International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 9, September- 2014

Gas Compressor Engine Cooling System Programmable Computation

P. Praveen Babu
PG Student: Thermal Engineering
Siddharth Institute of Engineering and Technology
Puttur, INDIA

B. Siddeswara Rao
Associate Professor: Mechanical Engineering
Siddharth Institute of Engineering and Technology
Puttur, INDIA

***Abstract*: -For an engine running at 24x7 needs proper cooling system. This thesis provides the entire mechanism of cooling system, parameters regarding and working condition guidelines for future scope of the engine and its assisted beginner operator. The content in this thesis had deal with the principles of Thermal engineering and fluid dynamics. Analysis starts with the cooling system model and terminates with the output finder programming language and construction of guidelines for the operation of the cooling system. A simple basic cooling system model constitutes pipings, cooler units and valves are considered to make a thermal and fluid dynamic analysis. The computed results are taken as graphs and compared with familiar operating conditions and the results are tabulated to give clear cut guidelines.**

Keywords- Mechanism, guidelines, thermal engineering, pipings, beginner operator, Basic cooling system, Programmable language.

I. INTRODUCTION

A. *Aims and Goals:*

- Projecting information on cooling system in to a document.
- Constructing or assuming a basic cooling system model for the analysis.
- Thermal analysis on engine and cooler units.
- Extracting equations by the application of thermal principles.
- Preparation of a flow chart based coding for the derived equations.

B. *Tasks to be performed:*

- Literature review.
- Onsite camp for scrutiny on the cooling system performance.
- Analysis on basic engine cooling system.
- Application of thermal and fluid dynamic principles.
- Deriving equations on the physical condition of the simple cooling system.
- Developing a program in a sequential manner to get output on flow chart basis.
- Construction of guidelines for the basic operator in an industry for proper maintenance of internal combustion engine cooling system.

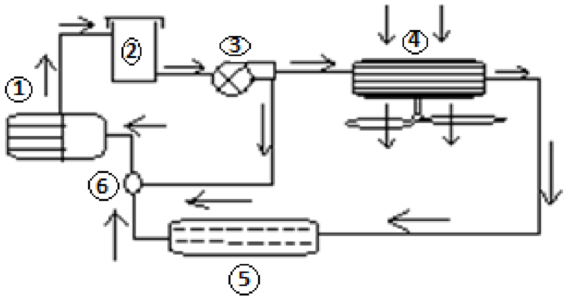

Fig.1 A simple basic cooling system model

Parts of the model:

- Internal combustion engine.
- Expansion room.
- A coupled coolant pump.
- Radiator.
- Oil cooling equipment.
- Thermostatic control valve.

C. *Engine as an open system:*

- Since we know that every engineering device is an open system in which both energy and mass transfer takes place from system to the surroundings.
- Then the system is said to be the engine, subsystem is the cooling water and ambient air is the surrounding.
- The heat energy from the engine is transferred to the subsystem i.e., water coolant, through the primary modes of heat transfer mechanism.
- The amount heat energy transferred from system to the subsystem, and subsystem to the surroundings can be calculated by the heat transfer principles.

D. *Analysis of the coolant circulation in pipelines:*

Parts of the piping system,

- Piping.
- Bends and fits.
- Coolant pump.
- Expansion room or container.
- Coolant.

The coolant in the pipe line is pressurized by the coolant pump and the pump run with help of the engine.

- The pressure drops in the pipelines is due to the number of fittings, bends and the heights of the pipes.
- The pressure drop at every section of the pipeline can be calculated by the application fluid dynamic principles.
- Water is the coolant used here and there is no problem of unavailability and cost.
- For the pressure calculations crowe, daily and Bernoulli's equations are considered in which all the losses are taken in to account.
- Pressure loss coefficients, friction factor, dimensionless friction factor are considered for each and every section of the pipe.

II. LITERATURE REVIEW

A. A Review On The Cooling Systems In Various Sites:

- Diesel engine cooling systems are reviewed in the presence of senior operators and technicians.
- The first review was made in the labs of university.
- Secondly referred for the similar simulation model which was made in the Michigan University in which they used GT-power software for analysis of the engine performance and other cooling units such as oil cooler, fin fan unit, pre-cooler and valves.

