A review on Heat Exchanger used in internal Combustion engine based on Rankin Cycle in order to improve the performance of engine

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***Abstract*: Most of the heat from automobiles (mostly diesel engines) is being wasted in different forms. This waste heat if recovered can be used for various other applications. The increasingly worldwide problem regarding rapid economy development and a relative shortage of energy, the internal combustion engine exhaust waste heat and environmental pollution has been more emphasized heavily recently. Out of the total heat supplied to the engine in the form of fuel, approximately, 30 to 40% is converted into useful mechanical work; the remaining heat is expelled to the environment through exhaust gases and engine cooling systems, resulting in to entropy rise and serious environmental pollution, so it is required to utilized waste heat into useful work. The exhaust gas temperature at 4000 RPM has got the maximum temperature. So a recovery system for aconstant RPM of 4000 is designed. The recovery system consists of a shell and tube heat exchanger and a uniflow steam engine which is coupled to the main engine. The coupled steam engine improves the efficiency of the main engine by lowering the frictional power at the power stroke and idle stroke of the main engine. The initial cost of the system is high due to the additional recovery system. But in the long run the system proves to be profitable.**

INTRODUCTION

The heat exchangers are found to have a wide range of applications ranging from the house-hold purposes to refineries andcryogenic operations. These heat exchangers had become the essential requirement of the current society as they do not cause any harmful effects to the environments. The cost involved in this energy extraction is also very less and economical. One of the concerns regarding these heat exchangers is to enhance the heat transfer and improve their efficiency. The survey and researches had been carried out in a large manner to improve the heat transfer enhancements. In this context, an objective is set to review the literature related to heat exchangers under the following categories: general study of heat exchangers, various configurations of heat exchangers, the compact heat exchangers and the effects of nanofluid in the heat transfer enhancements.

Moreover, increasingly stringent emissions regulations are causing enginemanufacturers to limit combustion temperatures and pressures lowering potential efficiency gains [1]. As the most widely used source of primary power for machinery critical to the transportation, construction and agricultural sectors, engine has consumed more than 60% of fossil oil. On the other hand, legislation of exhaust emission levels has focused on carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM). Energy conservation on engine is one of best ways to deal with these problems since it can improve the energy utilization efficiency of engine and reduces emissions [2,]. Given the importance of increasing energy conversion efficiency for reducing both the fuel consumption and emissions of engine, scientists and engineers have done lots of successful research to improve engine thermal efficiency, including supercharge, lean mixture combustion, etc. However, in all the energy saving technologies studied.

POSSIBILITY OF HEAT RECOVERY ANDAVAILABILITY FROM I.C. ENGINE

Waste heat is heat, which is generated in a process by wayof fuel combustion or chemical reaction, and then "dumped"into the environment even though it could still be reused for some useful and economic purpose. This heat depends in part on the temperature of the waste heat gases and mass flow rate of exhaust gas. Waste heat losses arise both from equipment inefficiencies and from thermodynamic limitations on equipment and processes. For example, consider internal combustion engine approximately 30 to 40% is converted into useful mechanical work. The remaining heat is expelled to the environment through exhaust gases and engine cooling systems [4]. It means approximately 60 to 70% energy losses as a waste heat through exhaust (30% as engine coolingsystem and 30 to 40% as environment through exhaust gas). Exhaust gases immediately leaving the engine can have temperatures as high as 842-1112°F [450-600°C]. Consequently, these gases have high heat content, carrying away as exhaust emission. Efforts can be made to design more energy efficient reverberatory engine with better heat transfer and lower exhaust temperatures; however, the laws of thermodynamics place a lower limit on the temperature of exhaust gases.

POSSIBILITY OF WASTE HEAT FROM INTERNAL COMBUSTION ENGINE

Today's modern life is greatly depends on automobile engine, i.e. Internal Combustion engines. The majority of vehicles are still powered by either spark ignition (SI) orcompression ignition (CI) engines. CI engines also known as diesel engines have a wide

field of applications and as energy converters they are characterized by their high efficiency. Small air-cooled diesel engines of up to 35 kW output are used for irrigation purpose, small agricultural tractors and construction machines whereas large farms employ tractors of up to 150 kW output. Water or air-cooled engines are used for a range of 35-150 kW and unless strictly air cooled engine is required, water-cooled engines are preferred for higher power ranges. Earth moving machinery uses engines with an output of up to 520 kW or even higher, up to 740 kW. Marine and locomotive applications usually employ engines with an output range of 150 kW or more. Trucks and road engines usually use high speed diesel engines with 220 kW output or more. Diesel engines are used in small electrical power generating units or as standby units for medium capacity power stations.

