THERMAL ANALYSIS OF COOLENT CONDITIONING SYSTEM BASED ON CFD

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ABSTRACT: Internal combustion engines at best can transform about 25 to 35percent of the chemical energy in the fuel into mechanical energy. About 35% of the heat generated is lost to the cooling medium, remainder being dissipated through exhaust and lubricating oil. During the process of combustion the cylinder gas temperature often reaches quite a high value. A considerable amount of heat is transferred to the walls of the combustion chamber. Therefore it Is necessary to provide proper cooling especially to the walls of the combustion chamber. Due to the prevailing high temperature, chemical and physical changes in the lubricating oil may also be occurs this causes wear and sticking of the piston rings, scoring of cylinder walls or seizure of the piston. Excessive cylinder wall temperature will therefore cause the rise in the operating temperature of the piston head. This in turn will affect the strength of piston. In view of the above, the heat that is transferred into the wall of the combustion chamber Is continuously removed by employing cooling system. For cooling purpose normally we are using air and water as cooling media. Here we are analyzing this system by using CFD analysis with different Nano fluids such as aluminum oxide, silicon oxide, titanium Carbide & titanium nitride, at different volume fractions (0.2 & 0.3). Here we are doing Fluid flow analysis to determine the temperature, heat transfer coefficient, mass flow rate and heat transfer rate.

Key words: CFD analysis, NANO fluids, heat exchanger.

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1. INTRODUCTION

During the combustion method in burning engines (ICE), an oversized quantity of warmth is generated. More or less one third of this energy is absorbed by the cylinder walls, pistons, and plate. So as to stop the heating of the engine oil, cylinder walls, pistons, valves, and different parts from these extreme temperatures, it's necessary to effectively get rid of the warmth.

Working Principle of typical Cooling Systems

In heavy diesel engines , no two approaches to cooling system are identical. The parts of cooling system are typically identical, however their configuration will be changed supported thermal management of the parts. The engineer should build a call on the systems to be combined and priority of subsystems within the cooling system. The pump is at the guts of the cooling system and also the fluid is tense through the oil cooler, then through the cylinder block by the pump. Then, the fluid leaves the cylinder block and is circulated through the plate and enters the thermostat that senses the temperature of fluid .

II. LITERATURE REVIEW

1) Experimental Study of Heat Transfer in a Radiator using Nano fluid ,Parashurama M Sstudent, Dr. Dhananjaya D A professor, Naveena Kumar R R Asst professor Dept. of Mechanical Engineering Rajeev Institute of Technology, Hassan, India

The experimental study of the thermal behavior of the single phase flow through a automobile radiator. Nano fluids have attracted attention as a new generation of heat transfer fluids in building in automotive cooling applications, because of their excellent thermal performance. This study attempts to investigate the heat transfer characteristics of an automobile radiator using water combination based CuoNano-fluids as coolants. Thermal performance of an automobile radiator operated with Nano-fluids is compared with a radiator using conventional coolants

NANO FLUID CALCULATIONS

DENSITY OF NANO FLUID

$\rho_{nf} = \phi \times \rho_s + [(1-\phi) \times \rho_w]$

SPECIFIC HEAT OF NANO FLUID

$$C_{pnf} = \frac{\phi \times \rho s \times Cps + (1-\phi)(\rho w \times Cpw)}{\phi \times \rho s + (1-\phi) \times \rho w}$$

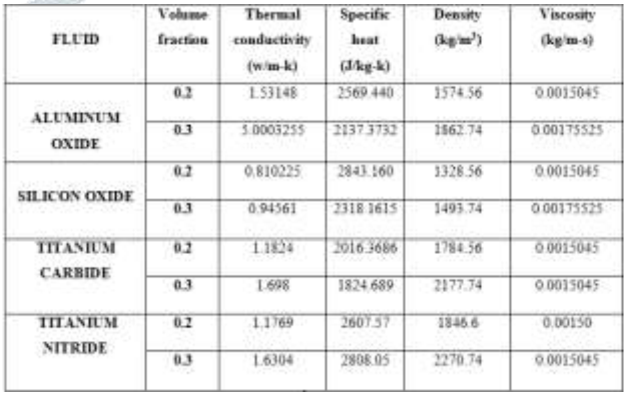
VISCOSITY OF NANO FLUID

$\mu_{nf} = \mu_w (1+2.5\, \phi)$

THERMAL CONDUCTIVITY OF NANO FLUID

$$K_{nf} = \frac{Ks+2Kw+2(Ks-Kw)(1+\beta)^3 \times \phi}{Ks+2Kw-(Ks-Kw)(1+\beta)^3 \times \phi} \times k_w$$

