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Flow Analysis of Car AC Duct to Find Temperature, Velocity and Pressure Difference

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Abstract: *Car AC ducts are consisting of two types of cross sections, rectangular and circular. Their performance also varies with the type of duct used. In most of the cases sharp turnings are avoided so as to avoid direct contact with duct inner surface. At some places the conditioned air flow also regulated with the help of duct wings. These types of conditions affect the performance of the duct. Rectangular AC duct is commonly used and well-known type of ducting system which is implemented for the transport of conditioned air. These are cost effective and sophisticated ducting systems. At many places we find the cross section of duct decreases gradually which may affect the air flow inside the duct. It may be done intentionally to control flow inside the duct. But if it is not, then the study of their effects on the flow must be done.*

Hence it is found that the study of air behavior in AC duct is very important to know the nature of air flow in duct. There are several methods are available to simulate air flow in AC duct. But the CFD analysis method is one of the best and simple method which gives us more approximate results.

In this project CFD analysis of Car AC duct is performed for efficiency test. Pressure, velocity and temperature counters can explain the change in behavior of flow. Also coated duct is analyzed with CFD tool. Further conclusion will be drawn according to results obtained..

Keywords: CFD Tool, AC Duct.

I. INTRODUCTION

An automotive air duct is assembled in your car for heating, air conditioning and ventilating your vehicle. Flaps and walls isolate two chambers of an air duct in automobiles. Vehicles have a climate control system to maintain temperature inside the vehicle. Automobiles include heating, ventilating and air conditioning (hvAC) assembly for air handling in climate control system. This assembly consists of ducts and vents to control the flow of air in and out of the vehicle.

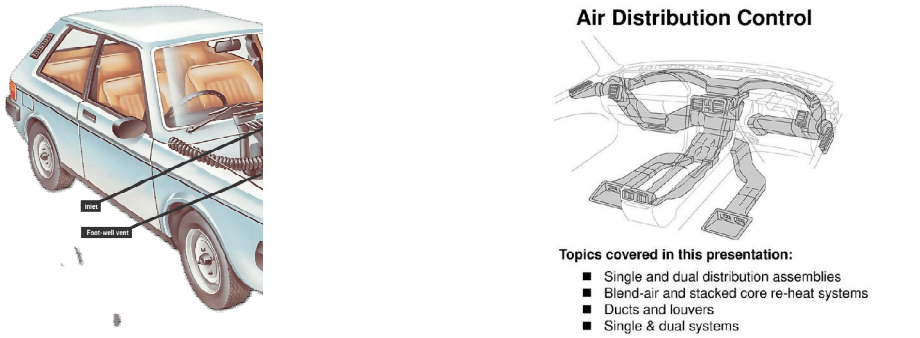

Fig. 1.1: Car Air Conditioning System

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An air duct is functionally responsible for controlling transfer of air flow into and out of the occupant compartment of automobiles. Additionally, the air duct is also designed to reduce noise or vibration to a minimum. There are two types of air ducts: conventional air duct and twinsheet thermoformed air duct. Conventional air ducts are made of solid material due to which they tend to occupy a lot more space in cars and uses a lot of thermal energy. Twin sheet thermoformed air ducts are the most advanced ducts in the automotive industry.

We all love the ultimate chill blasting from the car's vents, especially when we have to survive from the hot and humid climate. When the car AC is turned on and it emits cool and refreshing air, the whole travelling becomes easy and relish. However, believe it or not, no car comes with an ice machine that is full of multiple ice cubes. In fact, the cold air that we get from the AC vents is converted from the hot air. The hot air has to go through multiple steps to convert into the cool and fresh air.

The refrigeration cycle shows how the refrigerant is transformed in the closed loop system, and in so doing, absorbs heat on the left (blue low pressure side) and sheds heat on the right (red high pressure side).

The refrigerant gas at a low pressure enters the compressor and is pressurized to a higher pressure.the pressurized gas then flows to the condenser where it condenses to a liquid, and gives off its heat to the outside air.the pressurized liquid then moves to the expansion valve. This valve restricts the flow of the liquid, and this reduces its pressure. The low-pressure liquid then moves to the evaporator, where heat from the inside air is absorbed and changes it from a liquid to a gas. As a hot low-pressure gas, the refrigerant again moves to the compressor where the entire refrigeration cycle is repeated.