B. Thermal analysis:

- Since we have considered that every engineering device is an open system, our thesis made easy for the prediction of energies that transfer from system(Engine) to the Surroundings(Ambient air).
- First law of thermodynamics was applied because it is one of the laws of the conservation of energy and built the basic equations for heat transfer mechanism in the cooling system.

$$Q = u+W \qquad (1)$$

Q = Heat energy in KJ,
u = Specific internal energy in KJ/kg,
W = Work done in KJ.

- This thermal analysis is made at engine cylinder section, fin fan unit section and oil cooler section and formulated the desired equations for the further calculations.

C. Heat transfer from system to the subsystem:

- It is a convective mode of heat transfer whereas; heat transfer takes place between a wall and a moving fluid.

A graphical representation of engine is made to represent the thermal resistance.

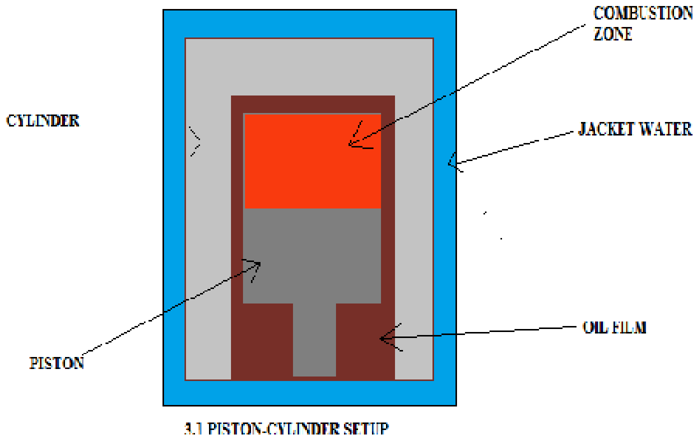

Fig.2 In-cylinder heat transfer mechanism

- The average in-cylinder gas temperature lies at 1980^0c during combustion and it may vary in remaining periods of the engine cycle.
- In the above figure red color indicates the combustion zone with high temperature gases, Dark grey is the piston, light grey is the cylinder thickness (steel), brown color indicates oil, and blue color indicates water jacket.
- The direction heat flow takes place from the combustion gases to the oil, piston steel, and water jacket.
- The in-cylinder gas heat transfer coefficient can be calculated with the help of woschni's equation in which he involved bore diameter, instantaneous pressure and temperature, and gas velocity inside the cylinder.

An example Woschni's equation,

$$H_g = D^x\, P^y\, T^z\, w^a \qquad (2)$$

- The heat transfer coefficients for the remaining elements in the above figure can be found in any data books at any particular temperatures.

D. Coolant flow in the pipeline:

- Since water is the element used as a coolant in the model, it is an incompressible fluid i.e., water runs in the pipeline at constant volume.
- For the perfect calculation of the pressures inside the pipes, we may consider certain factors related to the flow of an incompressible fluid.

The following factors are to be considered:

- Friction factor.
- Dimensionless friction factor.
- Number of fits and bends.
- Length and diameter of the pipe.
- Reynolds number.
- Dimensionless head loss coefficient.
- Velocity of the flow

The above factors are involved in the steady flow energy equation.

Q = delta (pressure + kinetic +potential) + W
(3)

Where,

Q = heat energy in KJ,

W = work KJ.

- Then the modified study flow energy equation is used to calculate the pressures at different sections of the pipe.

E. Summary of literature review:

- The in-cylinder heat transfer coefficient can be determined by the woschni's equation.
- The pressures at various sections of the pipe can be calculated by the modified steady flow energy equation.
- The heat flow across the engine elements and cooling units are determined by the thermodynamics and heat transfer principles.

III. MATH PART IN THE THESIS

Since the analysis part is made on the parts that which are taken into account, hence calculations may also involved in those.

