International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

Waste Heat Recovery using Heat Pipe Heat Exchanger

Prajapati Vinay

Department of Mechanical Engineering, ADIT College, New Vallabh Vidhayanagar, Gujrat, India -388121

Abstract: ***Now day till Many years to till now three factor is necessary to live the life for human, house, clothes and wage but now day energy is another factor also necessary to live the life for human. Global warning and greenhouse effect is increased in past 10 years with used fossil fuel, so all country turned to renewable source. Now day all country finds the how energy is utilised and how energy produce with minimumenvironment pollutions. So heat pipe heat exchanger is most efficient device for waste heat recovery for different application and reduction the production cost and reduced greenhouse gas emission. In this review paper waste heat recovery for different application and its design and how work and thermal analysis of heat pipe heat exchanger and also selected fluid for a heat pipe.***

Keywords: Heat pipe heat exchanger, Heat pipe, Heat recovery

1. Introduction

Conventional energy sources based on oil & natural gas is to be proven highly energetic drivers of economic progress, but they also harmful to human health and environment. They tend to be repetitive in nature, due to the effects of oligopoly in production and distribution. These conventional fossil fuel-based energy sources are facing increasing pressure on a cloud of environmental fronts, with feasibly the most serious task opposing the future use of coal is the Kyoto Protocol greenhouse gas reduction targets.

The history of a heat pipe could be trace back to Angier march Perkins who in 1831 took out a patent on a “hermetic boiler tube”. He has been dabbled with the think of working fluid, but only in the point of view of a single phase device at high pressure. A later descendant has been granted a patent on what was then referred Perkins tube in which a long in 1936, twisted tube filled with water has passed over a condenser and evaporator.

Now scenario how energy production and with reduced minimum carbon dioxide emission and how utilize maximum energy.so the reduced shortage of energy in developing country and wasted heat utilize for various application, so heat pipe heat exchanger better solution for waste heat recovery application

1.1 Working of heat pipe

Heat pipe is device which can transfer heat one place to another place by the vaporization and condensation of a liquid. Main part of the heat pipe heat exchanger is: (1) evaporator (2) condenser (3) adiabatic.

A metal cylinder has a sealed with a liquid fluid within it creating a closed system. One end of side the tube is heated and the other side is cooled. The heat source (the evaporator) effect the fluid to boil and turn to vapour phase (this is absorbing energy as heat). When that hap latent heat of the vaporization. The gas, which then has a higher pressure, moves inside the sealed container to a colder location where it condenses in condenser section.

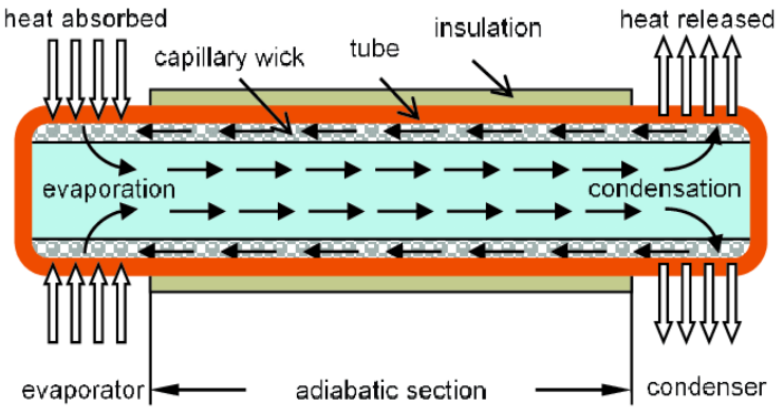

Figure 1.1: Heat pipe (S.h noie baghban et al, 1999)

Once the vapour has been reaches the cold end side of the tube (the condenser), the fluid changes phase again from vapour back to a liquid phase. Thus, the gas has given up the latent heat of the vaporization, moves heat from the input to the output end of the heat pipe. This liquid returns to the hot region (evaporator) end it meansof a wick so that the liquid could be repeat the process. This process has been capable of transporting heat from a hot region to a colder region. It is no addition of external energy required.

