# Review Report on heat pipe assisted heat exchanger used for industrial waste heat recovery

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***Abstract:*** The employ of industrial waste heat will economize and represents an efficient energy applies for business. This analysis reviews new methodology of recovering waste heat and electricity employing a combination of heat pipes and thermoelectrically generators (HP-TEG).The first heat pipe was connected to the hot side of the teg and therefore the second to the cold side of teg. The present study investigated the way to improve the utmost power output of a teg (Thermoelectric generator) system assisted with a heat pipe. The teg system will with efficiency utilize low temperature waste heat, like industrial waste heat and solar power. Additionally, the heat pipe will transfer heat from the automobile's exhaust gas to a teg. There are many varieties of heat recovery system readily accessible in the market including the convective-type recuperate, heat wheel, and economizer. Most of these systems would like auxiliary forces such as using a pump or compressor to move the heat transfer fluid in their operation.

***Index Terms* - Heat pipe heat exchanger, Waste heat utilization, Industrial heat recovery Passive heat transfer**

## I. INTRODUCTION

Energy is a basic source for all human activities on the earth. Recently, energy demand has increased very fast due to the high energy consumption in various fields. For a long time, fossil fuels have supplied all human requirements. The energy storage system that embedded in the heat-transfer device in useable manner can be converted into the practical form of a new idea. In fact, Energy storage diminishes the maladjustment between supply and demand and gets better performance, efficiency and reliability of systems and has a significant point in preserving energy. Phase transition Materials or Phase change material (PCMs) are referred to as heat energy storage materials that are utilizing in thermal energy storage systems. Latent Heat based Thermal Energy Storages (LHTESs) have tremendous advantages like high storage density, non-hazardousness to the environment, commercial availability, cost effectiveness and small temperature fluctuation. In thermodynamic energy is the capacity of a physical system to do work. Totally, the sources of energy have classified into two main groups; renewable and non-renewable. The non-renewable energy sources because of replenish rate are categorized in "limited resources" that will slowly decrease. When the speeds of the atoms/molecules increase in a material, it is getting warmer. This heat is related to the heat capacity of materials. Sometimes, phase change happens in an energy content of a material in a constant temperature. It can be clearly seen in the Fig. 1 that when phase change occurs through a material like water, it releases or absorbs energy as heat.

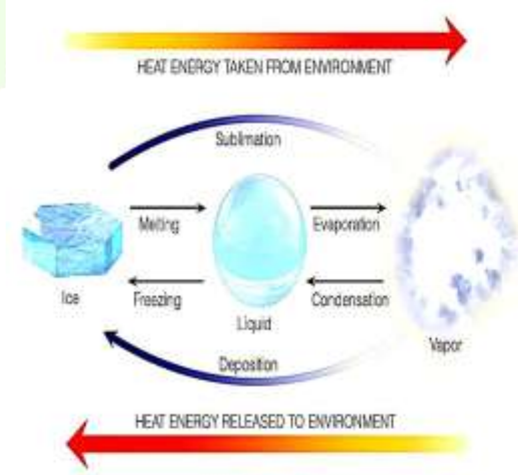


Figure 1. Latent heat exchanges of energy involved with the phase changes of water

The energy can be transferred through heat flow in different ways namely conduction, convection, radiation and most cases by a combination of them.

## II. HEAT TRANSFER AND ENERGY STORAGE

Heat is a form of energy that transfers between two systems with a temperature difference. According to the first law of thermodynamic the internal energy of both systems changes during the heat transfer. In General, heat transfer classified in three major mechanisms including Conduction, Convection, and Radiation. In energy storage systems conduction and natural convection are most common heat transfer mechanism. Different mechanisms of heat transfer are shown in Fig. 2.