Parts of analysis,

- In-cylinder heat generation.
- Radiator.
- Temperature control valve.
- Piping system

A. In-cylinder heat generation:

- The heat transfer across the engine cylinder is taken as the resistance offered by the elements inside the engine block.
- The figure2 shows the elements to analyze thermally.
- Then thermal resistance suits best for the calculation resistance offered by the elements.
- Resistance offered by the combustion gases, engine oil, cylinder thickness, water jacket are calculated through their mode heat transfer.
- Since the thermal resistance is the reciprocal of either heat transfer coefficient or thermal conductivity.
- These resistances are used to calculate the heat flux from engine cylinder to the jacket water.
- Therefore, we can say heat flux as:

$$\text{Heat flux } (q) = (T_g - T_w)/R \qquad (4)$$

Where,

T_g = gas temperature,

T_w = Water temperature.

R = sum of resistances offered by the elements.

B. Radiator mechanism:

- The primary mode of heat transfer in radiator is the convection.
- The hot water from the engine block enters the radiator with certain temperature and exits with temperature lower than the inlet temperature.
- The mechanism involves rejection of heat from the hot water to the radiator material and then to the ambient air through the convective heat transfer.
- Here water from the engine block is taken as the hot element and the ambient air is taken as the cold element.
- Since we know that it is the virtue of heat energy to flow from the high temperature region to the lower temperature region.
- The amount heat flow from the radiator system to the surrounding can be calculated with the help of the heat transfer principles.

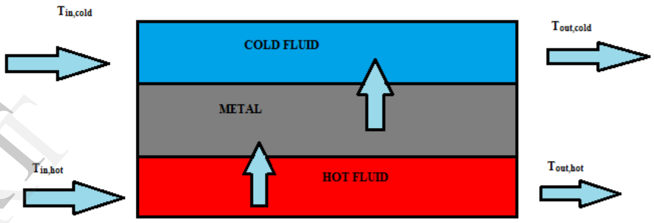

Fig.3 Radiator mechanism

The above figure shows the heat transfer mechanism in a radiator.

C. Temperature control valve:

- This valve activates at the engine average temperature i.e, it gets open when the operating temperature of the system reaches to an average temperature.
- It will mix the coolant in the short circuit with the coolant across the various cooling units without the disturbing the internal energies and specific heats of the coolant water.
- The mass flow rate will be affected here, i.e., 25% in the short circuit and 75% in the long circuit are mixed at this control valve and injected to the engine block again, hence mass flow rate changes.
- Temperature control valve provides an adiabatic mixing of the coolant and it is having two inlets and one outlet to the engine.

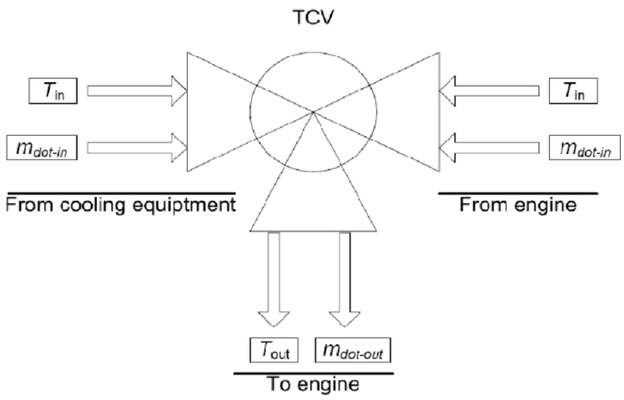

Fig.4 Temperature control valve

D. Piping system:

- The number of fitting s and bends in the pipelines, friction between fluid and the contact areas and the height pipe affect the pressure of the coolant at each section of the pipeline.
- The mass flow rate always depends on the difference in the pressure across the pipes.
- Hence the pressures are calculated at each and every point of the piping system taking modified steady flow energy equation as a tool.

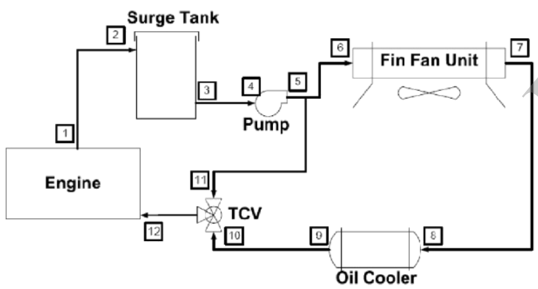

Fig.5 Various points in a piping system.

