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Thermal Analysis of I. C. Engine Fins by using ANSYS Software: A Conceptual Review

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ABSTRACT

Fins are the extended surfaces extending from a surface or body and which they are meant for increasing the heat transfer rate between the surfaces by increasing area for heat transfer. In present research work, attempts are made to analyze the research contributions of different researchers in the field of extended surfaces, and to identify the gaps in the research and objectives of the new research.

Keywords:— *Cooling Fins, heat transfer, extended surfaces.*

I. INTRODUCTION

In internal combustion engines (petrol engines), combustion of air and fuel takes place within the engine cylinder and hot gases are generated. Combustion within small capacity engine the temperature of hot gases reached around 1000-1500°C. This can be a really high and can result in burning of oil film between the moving elements and result into seizing of piston too. So, this temperature should be reduced to 150-200°C at which the engine can work satisfactorily (without the loss of oil film). An excessive amount of cooling is required to reduces the thermal efficiency of the system. So, the purpose of cooling system is to stay the engine running at its most effective operating temperature. There are two main types of cooling systems; water cooled and air cooled systems. In water cooled systems, cooling water is used to carry away the heat generated from the system. In air system fins or extended surfaces are provided on the cylinder walls, cylinder head, etc. Heat generate through combustion within the engine cylinder is conducted to the fins and when the air flows over the fins, heat gets dissipated by air. In present research work, investigations are made about the contributions of researchers in the field of fins. The paper acknowledges the summaries of different research works, identifies gaps in the research and objectives of new research

II. RESEARCH CONTRIBUTIONS FROM RESEARCHERS

Following are the details of research contributions from different researchers in the field of fins.

Sahu (2018)

According to researcher, to overcome the problem of overheating, especially in thermal systems, fins are usually provided. Fins can be analyzed in design phase only using Computational Fluid Dynamics as tool and assuming uniform heat transfer coefficient model on its surface. However, research investigators prove that heat dissipation is not constant, however varies along the fin length. It is mostly due to non-uniform resistance experienced by the fluid flow in the inter fin region. In order to dissipate high heat flux densities, the specified heat sink have to be larger than device. Consequently, the heat sink overall performance is decreased. The inter fin resistance can be decreased with the aid of adding the perforation to the fins. Adding a pass-fin in the middle enables to increase the heat dissipation area, but it forms the stagnant layer of hot air at the fin bottom. The fluid drift motion at the underside of the fin array may be improved by adding perforation to the fins. Also we can develop a model for the values of total heat flux and temperature distribution by using ANSYS.

Tekhre (2017)

In this research studied to investigate heat dissipative effect of fins made up of different materials and different geometries. It's necessary to analyze the heat transfer rate of fins. Study will lead to the different experiments which have been made to increase fin efficiency by changing fin material properties, climatic condition around fins, using perforations and notches in fins and fin geometry. The main thermal analysis tool is CFD analysis with the help of computer modeling software. The main study is focused on a two wheeler engine (Honda unicorn 150cc). It also founded that change in environmental condition causes great change in heat transfer coefficient and in its efficiency.

K. Sathishkumar and S. Balamurugan (2017)

This paper provides that The fins with various configurations were modeled using CREO 2.0 and analyses are done by using CFD – Fluent in order to find out the heat transfer rate. It is clear that the results from software and theoretically says that the fins with rectangular notch have greater heat transfer rate compared to that of the fins without holes, fins with holes and V shaped fins. Since the heat dissipation rate is more in rectangular notch so we conclude that the rectangular notch fins are most efficiency and best heat transfer notch among all types of notch.

Laad et al. (2016)

According to researcher, the impact of the pin-fin shapes on the general performance of the heat sink with inline and staggered arrangement is studied during this research. Six totally different shapes of fins square, trapezoidal, rectangular interrupted, rectangle, circular inline and staggered are subjected to study during this research. The optimization processes are allotted using computer simulations performed using ANSYS bench 14.0. Heat transfer was analysed in natural air and aluminum 6063 as a pin fin material. to review of thermal performance of different heat sink of fin profile at different velocities 5, 10 & 12 m/s and simulation is completed at totally different heat load of 15W, 20W & 25 W and air inlet temperature is taken as 295 K. the aim of this study is to look at the effects of the configurations of the various pin-fins design. It is determined from the results that optimum cooling is achieved by the heat sink design that contains Circular pin fins. After the choice of correct heat sink by CFD simulations the steady state thermal performance is allotted at different fin height of circular pin fin heat sink. The result shows that the temperature is increasing by reducing the fin height. At totally different loads the performance of all chosen fin profiles is allotted and located that at & 25 W load the maximum temperature is maximum for interrupted rectangular fin and minimum for circular pin fin. And therefore the price of Nusslet number is additionally maximum for circular pin fin design.