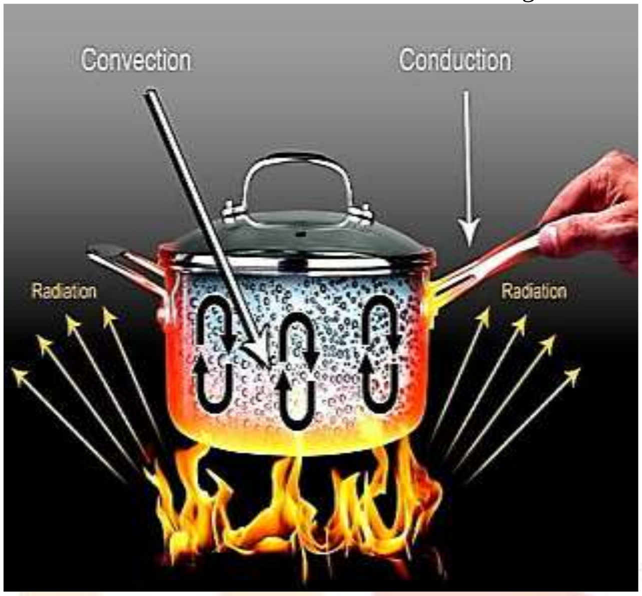


Figure 2. Different mechanism of heat transfer

### *2.1. Conduction*

The energy that is transported due to molecular motion and interaction is named Conduction heat transfer. It is based on molecular vibration throughout solids.

$$\frac{Q}{A} = -k\frac{dT}{dX}$$

The conduction heat transfer method are often calculated supported the heat transfer per unit area (W/m2), that is proportional to the temperature gradient dT/dx and therefore the constant of proportion that's referred to as thermal conduction k (W/m. K). The thermal conduction k (W/m. K) depends on the substance and temperature of a fabric. Thermal conduction of some typical materials are shown in Table 1.

Table 1. Thermal conductivity of typical materials

| **Substance** | **Thermal conductivity (W/m. K)** |
|---|---|
| Copper | 400 |
| Aluminum | 240 |
| Cast Iron | 80 |
| Water | 0.61 |
| Air | 0.026 |

### *2.2. Convection*

The energy that is transported due to bulk fluid motion is named Convection heat transfer. Generally, Convection heat transfer happens due to fluid motion along the surface through gasses and liquids from a solid boundary. In order to calculate the convection heat transfer, Newton determined the heat transfer effect on the area (W/m2) and - (K) the fluid-solid temperature difference. Frequently, the temperature difference happens across a thin layer of fluid adjacent to the solid surface that named boundary layer. The h (W/K.m2) is constant proportionality is called the heat transfer coefficient [7].

$$\frac{Q}{A} = h(T_s - T_f)$$

Type of fluid and the fluid velocity is two most significant items that influenced heat transfer coefficient.

### *2.3. Radiation*

The energy that is transported due to the emission of electromagnetic waves or photons from a surface or volume of materials is named Radiation heat transfer. One of the specific features of radiation is occurring in a vacuum. According to the radiation formula, the heat transfer by radiation is proportional to the fourth power of the surface or volume temperature. The σ is a constant coefficient that is named Stefan-Boltzman, and it is equal to 5.67×10-8 (W/m2.K4) [7].

## III. LITERATURE SURVEY

Hongting Ma. et. al. [1] "Experimental study on heat pipe assisted heat exchanger used for industrial waste heat recovery" The performance characteristics of a HPHE has been investigated by experimentation by analyzing heat transfer rate, heat transfer constant, effectiveness, energy efficiency and number of heat transfer units (NTU). Waste liquids and gases have crucial energy saving potential, particularly for steel slag cooling method. Steel industry plays a very important role economically in China. An excellent amount of hot waste liquids and gases are discharged into surroundings throughout several steelmaking processes. Optimization of the structure and improvement of heat transfer of HPHE should be paid additional attention.

Tushar Tiwatane et. al. [2] "Experimental Study of Waste Heat Recovery Using Heat Pipe Heat Exchanger with Hybrid Nano fluid: A Review" In this investigation, the attribute design and heat transfer restrictions of single heat pipes while not wick and working with Hybrid Nanofluids are investigated. There has been increasing interest in nano fluid and its use in heat transfer improvement. Analysis has been carried out on the idea, design and construction of waste heat recovery exploitation heat pipes heat exchanger with nano fluid, especially their use in waste heat recovery for energy recovery in automobile exist, reduction of air pollution and environmental conservation. Heat transfer performance in a straight circular tube is amplified by suspension of hybrid nanoparticles in comparison with that of pure water.

