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A OVERVIEW OF THE RANKIN CYCLE-BASED HEAT EXCHANGER USED IN INTERNAL COMBUSTION ENGINES TO ENHANCE ENGINE PERFORMANCE

A Shiva Reddy[1] and Dr. Dhananjay Yadav[2]

[1]Research Scholar, Department of Mechanical Engineering at SSSUTMS, Sehore, Madhya Pradesh, India

[2]Professor, Department of Mechanical Engineering at SSSUTMS, Sehore, Madhya Pradesh, India

ABSTRACT

The majority of the heat produced by automobiles, primarily by diesel engines, is squandered in various ways. If this waste heat is collected, it can be applied in a variety of other ways. Recently, increased emphasis has been placed on the global issue of rapid economic growth, a relative energy scarcity, internal combustion engine exhaust waste heat, and environmental degradation. The remaining heat is released into the environment through exhaust gases and engine cooling systems, leading to an increase in entropy and significant environmental pollution, so it is necessary to convert waste heat into useful work. Of the total heat supplied to the engine in the form of fuel, approximately 30 to 40% is converted into useful mechanical work. At 4000 RPM, the exhaust gas temperature is at its highest. So a recovery system is created for a constant RPM of 4000. A shell and tube heat exchanger and a uniflow steam engine connected to the main engine make up the recovery system. By reducing the frictional power at the main engine's power stroke and idle stroke, the linked steam engine increases the efficiency of the main engine. Due to the additional recovery system, the system's initial cost is significant. But over time, the system turns out to be profitable.

Keywords: Heat Exchanger, Combustion Engines, diesel engines, recovery system, environmental pollution.

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1. INTRODUCTION

From household uses to refineries and cryogenic operations, heat exchangers are discovered to have a wide range of applications. Due to their lack of negative environmental impacts, these heat exchangers have become a fundamental component of modern life. This energy extraction also has a very low and efficient cost. Enhancing heat transfer and increasing efficiency are two issues with these heat exchangers. In order to improve the heat transfer enhancements, extensive study and survey work has been done. A goal is set in this context to examine the literature on heat exchangers under the following headings: general research of heat exchangers, different heat exchanger configurations, compact heat exchangers, and the role of nano fluid in improving heat transmission.

Additionally, engine makers are limiting combustion temperatures and pressures, which lowers potential efficiency gains due to increasingly strict emissions rules [1]. Engines have used more than 60% of all fossil fuels since they are the most common primary power source for machines used in the transportation, construction, and agriculture industries. On the other hand, carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter have been the main subjects of legislation regarding exhaust emission standards (PM). One of the best solutions to these issues is energy conservation on engines, which can increase engine energy usage efficiency and lower emissions [2,] Scientists and engineers have conducted a great deal of successful research to improve engine thermal efficiency, including supercharging, lean mixture combustion, etc. This is due to the significance of improving energy conversion efficiency for decreasing both the fuel consumption and emissions of engines. Nevertheless, in every energy-saving technology examined.

2. POSSIBILITY OF HEAT RECOVERY AND AVAILABILITY FROM I.C. ENGINE

Waste heat is heat that is produced during a process through the burning of fuel or a chemical reaction and subsequently "dumped" into the environment even if it may still be utilised for another practical and cost-effective use. The temperature of the waste heat gases and the mass flow rate of exhaust gases both have an impact on this heat. Equipment inefficiencies and thermodynamic restrictions on tools and processes lead to waste heat losses. Consider an internal combustion engine as an example. Between 30 and 40 percent of its energy is turned into productive mechanical labour. Exhaust gases and engine cooling systems are used to release the leftover heat onto the surrounding environment [4]. It indicates that between 60 and 70 percent of the energy is lost as waste heat through exhaust (30 percent as engine cooling system and 30 to 40 percent as environment through exhaust gas). Temperatures in the exhaust gases coming out of the engine can reach 842–1112°F (450–600°C). These gases therefore contain a lot of heat, which they release as exhaust. The principles of thermodynamics set a lower limit on the temperature of exhaust gases, despite efforts to create more energy-efficient reverberatory engines with better heat transfer and lower exhaust temperatures.

3. POSSIBILITY OF WASTE HEAT FROM INTERNAL COMBUSTION ENGINE

Internal combustion engines, which power automobiles, play a significant role in modern life today. Spark ignition (SI) or compression ignition (CI) engines continue to power the majority of automobiles. CI engines, commonly referred to as diesel engines, have a diverse range of uses and are distinguished as energy converters by their great efficiency. For irrigation, small agricultural tractors, and construction equipment, tiny air-cooled diesel engines with an output of up to 35 kW are used, whereas large farms use tractors with an output of up to 150 kW. If a completely air-cooled engine is not necessary, water-cooled engines are used for greater power ranges. Engines are employed for a range of 35-150 kW. Engines with 520 kW or even 740 kW of power are used in earth moving machinery. Engines having an output range of 150 kW or more are typically used in marine and locomotive applications. High speed diesel engines with

220 kW or greater of output are typically used in trucks and road engines. Small electrical power producing units or backup units for medium capacity power stations employ diesel engines.