- The above figure shows the points at which the pressures are to be calculated.
- The conditions of fluid dynamics may apply at these points.
- The factors that which we discussed in the “coolant flow in a pipeline”, topic may also taken into account here.

IV.EQUATION EXTRACTION AND PROGRAMMING

The equations which are derived in the above sections are employed in to the different coding language.

The formulated equations on engine cylinder analysis, coolant piping system, radiator and oil cooler are arranged in a sequential order.

Type of parameters used,

- Constant parameters
- Variable parameters
- Assumed parameters

A. Constant parameters:

- The densities of the water and oil may get in the data books, the engine specifications and the routing system.
- The altitudes of the pipes, radiator unit, oil cooler unit and the engine block are taken as constant value here.
- The average temperatures inside the cylinder, water and the oil are taken as the constant value.
- The Surface area of the radiator, oil cooler, and pipe, areas of the coolant pipe and oil pipes.

B. Variable parameters:

- RPM of the engine and the pump.
- The Pressures and temperatures within the coolant system model.
- Mass flow rate and heat loads across each unit in the engine cooling system.

C. *Assumed parameters:*

- Heights of the pipelines, engine specifications and cooling system design

V. OUTPUT OF THESIS AND DISCUSSIONS

- The functions of the program are meant to help in concluding the thesis finally.
- The equations at different sections are embedded in to a programmable language.
- Then it is executed partially in order to examine the result at any particular point and made corrections and total program is followed by this procedure until we get an approximate results comparing with familiar operating conditions.
- The results are viewed in the form of graphs or tables.

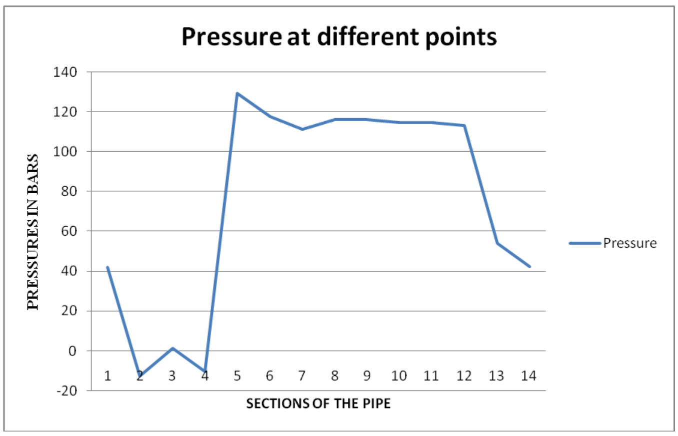

Fig.6 Pressures in the system.

