Enhancement of Heat Transfer Rate Using Transient Thermal Analysis For Actual And Proposed Design of The Single Cylinder Air Cooled Four Stroke Spark Ignition Engine: A Review

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Abstract - Heat transfer from the IC engine take place in all modes like conduction, convection & radiation. About 25 % of the fuel energy is converted into useful work and the remaining 75% to be transferred from the engine to the environment. The calculation of engine heat transfer is very difficult because the engine geometry is complex and there are periodic air and fuel flow during the entire cycle. The main object of this paper to make a literature survey on the heat transfer from the internal combustion engine and study that how much work have been done so far. For that lot of literature published in various reputed national and international journals have been studies and It can be understood clearly from the review the current status of research both experimental and theoretical findings leaves much more to be done on the field of heat transfer from the internal combustion engine. In the present paper it has been try to briefly summarize the work status have been done yet and also indicate that what authors feel needed to be done in future work.

Key words: Heat Transfer study, IC engine, literature study etc.

I. INTRODUCTION

Combustion temperature in the IC engines cylinders can be reached the values of 2700 K and more without sufficient cooling. The higher temperatures of this magnitude would destroy engine components quickly and lubricants used for cooling.

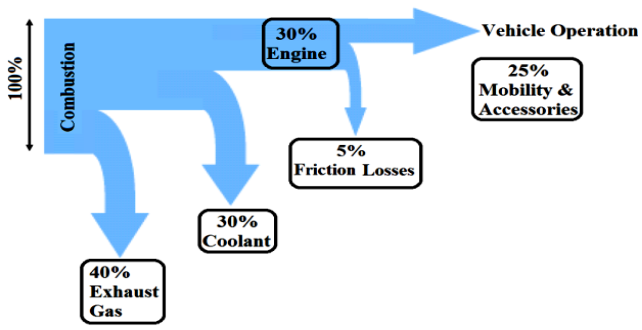

Figure 1: Energy transfer in internal combustion engine vehicle

Heat removed from engine cylinder is finally dissipated in the surroundings. Heat removed from overheated engine to the atmosphere transfer large percent of the generated heat from the engine due to transfer of Heat from the engines the brake thermal efficiency lie between 30-40%. [1]

II. LITERATURE REVIEW

Xueying Li at el [2] They investigated experimentally A typical end-wall configuration with matched non-dimensional parameters to the engine condition in this study. They use four different coolants to mainstream mass flow ratios were tested in a linear cascade. The temperature sensitive paint and pressure sensitive paint were used to get these parameters. One dimensional and two dimensional methods for overall effectiveness prediction based on experimental data for separate parameters and correlations were also studied.

Ravindra D. Jilte, Jayant K. Nayak & Shireesh B. Kedare [3] In this work an experimental testing have been done to analyze the heat losses from the cylindrical solar cavity. Tests are carried out under the temperature range from 225°C to 425°C at cavity inclination from 0° to 90° in steps of 30°. They observed that for off-flux investigation of solar cavity receiver with the differential heating arrangement. The total loss is found at sideways (θ = 0°). It decreases by 43-51% when the inclination was 90°. The conduction loss is found to accounts up to 32-34 % of the total heat loss whereas cavity radiative losses is estimated 13%, 16% and 20% of total heat loss respectively for cavity wall temperature 225°C, 325 °C and 425°C. The convective loss is found to accounts up to 46- 54 % of total heat loss when the cavity aperture is facing sideways (θ = 0°), whereas its value reduces to up to 4 % of total heat loss when the inclination was 90°.

Brajesh Kumar & Sanjay Kumbhare[4] they proposed three design of IC engine. Mathematical and analytical studies were performed in order to optimize

geometrical parameters for natural convective heat transfer from Actual cylinder block and proposed cylinder block. The transient thermal analysis in ANSYS v16.0 was performed on two different ambient temperatures; the first one is on 25 ^{o}C & another one is on 45 ^{o}C. They found that lower temperature is much below in proposed design-2 hence the proposed design -2 of cylinder block has better performance and heat dissipation from the heating zone in the IC engine.

Vijayakumar P, Sathyamoorthy G & Velavan R [5] The present paper is aiming to enhancing the performance of I.C engine, in order to change the fin materials and geometry. It is an attempt to study and analyze the internal combustion engine fins for maximizing the performance by considering different geometrical profile, fin material, and variable fin length for weight reduction. Fins are analyzed with different fin profiles, fin materials, variable fin profile and with minimal cooling conditions for an air cooled diesel engine of 5 H P. From the investigation they observed Trapezoidal profile or Stepped rectangular profile adoption will result in material saving and increases in performance.