Fixed Displacement Swash Plate Type Compressor

This compressor is constructed from the components shown in the illustration. The piston completes a 360 cycle when power from the engine causes the shaft and swash plate to rotate. One piston is comprised of cylinders on both sides. The ends of the piston intake pressurize and discharge refrigerant. **Operation** in the cylinder shown in the right of the illustration, the suction valve is opened when the piston moves to the left. The pressure difference between the suction shaft within the housing and inside the cylinder causes refrigerant to enter the cylinder through the suction valve. Conversely, when the piston moves to the right, the suction valve is closed and the refrigerant is pressurized. Continued pressurization increases the pressure of the refrigerant in the cylinder, causing the discharge valve to open. The refrigerant then flows to a high-pressure pipe. (the suction and discharge valves prevent flow back of the refrigerant.)

The balance of characteristics and reliability in this compressor make it suitable in a wide-range of vehicles around the world, such as small vehicles, mini-vans, large busses, and construction equipment. As the rotating scroll moves, the space between the two scrolls also moves, causing the volume of this space to gradually decrease.

Refrigerant flows in from the suction port and is gradually compressed by the rotating scroll rotation. It is discharged from the discharge port after approximately 3 rotations.

Refrigerant is actually discharged once for each rotation.

It is an extremely quiet and efficient compressor used mostly in small and light cars.

Components of the AC system

A **condenser** is a heat exchanger (operating to the same principle as a car's radiator). It consists of a series of coils over and around which ambient air is forced to circulate by a fan. Within the coils, the hot refrigerant gas cools to a liquid, as it sheds heat.

Condensers are of two types - depending on the way in which the refrigerant flows. The older parallel types of condenser, and the newer and almost ubiquitious serpentine type of condenser.

The serpentine type of condenser is much easier to clean and can easily be flushed clean. It is the preferred design in modern cars.

The parallel type of condenser has multiple flow paths from inlet to outlet. This means that any debris from the compressor or any obstructing material also can get stuck in one of several pipes. Hence a pressurized flush of the condenser will never dislodge all the debris or guck. This is an example of a parallel flow condenser seen in vintage cars.

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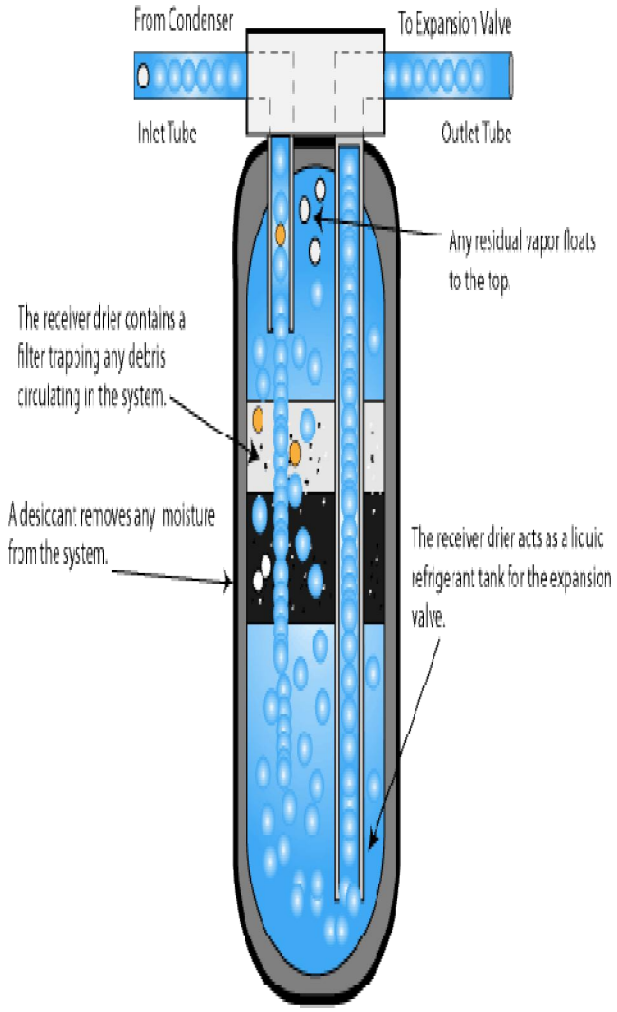