NANO FLUID PROPERTIES



FLUID	Volume fraction	Thermal conductivity (w/m-k)	Specific heat (J/kg-k)	Density (kg/m^3)	Viscosity (kg/m-s)
ALUMINUM OXIDE	0.2	1.53148	2569.440	1574.56	0.0015045
	0.3	5.0003255	2137.3732	1862.74	0.00175525
SILICON OXIDE	0.2	0.810225	2843.160	1328.56	0.0015045
	0.3	0.94561	2318.1615	1493.74	0.00175525
TITANIUM CARBIDE	0.2	1.1824	2016.3686	1784.56	0.0015045
	0.3	1.698	1824.689	2177.74	0.0015045
TITANIUM NITRIDE	0.2	1.1769	2607.57	1846.6	0.00150
	0.3	1.6304	2808.05	2270.74	0.0015045

SOFTWARE USED IN THE ANALYSIS OF COOLANT CONDITIONING SYSTEM:

1. Computer-aided design (CAD)
2. ANSYS
3. CFD

INTRODUCTION TO CAD

Computer-aided design (**CAD**) is the use of computer systems (or workstations) to aid in the creation, modification, analysis, or optimization of a design. CAD software is used to increase the productivity of the designer, improve the quality of design, improve communications through documentation, and to create a database for manufacturing. CAD output is often in the form of electronic files for print, machining, or other manufacturing operations. The term **CADD** (for Computer Aided Design and Drafting) is also used.

ANSYS Software:

ANSYS is an Engineering Simulation Software (computer aided Engineering). Its tools cover Thermal, Static, Dynamic, and Fatigue finite element analysis along with other tools all designed to help with the development of the product. The company was founded in 1970 by Dr. John A. Swanson as Swanson Analysis Systems, Inc. SASI. Its primary purpose was to develop and market finite element analysis software for structural physics that could simulate static (stationary), dynamic (moving) and heat transfer (thermal) problems.

INTRODUCTION TO CFD

Computational fluid dynamics, usually abbreviated as CFD, is a branch of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the calculations required to simulate the interaction of liquids and gases with surfaces defined by boundary conditions.

CFD ANALYSIS OF COLLING SYSTEM IN IC ENGINES

4.1FLUID-ALUMINUM OXIDE - 0.2

Save creo Model as .iges format.

→→Ansys → Workbench→ Select analysis system → Fluid Flow (Fluent) → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

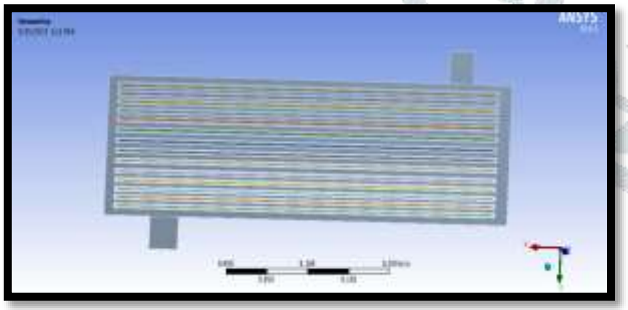
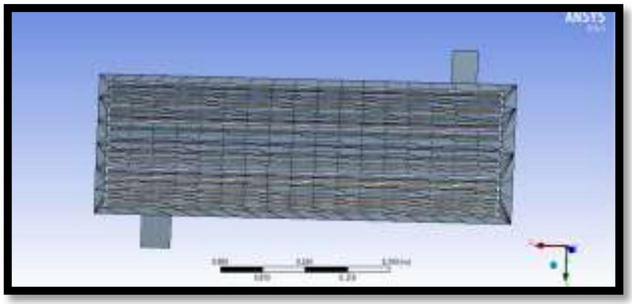