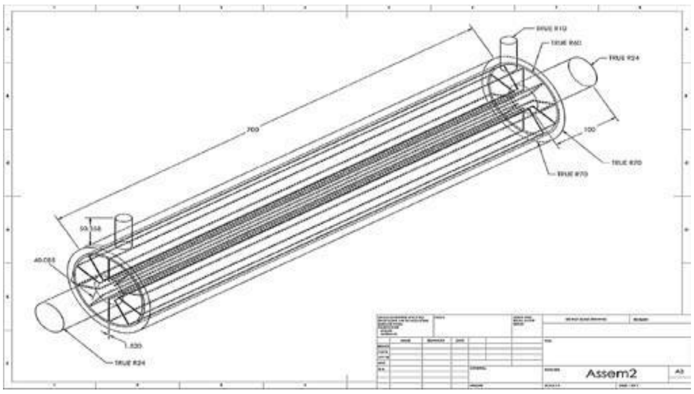

Figure 1 Optimized Heat Exchanger

4. EXISTING RESEARCH EFFORT

Nopparat Katkhawa et al. (2013) investigated various dimple intervals and arrangement kinds. They investigated the properties of heat transmission under conditions of external flow. The heated surface has dimples, and a stream of air passes over them. The air stream's velocity ranges from 1 to 5 m/s. We measured the temperature of the dimpled surfaces and the air stream. The use of dimples is chosen since the use of baffles, fins, and turbulizers for typical increased heat transfer procedures results in a large pressure decrease of the stream. This study compares and analyses the dimple configurations (staggered and inline) with different dimple pitches. .where Ci is the cost of the i-th station; Ki is the number of stations of the i-th type. The second condition is the condition of maximum coverage of a given territory [1]

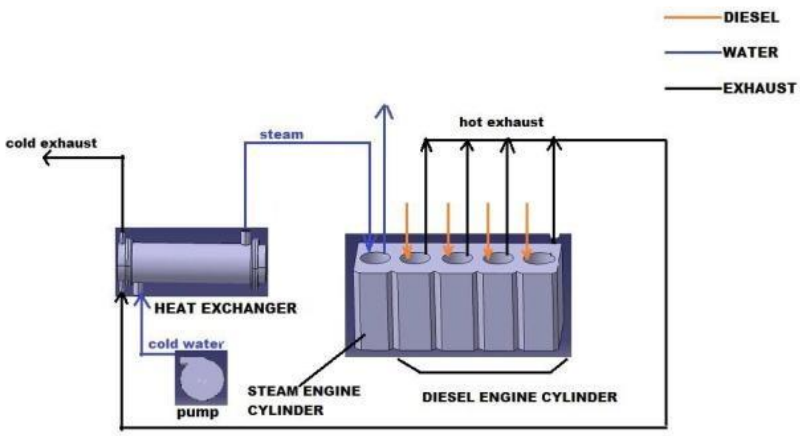

Figure 2 Schematic Representation of the System

For the purpose of recovering waste heat from IC engine exhaust, Hitami et al. (2014) conducted a numerical research of finned type heat exchangers. Following is a study of two heat exchanger cases: one type of heat exchanger is used in a compression ignition exhaust recovery system and another type is utilised in a spark ignition exhaust recovery system. Water is utilised as the cold fluid in the compression engine heat recovery system, whereas ethylene glycol and water are combined as the cold fluid in the spark ignition system.

In completely wet settings, Vahabzadeh et al. (2014) conducted an analytical analysis of porous pin fins with varying sections. The research of the porous pin fins' temperature distribution, efficiency, rate of heat transfer, and optimization under completely wet conditions is presented in this work. The fins are composed of aluminium and have insulation at their tips. The heat transmission coefficient depends on the temperature of the fin. The analytical solution for temperature distribution is achieved using the energy balance, Darcy model, and Least Square Method (LSM). Analysis is done on the geometric and thermographic characteristics, including the power index for geometry, porosity, Biotnumber, and relative humidity.

The thermal performance of a heat exchanger tube outfitted with regularly spaced twisted tapes and swirl generators was evaluated by Eiamsa-ard et al. in 2014. In the example of a heat exchanger equipped with regularly-spaced twisted tape (RS-TT) across fluid flow, the factors affecting heat transfer, friction, and thermal performance are presented. This is investigated in contrast to the impact of fully twisted tape. Additionally, the physical behaviour of fluid temperature, Nusselt number, and flow is monitored.

By implementing Six sigma DMAIC, Srinivasan et al. (2014) looked into ways to increase the efficiency of shell and tube heat exchangers (Define- Measure- Analysis- Improve-Control). The Critical to Quality (CTQ) parameters are found during the define phase. Measurement Phase: The exchanger's efficiency was calculated to be 0.61. In the analysis phase, the causes of the efficacy declines are found. The current design has been modified through brainstorming, and the solutions have been found. Control Phase - Performance-improving measures are advised. By using the circular fins that have been rolled over the tubes, the exchangers' efficiency has been increased by recovering the heat energy of the exhaust (flue) gas.

In a platefin and tube heat exchanger with in-line and staggered arrangements, Jiin-Yuh Jang et al. (2013) examined the span angle and placement of the vortex generators. Behind these tubes are positioned block-style vortex generators. When comparing surfaces with and without vortex generators, surfaces with vortex generators have a greater area reduction ratio. Transverse location (Ly) range for vortex generators is from 2mm to 20mm, and span angle range is from 30° to 60°. Regarding improving heat transmission, in-line arrangements in above exchangers are thought to be more effective.

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