An analysis of the ic engine's utilization of heat pipes as an exhaust heat recovery system

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ABSTRACT

Ever since the beginning of the industrial revolution, efforts have been undertaken constantly to recover and reduce waste heat. Different waste heat recovery systems are developed over time. This research study does a thorough review of heat pipes. Here, the authors' points of view are offered along with descriptions of various elements and applications. Additionally, the extensive use of heat pipes to recover waste heat from IC engine exhaust is examined, and a noteworthy result is reached that suggests there is a great deal of room for more research on heat pipes, particularly in relation to IC engine exhaust heat recovery systems.

KEY WORDS

Heat pipe, Exhaust Heat, Heat exchanger, I C Engine

INTRODUCTION

A heat pipe is a heat-transfer device that effectively regulates the transmission of heat between two solid contacts by combining the concepts of phase transition and thermal conductivity. A heat pipe is essentially a thin, sealed tube with a wick construction that is lined on the inside and a small amount of saturated fluid, such water. It is divided into three sections: an adiabatic part in the middle, a condenser section at one end, and an evaporator section at the other. Heat is absorbed and the fluid vaporizes in the evaporator; heat is rejected and the vapor condenses in the condenser section; and the fluid flows in both the liquid and vapor phases in the adiabatic section.

The saturated liquid and its vapor (gas phase) must be present in the heat pipe for it to transmit heat. As it approaches the condenser, where it is cooled and transformed back into a saturated liquid, the saturated liquid vaporizes. In a typical heat pipe, a wick structure that exerts a capillary action on the working fluid's liquid phase returns the condensed liquid to the evaporator. Wick structures in heat pipes are made of screen, grooved wicks that encompass a sequence of grooves parallel to the pipe axis, and sintered metal powder. Gravity has the ability to return liquid when the condenser is located above the evaporator in a gravitational field. The heat pipe in this instance is a thermosiphon. Ultimately, liquid is returned from the condenser to the evaporator by means of rotating heat pipes that utilize centrifugal forces.

HEAT PIPES' ROLE IN ENERGY SAVING AND HEAT RECOVERY

Researchers have recently made significant advancements in heat pipe technology for heat recovery. Research has examined the methodology, structure, design, thermal efficiency, and use of heat pipes. One excellent strategy to reduce energy consumption and stop global warming is to use heat pipes for waste heat recovery. In both commercial and industrial settings, a heat pipe heat exchanger (HPHE) is employed as an effective air-to-air heat recovery system. With virtually minimal cross-leakage between supply air and exhaust gas, the HPHE is the best option. Its effectiveness in recovering heat, compactness, low weight, minor air pressure drop, total separation of hot and cold fluids, relative economy, absence of moving components, and dependability are only a few of its numerous benefits.

The HPHE has been widely used as waste heat recovery systems in numerous industries, including energy, chemical, and metallurgical engineering. Recovering heat from exhaust gasses in a furnace stack is one of the most significant uses of HPHEs. Using an HPHE helps to preserve the environment and lower primary energy use. However, further research is required on the application of heat pipes for heat recovery, particularly in light of the potential energy and environmental savings.

HEAT PIPE FUNCTIONS IN AN IC ENGINE

VAPIPE is one of the most fascinating uses of heat pipe in IC engines. When installed in an automobile engine, it significantly lowers the amount of fuel used and emissions from the exhaust by vaporizing the gasoline mixture in the carburetor before it reaches the engine using heat collected from exhaust gas. Enhancing combustion, the vaporized mixture of petroleum and air creates a homogenous mixture.

After reviewing automotive waste heat recovery systems, Orr et al. came to the conclusion that heat pipes and thermoelectric generators (TEGs) were two viable technologies that may be used for this purpose. Heat pipes and TEGs are both solid state, passive, quiet, scalable, and long-lasting. Heat pipes have the ability to improve system flexibility in design while lowering pressure losses and thermal resistance. They can also help regulate the TEGs' temperature. TEGs do have certain drawbacks, like low temperature tolerance and comparatively poor efficiency. There are restrictions on heat pipes, such as upper and lower temperatures and maximum rates of heat transfer. These technologies can be combined to produce a waste heat recovery system that is entirely solid state and passive.