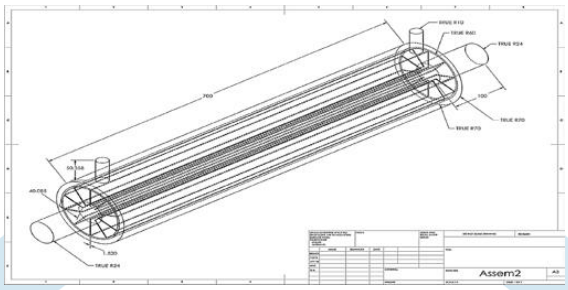

Fig.1 Optimized Heat Exchanger

EXISTING RESEARCH EFFORT

NopparatKatkhawa et al. (2013) studied the different types of dimple arrangements and dimple intervals. They studied the heattransfer characteristics in case of external flow conditions. The stream of air flows over the heated surface with dimples. The velocity of air stream varies from 1 to 5 m/s. The temperature of the air stream and dimpled surfaces were measured. Since the usage of baffles, fins and turbulizers for the conventional enhanced heat transfer approaches results in a significant pressure drop of the stream, the dimples are preferred. In this paper, the dimple arrangements (staggered and inline) with various dimple pitches are compared and studied.

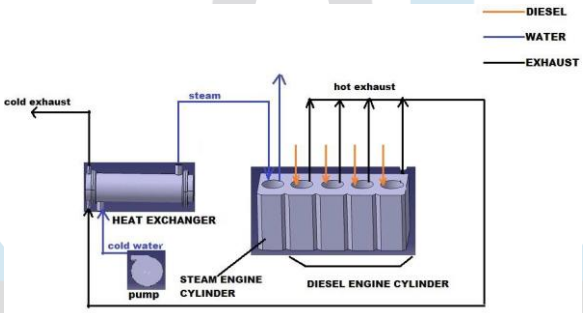

Fig.2: Schematic Representation of the System

Hitami et al. (2014) had done the numerical study of the finned type heat exchangers for IC Engines exhaust waste heat recovery. Two cases of heat exchangers are studied as follows: one type of heat exchanger is used in the Spark ignition exhaust recovery system and another type of heat exchanger is used in the Compression ignition exhaust recovery system. The Compression engine heat recovery system has water as cold fluid while in case of the Spark ignition system, a mixture of water (50%) and ethylene glycol (50%) has been used as cold fluid.

Vahabzadeh et al. (2014) had done the analytical investigation of porous pin fins with variable sections in fully wet conditions. Thepaper holds the investigations for the temperature distribution, efficiency, heat transfer rate and optimization of the porous pin fins in fully wet conditions. The aluminum made fins are used and they are tip insulated. The temperature of fin determines the heat transfer coefficient. Using the energy balance, Darcy model and Least Square Method (LSM), the analytical solution for temperature distribution is obtained. The geometric and thermo graphical parameters (power index for geometry, porosity, Biotnumber and relative humidity) are analyzed.

Eiamsa-ard et al. (2014) assessed the thermal performance of a heat exchanger tube equipped with regularly- spaced twisted tapes asswirl generators. The factors like heat transfer, friction factors and thermal performance factors in a heat exchanger are reported in case of a heat exchanger provided with the regularly - spaced twisted tape (RS-TT) across fluid flow. This is studied in comparison with the effect of full length twisted tape. Further, the physical behavior of fluid flow, fluid temperature and Nusselt number are observed.

Srinivasan et al. (2014) had investigated the ways to improve the effectiveness of the shell and tube heat exchangers byimplementation of Six sigma DMAIC (Define- Measure- Analysis- Improve-Control). Define phase – the Critical to Quality (CTQ) parameters are identified. Measure Phase – the effectiveness of the exchanger has been measured as 0.61. Analysis Phase – the reasons for the effectiveness reductions are identified. Improve Phase – Existing design has been modified by brainstorming and the solutions are identified. Control Phase – Strategies are recommended for improving performance. The effectiveness of the exchangers has been improved by recovering the heat energy of the exhaust (flue) gas by using the circular fins rolled over the tubes.

Jiin-Yuh Jang et al. (2013) conducted an analysis regarding the span angle and location of the vortex generators provided in a platefin and tube heat exchanger with in-line and staggered arrangements. Block type vortex generators are mounted behind these tubes. Comparing the plain surface and surface with vortex generators, the area reduction ratio is better in surface with vortex generators. Span angle range considered for vortex generators is from 30° to 60° and transverse location (Ly) range is from 2mm to 20mm. In-line arrangements in above exchangers is considered to be more effective regarding heat transfer enhancements

REFERENCES

[1] T. Endo, S. Kawajiri, Y. Kojima, K. Takahashi, T. Baba, S. Ibaraki, T. Takahashi, "Study on Maximizing Exergy in Automotive Engines," SAE Int. Publication 2007-01-0257, 2007.

[2] K. NanthaGopal, RayapatiSubbarao, V. Pandiyarajan, R. Velraj, "Thermodynamic analysis of a diesel engine integrated with a PCM based energy storage system," International Journal of Thermodynamics 13 (1) (2010) 15-21.

[3] HakanÖzcan, M.S. Söylemez, "Thermal balance of a LPG fuelled, four stroke SI engine with water addition," Energy Conversion and Management 47 (5) (2006) 570-581.

[4] P. Sathiamurthi, "Design and Development of Waste Heat Recovery System for air Conditioning," Unit European Journal of Scientific Research, Vol.54 No.1 (2011), pp.102-110, 2011.