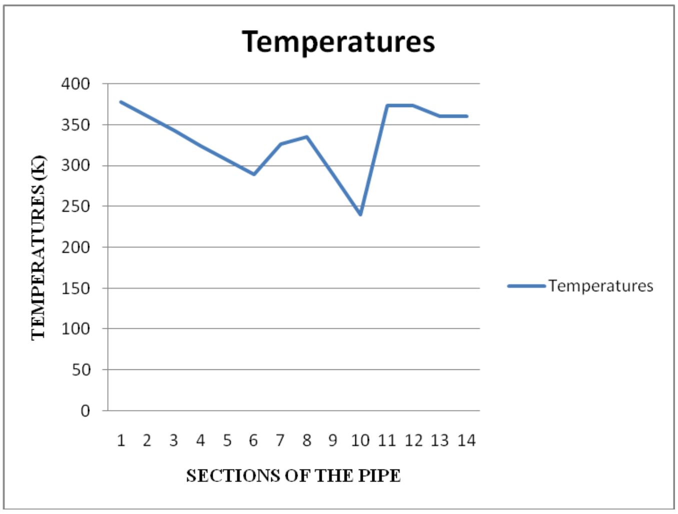

Fig.7Temperatures in the system

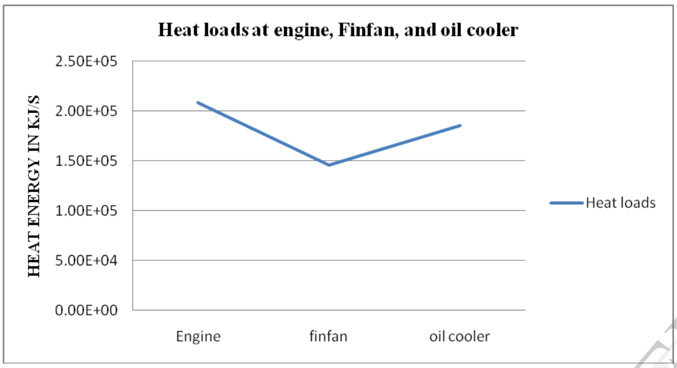

Fig.8 Heat loads.

VI. CONCLUSION

- This section is the main part of the thesis that which concludes the worth of the work in it.
- The developed program in the above section can be implemented for different engines of different specifications.
- But before the implementation there will be some modifications in the constant parameters or assumed parameters that which are discussed above.
- This program always suits for the all internal combustion engines; hence it can be applied anywhere and everywhere in the industrial area.
- Further in depth study makes this possible for a common cooling system of several internal combustion engines arranged in series.
- Hence we can provide guidelines for the beginner operators of the cooling system of an engine.

ACKNOWLEDGEMENT

An endeavor over a long period can only be successful with the advice and the support of many well-wishers. I take this opportunity to express our gratitude and appreciation to all of them.

I express our sincere thanks to our Chairman **Dr. K. ASHOK RAJU** for having provided all the facilities and support in completing our project successfully.

I express our sincere thanks to our Principal **Dr. K. CHANDRA SEKHAR REDDY** **M. Tech., Ph.D.** for having provided all the facilities and support in completing our project successfully.

I extremely thankful to Dr. **S. SUNIL KUMAR REDDY** **M.Tech, MISTE, Ph.D.** Head of the Department, Mechanical Engineering. For the valuable support given to us. Without whom we would not have been able to complete our work.

I wish to express my profound gratitude and thankfulness to our Project Guide **Mr. B.SIDDESWARA RAO** **M.Tech, MISTE.,** Associate Professor, Department of Mechanical Engineering for his valuable encouragement and helpful during the project work period.

I express our sincere thanks to our Coordinator **Prof. F.ANAND RAJU** **M.Tech, MISTE, (Ph.D).,** Professor, Department of Mechanical Engineering for his valuable guidance and support.

I take this opportunity to express our heart full gratitude's & thanks to our Teaching staff, Non-Teaching staff, parents & friends for their moral support through project.

REFERENCES:

[1] K.S. Chapman. "The Enhancement and Validation of a Vehicle Engine Cooling System Simulation for Use as a Cooling System Design Tool," M.S. thesis, ME, MTU, Houghton, MI, 1987.

[2] K.S. Chapman, E. Chiang, and J.H. Johnson, "The Use of the Vehicle Engine Cooling System Simulation as a Cooling System Design Tool," SAE Congress and Symposium, 880600, Detroit, MI, 1988.

[3] J. Luptowski, O. Arici, J.H. Johnson, G.G. Parker, "Development of enhanced vehicle and engine cooling system simulation and application to active cooling control". in SAE World Congress, pp. 197–210, Detroit, MI, USA, April 2005.

[4] K. Robinson, J.G. Hawley, N.A.F. Campbell, and D.G. Tilley, "A review of precision engine cooling," in International Congress and Exposition, Detroit, Mich., 1999.

[5] W.M. Kays, "Heat transmission from the engine to the atmosphere," Proceedings of the International Centre for Heat and Mass Transfer, pp. 333, 1989.

[6] M.J. Moran, H.N. Shapiro, Fundamentals of Engineering Thermodynamics, John Wiley, Hoboken, NJ 2007.

[7] W.F Stoecker. Design of Thermal Systems. New York: McGraw-Hill, 1989, pp. 80-152.

[8] S.V. Patankar, Numerical Heat Transfer and Fluid Flow, Hemisphere, Washington, D.C., 1980.

[9] F.P. Incropera, D.P. DeWitt, T.L. Bergman, A.S. Lavine, Fundamentals of Heat and Mass Transfer, John Wiley, Hoboken, NJ 2007.