FIG: 4.1 IMPORTED GEOMETRY OF COOLING SYSTEM

→→ select mesh on work bench → right click →edit

Select mesh on left side part tree → right click → generate mesh →

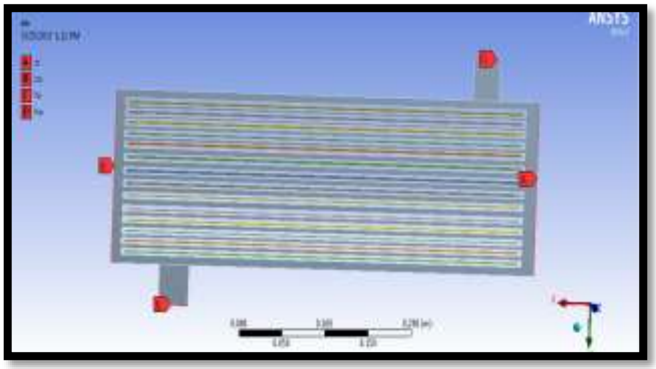


MESH MODEL

SPECIFYING BOUNDARIES FOR INLET AND OUTLET

Select edge → right click → create named section → enter name → inlet

Select edge → right click → create named section → enter name → outlet



BOUNDARY CONDITIONS

File →export → fluent →input file(mesh) → enter required name → save.

→→ ansys → fluid dynamics → fluent → select 2D or 3D → select working directory → ok

→→file → read → mesh → select file → ok.

General →Pressure based

Model → energy equation → on

Model → Viscous → Edit

Viscous Model

Model: k-epsilon (2 eqn)

k-epsilon Model: Standard

Near-Wall Treatment: Non-Equilibrium Wall Functions

Model Constants

Cmu: 0.09

C1-Epsilon: 1.44

C2-Epsilon: 1.92

TKE Prandtl Number: 1

User-Defined Functions

Turbulent Viscosity: none

Prandtl Numbers

TKE Prandtl Number: none

TDR Prandtl Number: none

Energy Prandtl Number: none

Materials → new → create or edit → specify Fluid material → aluminum oxide

Boundary conditions → Inlet → Edit

velocity 2.1 m/sec–pressure -101325 pa

Solution → Solution Initialization→ Hybrid Initialization →done

Run calculations → No of iterations = 100 → calculate → calculation complete

HEAT TRANSFER COEFFIECNT

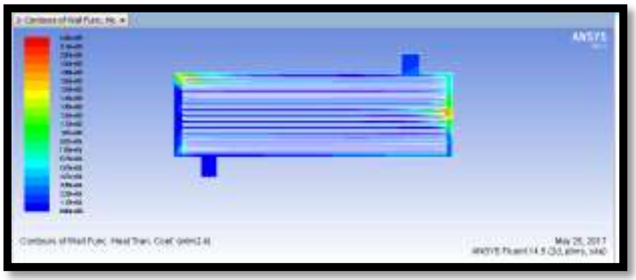


FIG :4.4 CONTOURS OF HEAT TRANSFOR COEFFICIENT FOR 0.2 VOLUME FRACTION OF ALLUMINIUM OXIDE

TEMPERTAURE

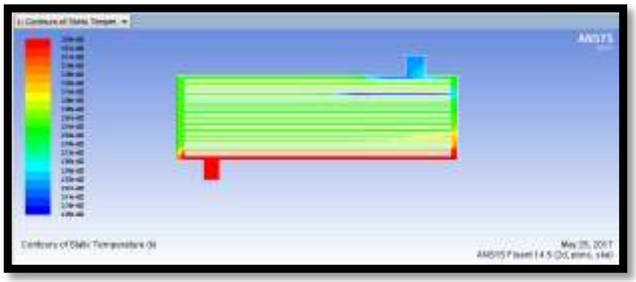
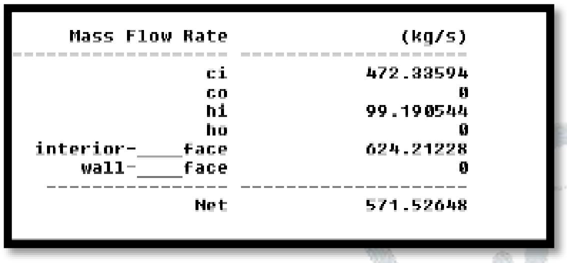


