methods. A study was based on two pillars: a dissertation for an industrial facility and technical information found after methodical research. [7]

S.J. Wright, D. Dixon-Hardy, P.J. Heggs: This study describes how the aircraft's air-conditioning system functions, such as those on the A320 including the components within the system. The need for an air-conditioning system requirement is explained, including the use of external air flow from outside to act as a cooling source (known in technical aviation terms as "ram" air). The A320 electronic controls are included in addition to the flight deck selections under normal operations and when the needs for higher levels of ventilation are required. This study addresses the failures of the ECS due to fouling, identifies the potential sources of fouling and operational measures that may effect this safety critical systems operation. [8]

SumeshPillai: In today's world air conditioning is almost used everywhere for the sake of human comfort but this comfort was affected by various other parameters like airflow and

temperature distribution. This Study focuses on the review of numerical and experimental study of the temperature distribution and air flow in air-conditioning system with varying human load using the simulation software named computational fluid dynamics (CFD). [9]

IkpeAniekanEssienubong: In this study, hand calculation and computer simulation was used to determine the pressure loses in air duct flow system for velocity of 5m/s, 10m/s, 20m/s and 40m/s and the results were compared to determine their accuracies. Total maximum pressure was recorded at inlet, while least pressure was observed at outlet. The pressure losses for both hand, and computer simulation increased proportionally to the velocity. Also, both pressures lose obtained from the hand calculation and simulation almost maintained the same pattern and direction. But for purpose of accuracy and fast computation, simulation is preferable. [10]

MukeshDidwania: This test case was calculated using a commercial finite volume CFD computer code ANSYS 12.0 Fluent. This test case focuses on the use of approximate models such as the turbulence models to predict the physical characteristics of the turbulent flow around a 90° bend. The results from the more sophisticated Reynolds stress model are shown to better capture the anisotropy behavior of the flow in contrast to the standard k-ε model that assumes isotropy in its original model formulation and also k-w SST model use to comparison. Finite Volume Discretization (FVM) is employed to approximate the governing equation. Velocity and pressure distribution at bend show by simulation of fluent CFD Code. By increasing the bend length in duct, losses can be reduce. [11]

JaharSarkar: Creating suitable thermal conditions for satisfying human desires, the thermal comfort has been recognized to be an essential requirement of the indoor environment. Thermal comfort is related to temperature and airflow distributions in air conditioning space, which play an important role in optimum design of air-conditioning system or ventilation system. No such general CFD model can be applicable for airflow and temperature distribution in room due to the suitability of turbulent models are dependent on application, operating conditions and other factors. The main aim of the present study is to investigate the airflow and temperature distribution of air-conditioning space. [12]

G.SUDHAKAR: In this study CFD is used to understand it compared to advantages of duct and diffuser system which aids in good amount of understanding flow behaviors inside the car cabin. Useful help in future modification to establish a optimum design to the climate control system in automobiles. [13]

S. Ibrahim: In this research, the air conditioning inside vehicle cabin is analyzed. The objective of the research is to develop an air depression design inside the top surfaces of the rear cabin. The optimal flow of air inside cabin increases the thermal comfort of the vehicle. The proposed cabin depression design inside the rear top surfaces areanalyzed under thermal variation and airflow circulation inside the cabin. The Ansys fluent tool is utilized in this study to evaluate the variation of air flow and the temperature inside the passenger vehicle cabin respectively. From the research analysis, the proposed evaluation of the depression design is more optimal for air conditioning in budgetary small passenger vehicles. [14]

2.2 Literature Observations

- CFD Tool is one of the most important tool for study of AC duct performance.
- Researchers have focused on quality and quantity o air supplied at the end of AC duct.
- CAE tools are more accurate and cheap method to check performance of AC duct.
- Researchers have also focused on manual methods of AC duct performance.
- Sealing of AC duct in order to avoid losses is also important parameter which is discussed by researchers.

2.3 Outcomes from Literature survey.

- We can use CAE tools for AC duct performance checking.
- CFD analysis can gives us point to point behavior of air in a duct.
- More concentration is needed on Finite Volume Method (FVM) to understand the losses through duct.
- Circular and rectangular ducts can be analyzed with same effect.

3. .METHODOLOGY ADOPTED FOR PERFORMANCE TEST.

Finite Volume Method (FVM) is the main methodology for the conduction of virtual test through the AC duct. Descritisation is the important step to perform CFD analysis. Hence the meshing is done by considering different curved areas. Whereas CFD (Computational Fluid Dynamic) analysis is done in three steps of CAE analysis which are as follows.

1. Pre-Processor.
2. Processor.
3. Post-processor.

CAD model of a AC duct is to be imported into CAE tool like ANSYS Fluent. Inlet pressure, velocity and temperature is to be assigned before. proper material properties are also to be assigned to the duct and air.

Experiment can be conducted virtually with the help of CFD software by setting proper boundary conditions.

3.1 Parameters in Consideration.

Following are the parameters, which are to be considered for analysis.

- Inlet velocity, pressure and temperature.
- Air and Duct material properties.
- Type of flow at inlet.
- Atmospheric temperature.

4. CONCLUSION

CFD tools are found most efficient tools to check performance of a AC duct. Researchers are also focusing on this area which provide easy steps to perform analysis. We can also simulate the flow conditions which gives us extra dimension for study.

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