Micheli et al.(2016)

According to the researcher work analyzed for the primary time, the heat transfer from pin micro-fins. The scope of the current paper is examination thermal performance of plate micro-fin and pin micro-fin arrays underneath natural convection conditions in air. Two fin geometries are considered: plate and pin fin arrays with a similar thermal exchanging surface are tested. The investigation shows that the pin micro-fins will improve the thermal performance compared to plate micro-fin arrays. Indeed, pin micro-fins are found to have higher heat transfer coefficients and lower thermal resistances, furthermore as a much better material usage. This makes pin micro-fins able to succeed each thermal enhancement and weight reduction than plate micro-fins. The radiative heat transfer is additionally calculated: a brand new model to work out the radiative view factors of pin fins is proposed and is employed in the analysis.

Gupta and Wankhade (2015)

This paper provides the cooling mechanism of the air cooled engine is mostly enthusiastic about the fin design of the cylinder head and block. Cooling fins are accustomed increase the heat transfer rate of specific surface. Engine life and effectiveness will be improved with effective cooling. The main aim of the research is to check and examination with 100 cc Hero Honda motorbike fins and analyzes the thermal properties by varied geometry, material and thickness. Parametric models of cylinder with fins are developed to predict the transient thermal behavior. The models are created by varied the geometry like rectangular, circular shaped fins and conjointly by varied thickness of the fins 3mm and 2.5mm. The 3D modeling software used is Pro/Engineer. The analysis is completed using ANSYS. Presently Material used for producing the models is gray cast iron that has thermal conductivity of 53.3 W/mk and aluminum alloy 6063 that has thermal conductivity of 200W/mk. Researchers designed models by taking the thermal temperature of 1100^0C.

Gupta et al. (2015)

Engine performance depends on varied parameters like kinds of material use for making engine, numbers of fins used, thickness of fins, and fins shape that escort thermal result thereon. In this project our main aim is to analyses the thermal properties by using differing kinds of materials for the fins with variable sizes slots to improve its performance and scale back its price. The 3D modeling of engine with different slot sizes keeping fin size and number of fin same designed on Solid works and therefore the analysis on the ANSYS steady state. Presently Material used for manufacturing fin body (shape is cylinder) is aluminum Alloy A204 and that we are examination its performance using completely different material like aluminum alloy 6061, Aluminum alloy C443 and aluminum alloy 2014 that having higher thermal conductivities. The result shows that 75mm slotted fins of aluminum alloy 2014 having most heat transfer rate and additionally discovered that because the slots size increase higher than 75mm there will decrease in heat transfer rate.

Micheli et al. (2015)

The current research resumes the progressive of the analysis on micro-fins, so as to identify the foremost convenient fin geometry for CPV applications. The results of the investigation conducted during this work show that compared to a traditional heat sink, micro-fins will improve the thermal performance and, at the same time, lower the weight of a system. For this reason, they are significantly useful for tracked systems, such as CPV, wherever a reduced weight means that a reduced load for the tracker. The heat transfer coefficients measured through an experimental setup are used to predict the performance of a micro-finned CPV system in natural convection: an optimized fin array is found able to enhance the mass specific power up to 500th compared to an unfinned surface.

Patel and Meher (2015)

In this research, we tend to study the variation of temperature distribution; efficiency and effectiveness of porous fin for various fractional orders α, porous parameter ξ and convection parameter δ by using a domain Decomposition Sumudu transform method (ADSTM). Here the geometry thought-about is that rectangular porous fin and also the passage velocity in heat transfer through porous media is simulated by using Darcy's model.

Thammala and Rao (2015)

A model of the cylinder fin body was created using Pro/Engineer software. Then the model will be imported to analysis using FEA in this connection ANSYS software is used. ANSYS to complete thermal analysis for determining maximum heat transfer rate and minimum heat transfer rate in W/ mm2.The temperature is maximum inside the cylinder with value in 'K' and decreasing to outside still reducing on the fins. A cylinder fin body for a 150cc motorcycle is modeled using parametric software Pro/Engineer. The original model is changed by changing the thickness of the fins. The thickness of the original model is 3mm, it has been reduced to 2.5mm. By reducing the thickness of the fins, the overall weight is reduced.