[5] S. Karellasa, A.-D.Leontaritisa, G. Panousisa , E. Bellos A, E. Kakaras, "Energetic And Exergetic Analysis Of Waste Heat Recovery Systems In The Cement Industry," Proceedings of ECOS 2012 - The 25th International Conference On Efficiency, Cost, Optimization, Simulation And Environmental Impact Of Energy Systems June 26-29, 2012, Perugia, Italy.

[6] H. Teng, G. Regner, C. Cowland, "Waste Heat Recovery of Heavy-Duty Diesel Engines by Organic Rankine Cycle Part I: Hybrid Energy System of Diesel and Rankine Engines," SAE Int. Publication 2007-01-0537 (2007).

[7] M. Hatazawa, "Performance of a thermo acoustic sound wave generator driven with waste heat of automobile gasoline engine," Transactions of the Japan Society of Mechanical Engineers 70 (689) (2004) 292–299. Part B.

[8] Diego A. Arias, Timothy A. Shedd, Ryan K. Jester, "Theoretical analysis of waste heat recovery from an internal combustion engine in a hybrid vehicle," SAE paper 2006-01-1605.

[9] J. Vazaquez, M.A. Zanz-Bobi, R. Palacios, A. Arenas, "State of the art of thermoelectric generators based on heat recovered from the exhaust gases of automobiles," Proceedings of 7th European workshop on thermoelectric, 2002.S.

[10] X. Liu, Y.D. Deng, K. Zhang, M. Xu, Y. Xu, C.Q. Su, "Experimentsand simulations on heat exchangers in thermoelectric generator for automotive application," Elsevier. Applied Thermal Engineering, vol. 71, pp. 364-370,July. 2014.

[11] ZhiqiangNiu, HaiDiao, Shuhai Yu, Kui Jiao , Qing Du, GequnShu, "Investigation and design optimization of exhaust-based thermoelectric generator system for internal combustion engine," Elsevier. EnergyConversion and Management, vol. 85, pp. 85-101, Jun. 2014.

[12] HuaTian , Xiuxiu Sun , Qi Jia, Xingyu Liang , GequnShu , XuWang, "Comparison and parameter optimization of a segmentednhermoelectric generator by using the high temperature exhaust of a diesel engine," Elsevier. Energy, Article in Press.

[13] N.D. Love, J.P. Szybist , C.S. Sluder, "Sluder Effect of heat exchanger material and fouling on thermoelectric exhaust heat recovery," Elsevier.Applied Energy, vol. 89, pp. 322-328, Aug. 2012.

[14] S Bari, S N Hossain,", Design and Optimization of Compact Heat Exchangers to be Retrofitted into a Vehicle for Heat Recovery from a Diesel Engine," Elsevier. Procedia Engineering, vol. 105, pp. 472-479, 2012.

[15] Tongcai Wang, Weiling Luan, Wei Wang, Shan-Tung Tu, "Waste heat recovery through plate heat exchanger based thermoelectric generator system," Elsevier.Applied Energy, vol. 136, pp. 860-865, Sep. 2014.

[16] Chi Lu, Shixue Wang, Chen Chen, Yanzhe Li, "Effects of heat enhancement for exhaust heat exchanger on the performance of thermoelectric generator," Elsevier. Applied Thermal Engineering, vol. 89, pp. 270-279, Jun. 2015.

[17] ShekhNisarHossain, Saiful Bari, "Waste heat recovery from the exhaust of a diesel generator using Rankine Cycle," Elsevier. EnergyConversion and Management, vol. 61, pp. 355-363, Aug. 2013.

[18] V. Dolz, R. Novella, A. García, J. Sanchez, "HD Diesel engine equipped with a bottoming Rankine cycle as a waste heat recovery system. Part 1: Study and analysis of the waste heat energy," Elsevier.Applied Thermal Engineering, vol. 36, pp. 269-278, Oct. 2012.

[19] AntónioDomingues ,Helder Santos, Mário Costa, "Analysis of vehicle exhaust waste heat recovery potential using a Rankine cycle," Elsevier. Energy, vol. 49, pp. 71-85, Dec. 2013.

[20] C.O. Katsanos, D.T. Hountalas, E.G. Pariotis, "Thermodynamic analysis of a Rankine cycle applied on a diesel truck engine using steam and organic medium," Elsevier. Energy Conversion and Management, vol. 60, pp. 68-76, Mar. 2012.

[21] Dimitrios T. Hountalas, Georgios C. Mavropoulos, Christos Katsanos, Walter Knecht, "Improvement of bottoming cycle efficiency and heat rejection for HD truck applications by utilization of EGR and CAC heat," Elsevier. Energy Conversion and Management, vol. 53, pp. 19-32, Sep. 2012.

[22] Seokhwan Lee, ChoongsikBae, "Design of a heat exchanger to reduce the exhaust temperature in a spark-ignitionengine," Elsevier. InternationalJournal of Thermal Sciences, vol. 47, pp. 468-478, May. 2008.