Objectives of Project

1) Performance of CFD Analysis on Simple Car AC Duct.
2) Study of ANSYS Fluent 2020 R1 Tool for AC Duct CFD Analysis.
3) Study of Coat Applied on Car AC duct to minimize losses due to convection.
4) Performance of CFD Analysis on coated Car AC Duct.
5) Comparison of results generated through both types of analysis.

II. CAD MODEL DEVELOPMENT

As computer-aided design (CAD) has become more popular, reverse engineering has become a viable method to create a 3D virtual model of an existing physical part for use in 3D CAD, CAM, CAE, or other software. The reverse-engineering process involves measuring an object and then reconstructing it as a 3D model. The physical object can be measured using 3D scanning technologies like CMMs, laser scanners, structured light digitizers, or industrial CT scanning (computed tomography).

Reverse engineering, sometimes called back engineering, is a process in which software, machines, aircraft, architectural structures and other products are deconstructed to extract design information from them. Often, reverse

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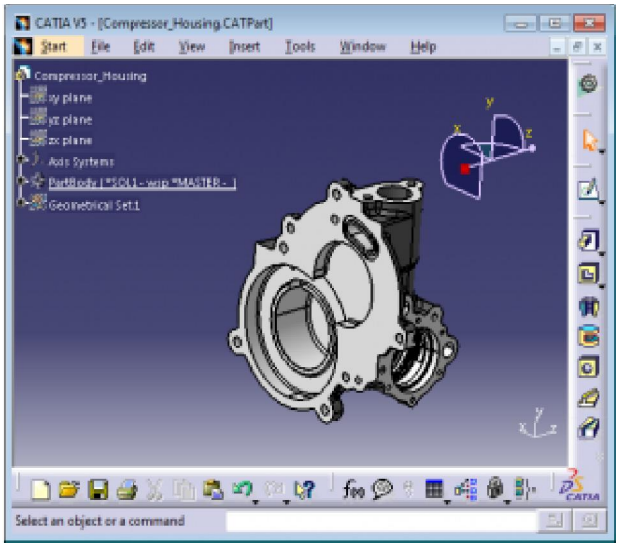
engineering involves deconstructing individual components of larger products. The reverse engineering process enables you to determine how a part was designed so that you can recreate it. Companies often use this approach when purchasing a replacement part from an original equipment manufacturer (OEM) is not an option.

The reverse engineering process is named as such because it involves working backward through the original design process. However, you often have limited knowledge about the engineering methods that went into creating the product. Therefore, the challenge is to gain a working knowledge of the original design by disassembling the product piece-by-piece or layer-by-layer.

Companies often use reverse engineering on old electronic components, such as discontinued printed circuit boards (PCBs) and connecting cards. Frequently, the products in question will come from manufacturers that have since gone out of business. If the manufacturer is still in business, they might no longer offer the part. The firms often reverse engineer old electronics for the sake of continuity.

If an old piece of computer equipment had functions that have since been lost amid the subsequent changes in technology, reverse engineering allows manufacturers to rediscover these formulas and bring them up to date. Reverse engineering also enables you to develop components that bridge the new and the old, allowing users of older equipment to connect their devices to modern computing equipment.



III. CONCLUSION

By observing all the results generated through CFD analysis for both coated and non-coated AC duct, it is found that the filament coatings can prevent the temperature losses and can improve the efficiency of the Car AC. The pressure and velocity will increase during increase of velocity value. But the temperature and density values are same for all condition. Only the region of getting maximum temperature is different in coated and non-coated AC duct. Hence implementation of filament insulation is desirable to achieve maximum efficiency of the car AC duct.

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