Yujie et al. (2015)

Researchers report that the Offset Strip Fin (OSF) in a very plate-fin heat exchanger provides a greater heat transfer constant than plain plate-fin, but it conjointly results in an increase in flow friction. a brand new parameter, referred to as relative entropy generation distribution factor, ψ^*, is proposed to evaluate the thermodynamic advantages of OSFs. This parameter presents a ratio of relative changes of entropy generation. The relative effects of the geometrical parameters $\alpha, \gamma and \delta$ are mentioned. The results show that there exist the optimum values of α and γ at a definite flow condition that clearly maximize the degree of the heat transfer enhancement of OSFs.

Ramesh et al. (2015)

According to researchers, heat exchangers find use in many applications like in vehicles, refrigeration, air conditioning, and water treatment plants. Radiators are a category of heat exchangers in which heat transfer happens by means of air flowing across a series of finned tubes, eventually decreasing the temperature of the fluid to be cooled. The energy crises of recent times have necessitated improved heat transfer rates and at a similar time the requirement for creating heat exchangers smaller and additional energy efficient. A simple modification has been carried out in the existing configuration of radiators, with a view to boost its efficiency and has resulted in the development of a compact spiral radiator against a standard air cooled fin and tube radiators used normally especially in vehicles. During this configuration, water flows through spiral tubes, that are fitted with circumferential fins and air flows across the tubes for bringing regarding heat transfer. A numerical investigation has been carried out on the spiral radiator to study flow characteristics and thermal performance by means of local component by component analysis utilizing ε-NTU method. Experiments were performed and therefore the results after comparison with the theoretical values were found to be promising. From the experimental information, a correlation among the necessary dimensionless numbers has been obtained using GARCH tool.

Chabane et al. (2014)

Researcher reports that A single pass solar air heater with five fins attached was investigated experimentally is thermal performance. Longitudinal fins were used inferior the absorber plate to extend the heat exchange and render the flow fluid in the channel uniform. The effect of mass flow rate of air on the outlet temperature, the heat transfer in the thickness of the solar collector, and also the thermal efficiency were studied. Experiments were performed for two air mass flow rates of 0.012 and 0.016 kg s1. Moreover, the maximum efficiency values obtained for the 0.012 and 0.016 kilogram s1 with and without fins were 40.02%, 51.50% and 34.92%, 43.94%, respectively. A comparison of the results of the mass flow rates by solar collector with and without fins shows a substantial improvement in the thermal efficiency.

Chaitanya et al. (2014)

The Engine cylinder is one in all the key automobile parts that is subjected to high temperature variations and thermal stresses. So as to cool down the cylinder, fins are provided on the surface of the cylinder to extend the speed of heat transfer. By doing thermal analysis on the engine cylinder fins, it is useful to understand the heat dissipation within the cylinder. We all know that, by increasing the surface area we will increase the heat dissipation rate, therefore planning such an outsized advanced engine is incredibly troublesome. The main aim of this research is to investigate the thermal properties by varied geometry, material and thickness of cylinder fins using annoys work bench. Transient thermal analysis determines temperatures and different thermal quantities that fluctuate over time. The variation of temperature distribution over time is of interest in several applications like in cooling. The correct thermal simulation may allow important design parameters to be known for improved life. Presently Material used for manufacturing cylinder f in body is aluminum Alloy A204 that has thermal conductivity of 110-150W/mk. Present analysis is administrated for cylinder fins using this material and additionally using aluminum alloy 6061 that have higher thermal conductivities.

Suresh et al. (2014)

The Engine cylinder is one among the key automobile parts that is subjected to high temperature variations and thermal stresses. In order to cool the cylinder, fins are provided on the cylinder to increase the speed of heat transfer. By doing thermal analysis on the engine cylinder fins, it is useful to know the heat dissipation within the cylinder. The principle enforced during this project is to extend the heat dissipation rate by using the invisible working fluid, nothing however air. We all know that, by increasing the surface area we will increase the heat dissipation rate, the main purpose of these cooling fins is to cool down the engine cylinder by air. The parametric model is created in 3D modeling software Pro/Engineer. Thermal analysis is completed on the fins to see variation temperature distribution over time. The analysis is completed using ANSYS. Analysis is conducted by varying material. Presently Material used for manufacturing fin body is cast iron. During this thesis, it is replaced by aluminum alloy. Transient thermal analysis is for above two materials to validate the higher material for fin body. The die is ready by first modeling the half, extracting core & cavity and generating CNC program. Die is designed during this thesis in step with HASCO Standards.