Hussam Jouhara et. al. [3] "Experimental investigation of wraparound loop heat pipe heat exchanger used in energy efficient air handling units" In this article, an investigational analysis on the thermal performance of an air-to-air device, that utilizes heat pipe technology, are going to be presented. The heat exchanger was totally instrumented to check for the impact of the variation of heat load and therefore the air speed, through the heat exchanger, on the general thermal resistance of the loops. The paper concludes with a theoretical analysis of the energy savings that might be expected when utilizing the technology in a very representative application.

MA Guang-yu et. al. [4] "Analytical Research on Waste Heat Recovery and Utilization of China's Iron & Steel Industry" As energy crisis become increasingly prominent, the energy consumption has became the most downside which restricts the sustainable development of China's iron & steel industry. All analyses show: the inferior waste heat in China's iron & steel industry has not been used basically; it's the key purpose of the recovery and utilization of waste heat of iron & steel industry in future.

A. Akbarzadeh et. al. [5] "A review of car waste heat recovery systems utilising thermoelectric generators and heat pipes" A majority of this energy is dissipated as heat within the exhaust and coolant. Instead of directly improving the efficiency of the engine, efforts are being created to enhance the efficiency of the engine indirectly by employing a waste heat recovery system. the employment of heat pipes will potentially cut back the thermal resistance and pressure losses within the system also as temperature regulation of the TEGs and increased design flexibility. Investigations have found that an appropriate method of rising the overall efficiency of the fuel use in an exceedingly car is to recover some of the wasted heat. 2 technologies known to be of use for waste heat recovery are TEGs and heat pipes.

## IV. PASSIVE HEAT RECOVERY SYSTEM

### *4.1.* Before *Heat pipe and thermosyphon*

The heat pipe is a device which can transfer heat efficiently over large distances at close to uniform temperature without adding external electrical energy. Despite its simple design; a heat pipe has high thermal conductance and operates without moving parts. The evaporator absorbs heat and vaporizes the operating fluid at extreme temperature. The vapor rises and flows to the cooler condenser effectively transferring the heat energy of vaporization. This method is assisted by buoyancy forces. The heat pipes are often divided into three sections that are an evaporator at one end, a condenser at the other end and an adiabatic section within the middle (Figure 3).

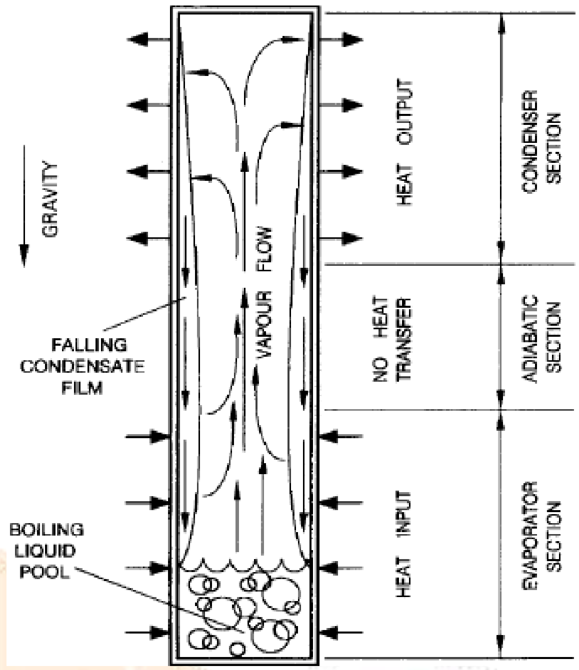


Figure 3 Diagram of heat pipe.

## V. CONCLUSION

Even This paper gives a survey report on Experimental study on heat pipe assisted heat exchanger used for industrial waste heat recovery and related work on it. In which several papers has been studied and gives several results. In [1] The minimum values of heat transfer rate and heat transfer coefficient were 6.37 kW and 129.24 W/(m2 K) when the waste water mass flow rate was 0.83 m3/h and the cold fresh water mass flow rate was 2.46 m3/h. In [2] the manufacture of light-weight heat pipes could be a vital objective for current heat pipe industries and researchers, and additional investigations are required .The understanding of the fundamentals of heat transfer and wall friction is extremely vital for developing nano fluids for a wide vary of heat transfer applications.

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