Ashkan Alimoradi [6] In this work the effect of operational and geometrical parameters on the thermal effectiveness of shell and helically coiled tube heat exchangers was investigated. Analysis was performed for the steady state. The working fluid of both sides is water. They found for same values of NTU and Cr, the effectiveness is averagely 12.6% less than the effectiveness of parallel flow heat exchangers and this difference is approximately constant.

Adnan M. Hussein, H.K. Dawood, R.A. Bakara & K. Kadirgamaa [7] In this paper the friction factor and forced convection heat transfer of TiO_2 nano particles dispersed in water in a car radiator. Four different nano fluid volume concentrations (1%, 2%, 3% and 4%) were used The Reynolds number and inlet temperature ranged from 10000 to 100000 and from 60 to 90 °C, respectively. It has been concluded that the used nanofluid at low concentration can improve the heat transfer efficiency upto 20% as compared with pure water.

Pooya Arbabi, Abbas Abbassi, Zohreh Mansoori, Mohammad Seyfi [8] This work is devoted to provide a numerical model to estimate the amount of generated power and recovered heat, based on the engine performance features. Grey Systems Theory is proposed as a multi decision making strategy to determine the optimal engine. Applying the numerical model on engines provides the efficiency,power and heat production characteristics of the engine.

Teresa Castiglione, Sergio Bova & Mario Belli [9] This paper presents results of the Model Predictive Controller methodology applied to the cooling system of an Internal Combustion Engine. The proposed controller is evaluated during the city driving part of the NEDC homologation cycle, and replaced at the engine test rig. The results show that the proposed controller is robust in terms of disturbance rejection and is effective in reducing warm up time.

Chidiebere Okeke-Richard & Sunny Sharma [10] They analyze cylinder blocks of four stroke SI engine of two wheeler of three different companies HONDA, TVS, YAMAHA, in order to find out the thermal effects of combustion gases with respect to change in temperature and heat flux throughout the analysis time, and to also compare the three blocks. A replica of these blocks each is first designed using Solid Works design software. These blocks are then analyzed using ANSYS software to find the thermal effects.

G.Bahadur Vali & Krishna Veni [11] In this project they have designed an assembly of cylinder and cylinder head. The materials used as two different Aluminum alloys 6061 and 7475.Thermal analysis is done on the cylinder to determine the thermal behavior for two aluminum alloys for original model and also by reducing the thickness of the cylinder head. By reducing the thickness, the weight of the component reduces. They observe thermal analysis results where fluxes are more for the modified model and conclude that using Aluminum alloy 6061 with reduced thickness of cylinder is better.

Abhishek Mote at el [12] they analysis of heat transfer across finned surfaces is done using CFD software. CFD software was used to simulate the heat transfer across fins of an IC Engine. The simulated results were found to be comparable with experimental results.

KM Sajesh, Neelesh Soni and Siddhartha Kosti [13] They perform CFD analysis of a rectangular fin engine of two wheeler bike. Hear they made modification in design of engine is made by creating holes on fin. Transient and Steady state heat transfer simulation is carried out on the engine for a period of 400 seconds. Transient temperature of all fins has reached to steady state temperatures fin with a hole of 10 mm diameter has decrease the minimum temperature of 1036.5 K for an imperforated fin to a minimum temperature of 989.03K.

Mr. Manir Alam & Mrs. M. Durga Sushmitha[14] They worked on a cylinder fin of motorcycle, the original model is changed by changing the geometry of the fins, distance between the fins and thickness. By observing the thermal analysis results, thermal flux is more for Aluminum alloy than other two materials and also by using Aluminum alloy its weight is less.

V.A. Romanov & N.A. Khozeniuk [15] The cooling system of the designed diesel engine was investigated

using specially prepared models. they found that the uniformity of the cylinder cooling and the intensity of cooling of the cylinder heads can be controlled by choice of the place of coolant penetration into the jacket for the considered design of a crankcase and cylinder heads.

Shubham Shrivastava & Shikar Upadhyay [16] cylinder block was made in 3D software Solidworks in which perpendicular fins are mounted. After that modification is done in engine cylinder block fins, thickness is reduced from 3 mm to 2 mm. so that weight will reduced, second thing to choose material which has to replace the existing materials, in this analysis aluminium alloy 1050 is chosen for thermal analysis. By doing this weight of block reduced to 13.2 %, and due to material change weight reduced 2.1 % without compromising with strength.

P.T. Nitnaware & Prachi S. Giri [17] They investigate the effect of fin geometries, coefficient of heat transfer coefficient and material for the heat loss by air cooling in IC engine. The rate of heat transfer increases with increase in h, linearly, for small values of h. they conclude that aluminum is the superior material for designing of fins for air cooled IC engines due to low weight.

H.Sumithra & B. Sandhya Rani [18] After doing the three different analysis with three different materials, they found that the maximum stresses for those three materials. Before Modification For Material Aluminum-92, Material Aluminum-96 and Material Aluminum- Silican Nitrate the maximum temperatures are 671.45, 665.74 and 505.73. After Modification maximum temperatures are 459.68, 449.91 and 294.95.Finally they concluded that the Silican Nitrate was the best material among all.