Patel and Vora (2014)

This research provides that The Engine cylinder is one among the most important I C Engine parts that is subjected to high temperature variations and thermal stresses. To cool down the cylinder, fins are provided on the surface of the cylinder to extend the speed of heat transfer. By doing thermal analysis on the engine cylinder fins, it is useful to understand the heat dissipation within the cylinder. The principle enforced in the project is to extend the heat dissipation rate by using the invisible working fluid of air. According to researchers we all know that, by increasing the surface area we are able to increase the heat dissipation rate, therefore planning such an oversized advanced engine is extremely troublesome. The main purpose of using these cooling fins is to chill the engine cylinder by air. The main aim is that the research is to analysis thermal properties by variable geometry, material and thickness of cylinder fins. Transient thermal analysis determines temperatures and alternative thermal quantities that fluctuate over time. The variation of temperature distribution over time is of interest in several applications like in cooling. The correct thermal simulation might allow vital design parameters to be known for improved life.

Ali and Kherde (2014)

According to researcher an air-cooled motorbike engine releases heat to the atmosphere through the mode of forced convection to facilitate this, fins are provided on the outer surface of the cylinder. The heat transfer rate depends upon the velocity of the vehicle, fin geometry and therefore the ambient temperature. Insufficient removal of heat from engine can cause high thermal stresses and lower engine efficiency. The cooling fins permit the wind to maneuver the heat far from the engine. Low rate of heat transfer through fins is that the main downside of air cooling system. A trial is created to simulate the heat transfer using CFD for various shape and geometry of Fins to investigate effects on rate of heat dissipation from fins surfaces. The heat transfer surfaces of Engine are modeled in CATIA and simulated in FLUENT software. The main of aim of this work is to review different shapes and geometry of fins to boost heat transfer rate by dynamical fin geometry under different velocities.

Gupta et al. (2014)

This research studied that the development of the digital computer and its usage day by day is speedily increasing. However the reliability of electronic elements is obtaining affected critically by the temperature at that the junction operates. As operative power and speed will increase, and because the designers are forced to reduce overall systems dimensions, the issues of extracting heat and dominant temperature becomes crucial. In the last decade close to, CFD simulations became additional and additional wide utilized in the studies of electronic cooling. During this research the CFD simulation and Thermal analysis is carried out commercially with a package provided by ANSYS-FLUENT. The geometric parameters and design of heat sink for raising the thermal performance is experimented. This research utilizes CFD to spot a cooling solution for a personal computer, which uses a 5 W CPU. The design is in a position to cool down the chassis with heat sink connected to the CPU is adequate cool the entire system. This research considers the circular cylindrical pin fins and rectangular plate heat sink design with aluminum base plate and therefore the management of CPU heat sink processes.

Rairker et al. (2014)

This research studied through an experiment the impact of heat transfer of fin and tube kind heat exchanger for various mass rate of flow of fluid. The thermal stresses induced on fin and tube is additionally studied by ANSYS software at steady state condition by ever-changing the width of fin and diameter of tube. Readings were taken through an experiment by changing mass flow rate of fluid at various temperatures. Comparison was done on theoretically and through an experiment obtained results. it is determined that because the width of fin will increase thermal stresses on fin additionally will increase. Likewise for tube, by variable diameter of tube completely different values of stress are obtained. it is additionally determined at full valve position maximum thermal stresses are induced on fin further as tube.

Pal (2014)

This research addresses thermal performance of few standard designing approaches on Fins of heat sink and it is correlation with junction temperature (also referred as soldering point temperature) of LEDs cooled by natural convection. A comparative thermal simulation results has been conferred on basic rectangular fins, pin fins and trapezoidal scaled tapered fins using Solid Works Thermal Simulation. It is determined that exposed surface area, geometric placement & thermal mass of fins plays a key role decide performance of fins and heat Sink. A high power led array is employed as uniform heat load of 65 watt. an optimized heat sink has typical functional dependencies on material, fin structure, close temperature of surrounding fluid, orientation with reference to gravity, color, texture and conductivity of interface layer used between led and heat sink.

