DESIGN AND CFD ANALYYSIS OF RADIATOR USING NANO-FLUIDS

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***Abstract*: Radiators are the heat exchangers used for cooling and heating purposes to transfer the thermal energy from one medium to another medium. Some radiators were designed to operate in vehicles, homes and electronics. The radiator is a source of heat for its environment, as it can either be used to heat this atmosphere or cool the supply of coolant. Most radiators use the convection to transfer the bulk of their heat.**

An automotive radiator is the cornerstone of an automotive cooling system that plays a crucial role in transmitting the heat from engine components to the atmosphere through its complex operations. It is a form of heat exchanger designed to transfer heat from warm coolant of the engine to the fan's blown air. The cycles of heat transfer takes place from the coolant to pipes, then through fins from the tubes to the water. They are used to cool internal combustion engines, especially in vehicles, as well as in piston-engine aircraft, railway locomotives, power generating plants or any similar use of applications. The main function of this radiator is to cool the engine bypassing the coolant through the water jackets of the cylinder. The main objective of the project is to design a radiator and assign aluminium and nanofluids to find out the better material for heat transfer. CFD analysis is carried out to find the heat transfer through the radiator.

Designing of radiator is done in Catia V5R20 software. And, CFD analysis is performed in Ansys Fluent.

***Keywords*: Radiators, Automobiles, Nanofluids, Cooling System, Catia V5R20, Ansys Fluent**

I. INTRODUCTION

1.1 Radiators

A radiator is a type of heat exchanger. It is designed to transfer heat from the hot coolant that flows through it to the air blown through it by the fan. Most modern cars use aluminium radiators. These radiators are made by brazing thin aluminium fins to flattened aluminium tubes. The coolant flows from the inlet to the outlet through many tubes mounted in a parallel arrangement. The fins conduct the heat from the tubes and transfer it to the air flowing through the radiator. The tubes sometimes have a type of fin inserted into them called a turbulator, which increases the turbulence of the fluid flowing through the tubes. If the fluid flowed very smoothly through the tubes, only the fluid actually touching the tubes would be cooled directly. The amount of heat transferred to the tubes from the fluid running through them depends on the difference in temperature between the tube and the fluid touching it. So if the fluid that is in contact with the tube cools down quickly, less heat will be transferred. By creating turbulence inside the tube, all of the fluid mixes together, keeping the temperature of the fluid touching the tubes up so that more heat can be extracted, and all of the fluid inside the tube is used effectively. Radiators usually have a tank on each side, and inside the tank is a transmission cooler. In the picture above, you can see the inlet and outlet where the oil from the transmission enters the cooler. The transmission cooler is like a radiator within a radiator, except instead of exchanging heat with the air, the oil exchanges heat with the coolant in the radiator [1].

Automobile radiators are constructed of a pair of metal or plastic header tanks, linked by a core with many narrow passageways, giving a high surface area relative to volume. This core is usually made of stacked layers of metal sheet, pressed to form channels and soldered or brazed together. For many years radiators were made from brass or copper cores soldered to brass headers. Modern radiators have aluminium cores, and often save money and weight by using plastic headers with gaskets. This construction is more prone to failure and less easily repaired than traditional materials. An earlier construction method was the honeycomb radiator. Round tubes were swaged into hexagons at their ends, then stacked together and soldered. As they only touched at their ends, this formed what became in effect a solid water tank with many air tubes through it. Some vintage cars use radiator cores made from coiled tube, a less efficient but simpler construction [2].

1.2 Nanofluids

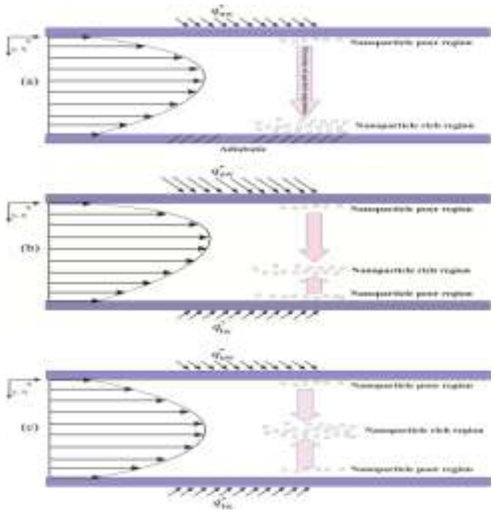
A **nanofluid** is a fluid containing nano meter-sized particles, called nanoparticles. These fluids are engineered colloidal suspensions of nanoparticles in a base fluid. The nanoparticles used in nanofluids are typically made of metals, oxides, carbides, or carbon nanotubes. Common base fluids include water, ethylene glycol[3] and oil. Nanofluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behaviour of nanofluids is found to be critical in deciding their suitability for convective heat transfer applications. Nanofluids also have special acoustical properties and in ultrasonic fields display additional shear-wave reconversion of an incident compressional wave; the effect becomes more pronounced as concentration increases [3].