FIG : 4.5 CONTOURS OF TEMPERATURE FOR 0.2 VOLUME FRACTION OF ALLUMINIUM OXIDE

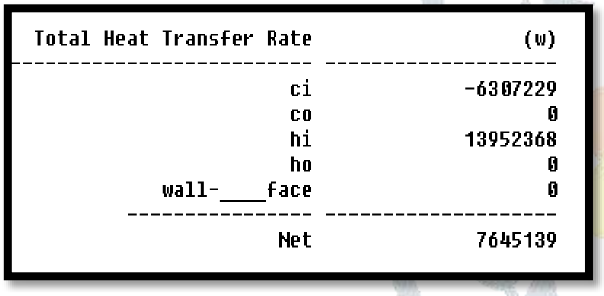
MASS FLOW RATE



```
        Mass Flow Rate                      (kg/s)
 -------------------------- --------------------
                      ci                 472.33594
                      co                         0
                      hi                 99.190544
                      ho                         0
     interior-____face                   624.21228
         wall-____face                           0
      ------------------ --------------------
                     Net                 571.52648
```

FIG:4.6 CONTOURS OF MASS FLOWRATE FOR 0.2 VOLUME FRACTION OF ALLUMINIUM OXIDE

HEAT TRANSFER RATE



```
 Total Heat Transfer Rate                    (w)
 ------------------------- --------------------
                       ci               -6307229
                       co                      0
                       hi               13952368
                       ho                      0
            wall-____face                      0
      -------------------- --------------------
                      Net                7645139
```

FIG :4.7 CONTOURS OF HEAT TRANSFOR RATE FOR 0.2 VOLUME FRACTION OF ALLUMINIUM OXIDE

4.2 FLUID-ALUMINUM OXIDE - 0.3

HEAT TRANSFER COEFFIECNT

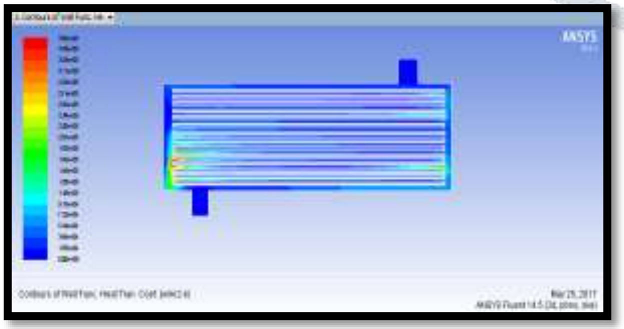


FIG : 4.8 CONTOURS OF HEAT TRANSFOR COEFFICIENT FOR 0.3 VOLUME FRACTION OF ALLUMINIUM OXIDE

TEMPERTAURE

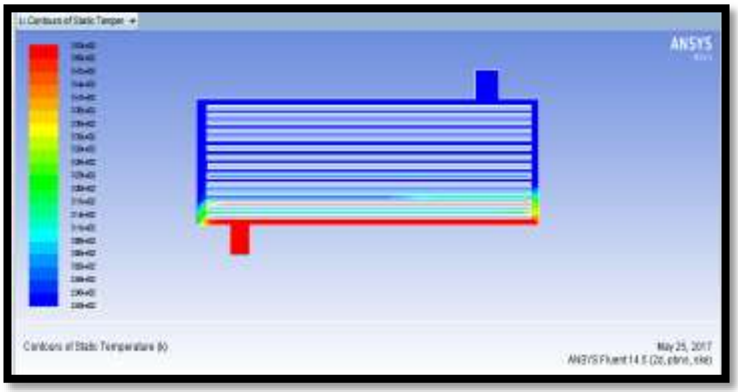
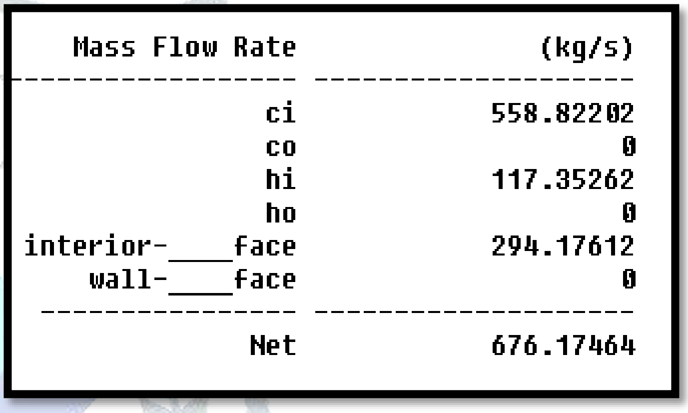