1.2 Ideal thermodynamic cycle

Heat pipe is device which can transfer heat one place to another place by the vaporization and condensation of a liquid. thermodynamic cycle represent how heat pipe works its operating principle.

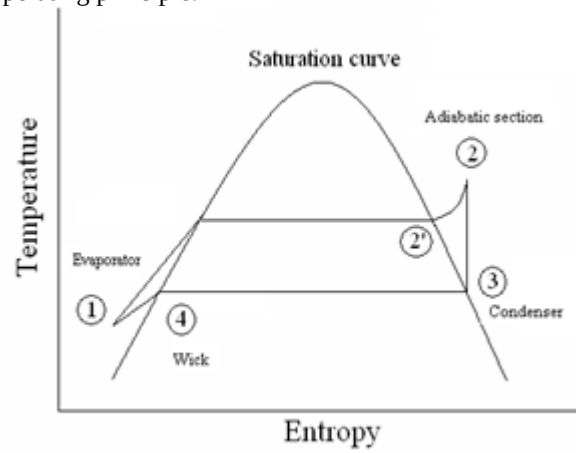

Figure 2: Ideal thermodynamic cycle for heat pipe principle (Faghiri et al,1995)

1-2 process is Heat applied to the evaporator side through the external sources vaporizes working fluid to absorb of the latent of heat. So process 1-2 is liquid converted into the vapor.it is phase change process.

2-3 Vapor pressure has a drives vapor to adiabatic section to condenser section.in this process vapor phase passing to condenser section due to sufficient capillary pressure.

3-4 In the condenser section Vapor has a condenses, releasing to heat to a heat sink. This process vapor releasing latent heat of heat and phase the change liquid to vapor. The liquid store of the bottom section. It called the wick.

4-1 The wick is a produced the capillarity force to passing the liquid condenser to evaporator side. This process is continuing and heat transfer occur done.

2. Waste heat recovery applications

2.1 Waste heat recovery for surgery room in hospital

Waste heat recovery for surgery room in hospital where the air is changed 40 times per hours in laboratories. The temperature in the laboratories of 15ºc to 55ºc.Under this condition design of heat pipe heat exchanger, experimental and tested with different fluid (methanol, water, acetone) and wick (50 mesh nickel,250 mesh of nickel,100 mesh of stainless steel. After CFD simulations we are choose methanol as working fluid and 100 mesh stainless steel used as weak in heat pipe and recovered 850W Waste heat using air to air heat pipe heat exchanger.