M Syamala Devi1, E Venkateswara Rao & K Sunil Ratna Kumar [19] From this analysis they concluded that shape and thickness along with material plays an important role of heat transfer from the fins. They found that the elliptical shape fins having best results than the rectangular and triangular fins. They observed 2 mm thickness is giving the better results compared to 3 & 2.5 mm thickness. they also analyzed that Al alloy is giving the better results compared to the LM13 .

Athirah Abdul Aziz, at el [20] They proposed the design of modular cylinder head for a 150 cc racing motorcycle engine which provides the flexibility to change the internal architecture and use different components in the cylinder head to achieve the desired engine performance. The heat transfer from exhaust gases are minimized by shortening the length of exhaust manifold. The cylinder head is divided into three parts consisting of the cylinder head cover, the valve train housing and the combustion chamber.

Gokul Karthik [21] The main aim of the project is to analyze the thermal properties and to increase the air flow efficiency of two wheelers by varying geometry of the fins. The model is created by varying the geometry of the fins. The three dimensional modeling software used is Pro/Engineer. The analysis is done using ANSYS. Presently Material used for manufacturing cylinder fin body is Aluminum 1060 Alloy which has thermal conductivity of 202.4W/mk.

Shamim Alam & Dr. Gaurav Tiwari [22] They Investigate that if excess heat is not removed engine components fail due to excessive temperature. Only approximately 25-30% of the energy released is converted into useful work. The remaining 70% must be removed from the engine to prevent the parts from melting. They work to increase the efficiency of fins by changing the geometry of engine fins used in two wheeler four stroke internal combustion engine.

Ashwin Shridhar at el [23] They performed CFD analysis on helical airfoil fin model with a standard rectangular cross section circular finned .They obtained the Velocity distribution, Temperature distribution and the heat transfer coefficient distribution for both the models in the form of contour and scatter plots. They conclude that the helical airfoil model is more efficient than the circular fin model with rectangular cross-section.

A.C.Deshpande & Mohd. Razik [24] They Investigate that there is a scope of improvement in heat transfer of air cooled engine cylinder fin. From this work after experiment values and FEA validation they concluded that contact surface available for the air flow over the fin is also important factor in heat transfer rate. If the turbulence of air is increased by changing the design and geometry of the fins will increase rate of heat transfer.

Mahendran.V & Venkatasalakumar.A [25] They investigate a cylinder fin body for Bajaj CT 100cc motorcycle The thickness of the original model is 3mm, in this work they reduced thickness 2 mm. The fin shape is Rectangular with curves at corner. They used Circular fins with radius of 0.5 mm. and material is Cast Iron. they performed thermal analysis using cast iron and aluminum alloy 6061.

Padhiyar Abhesinh J & Vasim G Machhar [26] They improve heat transfer rate of cooling fins by changing cylinder block fin geometry in honda. They state that modified fins are more effectively heat transfer in Honda shine bike compare to existing fins. After FEA Analysis it checking on fin whether efficiency of heat transfers increases or not. This work validation with Experimental and Mathematical.

K. Ashok Reddy, T. V. Seshi Reddy and S Satpagiri[27] They investigate comparing theoretical

values with analytical values of existing rectangular cylinder head. After changing cylinder head to circular shape and conducting the same experiments with same boundary conditions they got the difference in the efficiency as around 3%. They performed steady state thermal analysis for rectangular and circular fins and conducted that the circular fin are more suitable than rectangular fins.

Sachin Kumar Gupta, Harishchandra Thakur & Divyank Dubey[28] They analyses the thermal properties by using different types of materials for the fins with variable sizes slots to improve its performance and reduce its cost. The three dimensional modeling of engine with different slot sizes keeping fin size and number of fin same designed on Solidworks and the analysis on the ANSYS steady state. Presently Material used for manufacturing cylinder fin body is Aluminium Alloy A204 and compare different material like Aluminium alloy 6061, Aluminium alloy C443 and Aluminium alloy 2014. The result shows that fins of Aluminium alloy 2014 having maximum heat transfer rate.

Dinesh kumar. S & Sriprashanth.V [29] They study the performed an analysis of diesel engine by changing the cylinder wall like sleeve material. The scope of this work is to select proper material for the cylinder liners so that the heat loss through liner wall in IC engine can be reduced. To achieve this low thermal conductivity materials with required mechanical properties is considered and compared.