Yodrak et al. recovered furnace waste heat during a hot brass forging operation by using an HPHX air preheater. The air that was delivered to a furnace burner was preheated by the HPHX using hot exhaust gas. In order to forecast the rate of heat transfer using the LMTD method, a thermal resistance model was created and the HPHX was conceived, built, and tested. Increases in the inlet gas temperature, the HP diameter, and the staggered arrangement of HPs in comparison to an inline configuration all resulted in an increase in the heat transfer rate. It has been demonstrated that the HPHX can cut furnace fuel usage by roughly 20%.

In order to lessen the cooling load in buildings, El-Baky and Mohamed looked into the overall efficacy of using heat pipe heat exchangers for heat recovery using external air conditioning systems. The analysis focused on the system's thermal performance under different fresh air inlet mass flow rates and temperatures. A mathematical model was created using the experimental setup, which included two 0.3 m × 0.22 m sectional areas air ducts and a heat pipe arrangement with 25 copper tubes having 0.2 m adiabatic section and 0.1 m evaporator and condenser sections, respectively. The working fluid, R-11, was employed at 303 K saturation temperature.

The study's conclusions showed that when the temperature of the fresh air intake rises, so do efficacy and heat transfer rates. The study also showed that the mass flow rate ratio significantly influences the temperature of the fresh air, and that an increase in the fresh air input temperature causes the heat recovery rate to rise by about 85%.

Heat pipes are widely used in the business sector in conjunction with solar collectors to transfer both direct and diffuse solar radiation to the water stream. The study conducted by Hussein aimed to compare three different cross-sectional geometries of wickless heat pipes with different fill ratios and determine how their performance affected flat plate solar collectors in Cairo, Egypt. Heat pipe cross-sections that merged with circular, elliptical, and semi-circular arrangements that constituted the industrialized group. The group underwent experiments in which the heat pipes were integrated into the solar collector array. The comparative analysis revealed that the elliptical design performed better at 10% water fill ratios, while the circular cross-section design performed best at 20% water fill ratio.

APPLICATION OF HEAT PIPE

1. Electronics: electronic circuit cooling
2. Transformers, generators, and electrical motors
3. Utilization in HVAC frameworks

Fourth use in IC engines

5. Generators for gas turbines.

APPLICATION TO I C ENGINE (VAPIPE)

VAPIPE is one of the most fascinating uses of heat pipe in internal combustion engines. Installed in an automobile engine, it dramatically lowers exhaust emissions and fuel consumption by vaporizing the gasoline mixture in the carburetor before to it entering the engine using heat collected from exhaust gas. Enhancing combustion, the vaporized mixture of petroleum and air creates a homogenous mixture. Some other application are-

1. Snow melting, space uses and solar collectors
2. Ovens for bread and biscuits
3. Cleaning supplies
4. Medicines
5. Utilizing spray drying
6. Booths for welding
7. Kilns made of bricks
8. Plastic material extrusion and drying during plastic lamination. Text rising fibers can be kept at a consistent temperature.
9. Opening fireplaces
10. Dehumidifier with chemical fluid bed
11. Coating with epoxy Oven for curing, etc.

CONCLUSION

A comprehensive examination of a work that was published in a reputable publication shows how crucial waste heat recovery is. Waste heat recovery and usage have many facets and perspectives. It protects the environment while also conserving energy. Although there are many other heat recovery methods, the heat pipe is still in its infancy, according to the literature. It is used in many different applications, such as the heat recovery of IC engines. However, despite this, not much research has been done on this heat pipe. The important finding of this research review on heat pipes suggests that there is a lot of room for more study in this area.

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