Nano lubricants

Another word used to describe nanoparticle-based suspensions is Nano lubricants. They are mainly prepared using oils used for engine and machine lubrication. So far, several materials including metals, oxides and allotropes of carbon have been used to formulate nano lubricants. The addition of nanomaterials mainly enhances the thermal conductivity and anti-wear property of base oils. Although MoS2, graphene, Cu based fluids have been studied extensively, the fundamental understanding of underlying mechanisms is still needed. Molybdenum disulphide (MoS2) and graphene work as third body lubricants, essentially becoming tiny microscopic ball bearings, which reduce the friction between two contacting surfaces. This mechanism is beneficial if a sufficient supply of these particles are present at the contact interface. The beneficial effects are diminished as the rubbing mechanism pushes out the third body lubricants. Changing the lubricant, like-wise, will null the effects of the nano lubricants drained with the oil. Other nano lubricant approaches, such as Magnesium Silicate Hydroxides (MSH) rely on nanoparticle coatings by synthesizing nanomaterials with adhesive and lubricating functionalities. Research into nano lubricant coatings has been conducted in both the academic and industrial spaces. Nano borate additives as well as mechanical model descriptions of diamond-like carbon (DLC) coating formations have been developed by Ali Erdemir at Argonne National Labs. Companies such as TriboTEX provide consumer formulations of synthesized MSH nanomaterial coatings for vehicle engines and industrial applications [4].

Nanoparticle Migration

The early studies indicating anomalous increases in nanofluid thermal properties over those of the base fluid, particularly the heat transfer coefficient, have been largely discredited. One of the main conclusions taken from a study involving over thirty labs throughout the world was that "no anomalous enhancement of thermal conductivity was observed in the limited set of nanofluids tested in this exercise". The COST funded research programme, Nanouptake (COST Action CA15119) was founded with the intention "to develop and foster the use of nanofluids as advanced heat transfer/thermal storage materials to increase the efficiency of heat exchange and storage systems". Brownian diffusion is due to the random drifting of suspended nanoparticles in the base fluid which originates from collisions between the nanoparticles and liquid molecules. Thermophoresis induces nanoparticle migration from warmer to colder regions, again due to collisions with liquid molecules. The mismatch between experimental and theoretical results is explained in Myers et al. In particular it is shown that Brownian motion and thermophoresis effects are too small to have any significant effect: their role is often amplified in theoretical studies due to the use of incorrect parameter values [5].



Nano Particle Migration Effect

II. LITERATURE

Sandeep Patel and Dr. S.P. Deshmukh in their paper "Analytical Design and Verification of Automotive Radiator using 1-D Simulation" have concluded that The brief overview of this case study that has been given revealed several points as follows: Optimal design of cooling system leads to less fuel consumption & more cabin comfort but at the same time compactness needs to be ensured. Downsizing of engine and less under hood package space are the key challenges in designing engine cooling system. Analytical design procedure for industrial design of automotive radiator system is gives coarse estimations for core sizing but to make it more optimize we need to use simulation programs. Simulation of cooling system helps design engineers to ease the work of design by using different configurations. This work can be continued for studying NTU method for radiator design. In depth study of more simulation techniques are necessary. The Key design considerations to design optimal Radiator are, compactness, low pressure drop, Low cost, High volume, durability, requirement, heat transfer and fluid flow [6].

Rahul S Gupta and et.al in their paper "Thermal Analysis of Car Radiator by using Nano-fluid" have concluded that Therefore, at higher temperature, thermal conductivity and specific heat increased while viscosity and density decreased. Hence, MBNF exhibited better thermo–physical properties compared to pure methanol. From above analysis we can predict that ethanol will be found more effective than conventional base fluid rather than EG (Ethelyn glycogel), Water, Al2o3. After certain studied parameter we found that Cuo will be best dispersion capability and having larger heat dissipation capacity. By observing thermal analysis results, heat flux is more when Copper is used than Aluminium alloy [7].

Dipesh Joshi and Deepthi Sharma in their paper "Thermal Analysis of Helical coil radiator using Nano Fluids" have concluded that CFD analysis is conducted on helical tube radiator using ANSYS CFX software. The application of nano fluid as coolant has proved to be viable option for use in heat exchangers as follows:
Two variable k – epsilon model provided reasonably good predictions for turbulent flows and complex geometries. Application of nano fluids (Alumina/water and CuO/water) has enhanced heat dissipation rate to a considerable extent as compared to water as coolant. The increase in nano particle concentration increases heat transfer rate but may lead to increase in friction. CuO/water nanofluid has better heat dissipation characteristics as compared to Al2O3/water nanofluid. The highest heat dissipation rate is found with CuO/water 3% nanofluid. Al2O3/water with 3% nano particle concentration provided 37% increase in heat transfer rate. CuO/water 3% nano particle concentration provided 53% increase in heat transfer rate [8].

V. Surendra Reddy and N. Prabhu Kishore in their paper "Design and Analysis of Radiator by using Nano Fluids" have concluded that the internal combustion engine cooling system's efficiency depends primarily on its unit performance. The radiator is the central component in this system. In this project, brief studies are carried out on radiators, types and work of nano fluid studies, applications are being made. Radiator modelling is done using software for Solid Works 2016. Flow simulation module CFD research is performed on the radiator using strong plays. Three different liquids, namely common fluid water and two, nano fluids that are titanium oxide and aluminium oxide, by selecting radiators. Boundary conditions are provided as 800c for fluid inlet temperature, which is cooled at 250c ambient temperature by radiator pipe and fins through the convection process. After analysis, temperature, velocity and fluid pressure are noted and tabulated due to the convection temperature of the fluid flow inside the radiator. We can conclude from the result table that nanofluids give better convection, i.e. gives better cooling compared to water for the engine. Compared to all the fluids used for analysis, Aluminium Oxide yields the best results [9].

CONCLUSION

In this project modelling of radiator is carried out with CATIA V5R20 software by using various commands and CFD analysis is carried out by using Ansys 14.5 software using different nano-fluids

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