Mohsin A. Ali and Dr. S.M Kherde [30] They performed CFD analysis on a motor cycle engine. A conclusions derived from this work are highlighted below. 1) Models for three different shapes of Fins were developed and effects of wind velocity and heat transfer coefficient values were investigated. 2) An Analysis is carried out in Ansys Fluent to find the effect of change in geometry of Fins in terns of HTC and air turbulence. 3) Heat transfer rate increases after changing fin geometry and it is observed that HTC and turbulence are more in case of step shape fin model as compare to S shape Fin model. Due to non uniform in the geometry of fins turbulence of flowing air increases which results in more heat transfer rate.

Aswin Mohan at el [31] They performed heat transfer simulation on aluminium fins at three different speed. Minimum temperature variation is absorbed at all loads and speeds without cooling. CFD is done for aluminium and hybrid fins. Hybrid fins shows better heat transfer rate than normal fins. More heat is rejected from the engine from hybrid fins than from normal fins. The temperature of the fluid is increased by an average of $4.75^{o}C$, $3.81^{o}C$, $4.3^{o}C$ respectively.

Subodh Kumar Sharma at el [32] They investigate that as the engine load increases temperature of the piston and cylinder wall increases exponentially. The proposed methodology can also be extended to determine temperatures of other components of the combustion chamber the temperatures together with experimental measurements and the estimated calculation can be used to obtain an integral heat engine losses model for the engine.

T.M.Yunus khan, Irfan Anjum Badruddin at el [33] They reviews the effects of different engine variables such as compression ratio, load and speed, fuel injection parameters, air swirl, piston design on the performance of engine. Special attention has been paid on the future automotive engines which would be significantly governed by electronic systems. According to use the same technology can also be employed in analyzing engines running on bio fuels.

Pudiri Madhu, N. Sateesh at el.[34] They investigate a cylinder fin body for 150cc motorcycle is modeled using parametric software Pro/Engineer. The thickness of the original model is 3mm. and it is reduced to 2.5mm. Present used materials for fin body are Al 204, CI and Al 6061. they performed thermal analysis for three materials Cast Iron, Aluminum Alloy 204, and Aluminum alloy 6061. By observing the thermal analysis results, thermal flux is more for Aluminum alloy 6061 than other two materials.

Mr. PREM PRAKASH PANDIT & Dr. P S CHAUHAN [35] They study different shapes of fin have been studied by changing the length of the fin. Aluminium has been used as a fin material. A mathematical formulation has been developed in this wok which can be used to study the effect of fin length and fin material for any real fin problem. Using the above formulation one can also study the temperature contour inside the fin for any fin length and fin material. MATLAB will be used to code the algebraic governing equation.

Andrew Roberts, Richard Brooks, Philip Shipway [36] They found that the thermal efficiency of the internal combustion engine is significantly lower at cold-start than when the vehicle reaches steady state temperatures. The approaches have a common theme of attempting to reduce energy losses so that systems and components reach their intended operating temperature range as soon as possible after engine start. they observed at the target operating temperature. The approaches used to tackle the problem include the use of phase change materials and the use of thermal barrier coatings in an attempt to insulate the cylinder bore and prevent heat loss. a critical review of the research into vehicle thermal management during the cold-start phase which has been driven by a desire to improve both engine and overall vehicle engine efficiency.

G. siva kumar & S. Senthil kumar[37] They perform experimental investigation under different loading conditions in a three cylinder diesel engine with its piston crown with yttria stabilized zirconia to understand the influence of the thermal barrier coating on performance and emission characteristic in comparison with baseline engine characteristics. For the measurement of emission characteristics, ISO 8178-4 'c' 8 mode testing cycle procedure is followed. Results show that the heat loss from the cooling water is reduced up to 5-10% and thermal efficiency is increased by 3 -5% with reduction of brake specific fuel consumption upto 28.29% & hydrocarbon emission and carbon monoxide upto 35.17%, and 2.72% where carbon dioxide emission is increased by up to 5.6%.

Rolf D. Reitz, & Ganesh Duraisamy [38] They worked in the area of high efficiency and clean internal combustion engines. They try to increase fuel efficiency while simultaneously meeting emissions consent has thus motivated considerable research they describe recent progress to improve the fuel efficiency of diesel engines through the controlled compression ignition which are the variant of homogeneous charge compression ignition is highlighted since it provides more efficient control over the combustion process and have capability to lower fuel use and pollutant emissions.

III. CONCLUSION

A lot of literatures have been studies and reviews all research work done on heat transfer from an IC engine. It has been noted from above literature that heat transfer from the IC engine can be increased by three ways, first is to increase surface area by changing its geometry of fins to explore heat from the heated area, second is to increase the value of convective coefficient and third is to increase temperature difference, but it has limitation due to atmospheric conditions. Many researchers performed their research work by changing the geometry of fined surface of the IC engine and its material also. As per available literatures there is a little work available on changing fins geometry with intercooler till date, so there is a scope to work on single cylinder four stroke SI engine by changing its geometrical design and other parameters.

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