FIG : 4.9 CONTOURS OF TEMPERATURE FOR 0.3 VOLUME FRACTION OF ALLUMINIUM OXIDE

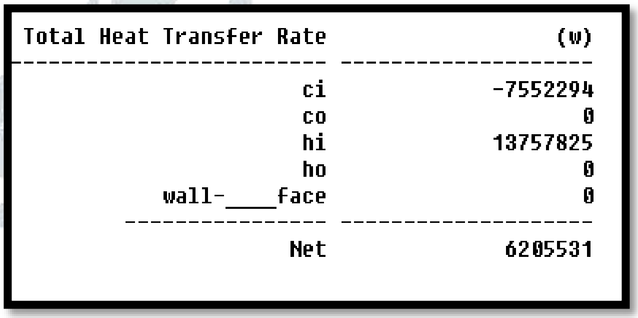
MASS FLOW RATE



```
   Mass Flow Rate                  (kg/s)
-------------------- ---------------------
               ci              558.82202
               co                      0
               hi              117.35262
               ho                      0
interior-____face              294.17612
    wall-____face                      0
  ----------------- ---------------------
              Net              676.17464
```

FIG : 4.10 CONTOURS OF MASS FLORATE FOR 0.3 VOLUME FRACTION OF ALLUMINIUM OXIDE

HEAT TRANSFER RATE



```
Total Heat Transfer Rate                  (w)
------------------------ --------------------
                      ci             -7552294
                      co                    0
                      hi             13757825
                      ho                    0
           wall-____face                    0
        ---------------- --------------------
                     Net              6205531
```

FIG :4.11 CONTOURS OF HEAT TRANSFOR RATET FOR 0.3 VOLUME FRACTION OF ALLUMINIUM OXIDE

THEORETICAL CALCULATIONS DONE BY THIS FORMULAS

Heat transfer coefficient

$hfg=\frac{Kw\times Nu}{D}$

. $Nu = 0.024\times Re^{0.8}\times Pr^{0.4}$

:. $Re =\frac{\rho VD}{\mu}$

:. $Pr= \frac{Cp\times\mu}{Kw}$

RESULT TABLE

FLUID	Volume fraction	Temperature (K)		Heat transfer coefficient (W/m^{2}K)	Mass flow rate(kg/sec)	Heat transfer(w)
		Min	Max			
ALUMINUM OXIDE	0.2	228.2	353.2	2.25e+05	571.526	7645139
	0.3	292.9	353.07	3.66e+05	676.174	6205531
SILICON OXIDE	0.2	293	353.01	1.68e+05	482.267	1554217
	0.3	293	353.02	1.66e+05	542.227	15063067
TITANIUM CARBIDE	0.2	293	353	2.33e+05	647.795	18650110
	0.3	293	353.01	2.00e+05	790.447	23625894
TITANIUM NITRIDE	0.2	293	353	2.87e+05	671.40	22720716
	0.3	293	353	2.21e+05	824.27	21897467

CONCLUSION

- In this thesis the CFD analysis is done in ANSYS software at different Nano fluids (aluminum oxide, silicon oxide, titanium Carbide & titanium nitride) at different volume fractions (0.2 & 0.3).
- By observing the CFD analysis the heat transfer rate increases titanium carbide at volume fraction 0.3.
- So it can be concluded that titanium carbide Nano-fluid has more cooling efficiency

REFERENCES

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