Dhanawade et al. (2014)

Researcher report that Heat dissipation could be a forceful issue to tackle as a result of continued integration, miniaturization, compacting and lightening of apparatus. Heat dissipaters are not only chosen for his or her thermal performance; however additionally for alternative design parameters that has weight, price and reliability, depending on application. The current paper reports an experimental study to analyze the heat transfer improvement over horizontal flat surface with rectangular fin arrays with Lateral Square and circular perforation by forced convection. The cross sectional area of the rectangular duct was 200 millimeter x 80 millimeter. the information utilized in performance analysis were obtained by experimentation for fin arrays of material aluminum, by variable geometry and size of perforation also as by variable Reynolds number from 21 104 to 8.7 104. It is determined that the Reynolds number and size perforation have a bigger impact on Nusselt number for the each kind of perforations.

Torabi et al. (2013)

This paper provides heat transfer analysis in a very straight fin with a step modification in thickness and variable thermal conductivity that is losing heat by simultaneous convection and radiation. The calculations are applied by using the differential transformation method (DTM) that may be applied to varied kinds of differential equations. The results obtained using DTM are compared with an correct numerical solution to verify the accuracy of the planned method. Many graphs are provided for example however the temperature distribution is full of the

(i) thickness parameter,

(ii) dimensionless fin semi thickness,

(iii) length ratio,

(iv) thermal conductivity parameter,

(v) Biot's number, and

(vi) radiation-conduction parameter.

This assortment of graphs provides a comprehensive picture of the thermal performance of the system below steady state conditions.

Ismail et al. (2013)

Researchers report that micro heat sinks are adopted in electronics cooling along with totally different technologies to boost the heat transfer process. To improve the cooling performance of heat sink, perforations like small channels of square and circular cross sections are organized alongside stream wise fin's length. A numerical investigation is conducted in this study for three-dimensional fluid flow and convective heat transfer from an array of solid and perforated fins that are mounted on a flat plate. Incompressible air as working fluid is modeled using the Navier–Stokes equations and RNG based mostly k-turbulent model is employed to predict turbulent flow parameters. Temperature field within the fins is obtained by solving Fourier law of heat conduction equation. Flow and heat transfer characteristics are given for Reynolds numbers from 2×104 to 3.9 ×104 based on the fin length and Prandtl number is taken as Pr = 0.71. Numerical simulation is valid with the revealed experimental results of the previous investigators and smart agreement is determined. Results show that the fins of circular perforations have exceptional heat transfer enhancement and reduced pressure drop. The results of this study will help designing micro heat sinks for heat removal from electronic devices.

Tamayol et al. (2012)

Passive heat transfer from enclosures with rectangular fins is studied both through an experiment and in theory. Many sample enclosures with numerous lengths are prepared and tested. To calibrate the thermal measurements and also the analyses, enclosures without fins are prepared and tested. Surface temperature distribution is decided for varied enclosure lengths and heat generation rates. Existing relationships for natural convection and radiation heat transfer are accustomed calculate the heat transfer rate from the tested samples. The theoretical results with success predict the trends determined in the experimental information. it is determined that the contribution of the radiation heat transfer is on the order of 50% of the overall heat transfer for the tested enclosures. As such, a new correlation is reported for calculating an optimum fin spacing for vertically-mounted uniformly finned surfaces, with rectangular straight fins that takes into consideration each natural convection and radiation.

2.1 Gaps in the Research and Objectives of New Research

On the basis of literature survey, following research gaps are being investigated.

1. There is very limited research based on effect of materials change on fin performance;

2. There is very limited research which compares different thermal properties of fins.

Based on above mentioned research gaps, following objectives of the new research are being formulated.

Following are the objectives of the research:

1. To create a simulation model of IC engine fins; and
2. To analyze the effect of material changes on thermal characteristics of IC engine.

III. Conclusion

The research work tells about the investigations in fin research, gaps identified in the survey of literature and objectives of research. Survey of literature helps in knowing the contributions in the field of study, which makes a baseline assessment for analyzing the problem. On the basis of present research work, a new research work shall be initiated which shall be leading in the direction of enhanced performance of internal combustion engines.

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