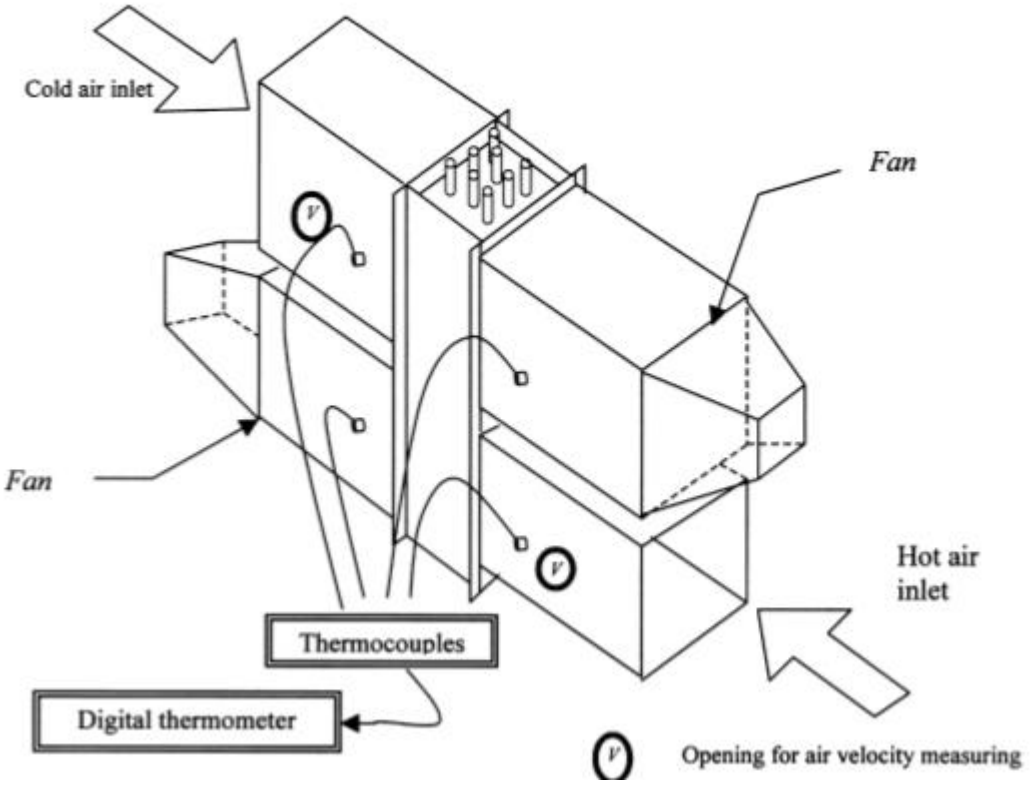

Figure 2: 1mechanism of heat pipe heat exchanger (S.H. Noie Baghban et.al, 1999)

Water is a higher degree of superheat value so is not applicable for this applications. Because it is low temperature application. Methanolhas a larger merit number an acceptable freezingpoint because below freezing point heat transfer not occur done. Stainless steel material wick compatible with methanol fluid so we are choosing 100 mesh stainless steel wick and recovered 850 w waste recovery in surgery room. This energy used in drying process and in building to provide hot water. This heat used for drying process and heating water in commercial building.

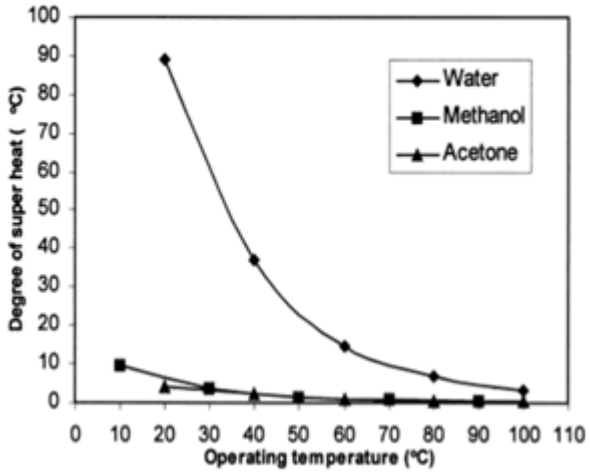

Figure 2.2: Degree of superheat for the three working fluid **(**S.H. Noie et al,1999)

2.2 Waste heat recovery in air conditioning device and reduce cooling load

Heat pipe heat exchanger is excellent device for waste heat recovery in air conditioning device. The heat rejected of condenser section in air conditioning device this heat utilised for another work using heat pipe heat exchanger.

The temperature of this application is 15ºc and 55ºc.first off hot air to come condenser section passing to evaporator section.so heat pipe absorbed latent of heat and changed the phase liquid vapor and moves upward and hot air is cool. This cold air passing to upward condenser section at absorb that latent heat of vapor fluid and cold air converted to hot air below atmospheric temperature. This hot air used for another purpose.

The hot air outside of heat pipe heat exchanger of condenser section below the atmospheric temperature. The function of Ac to air sucked atmospheric temperature and cool and passing to the room.so atmospheric air temperature is high. Air conditioning system used to air to outside air of condenser section heat pipe heat exchanger so less cooling load is applied because atmospheric temp is high compare to condenser come outside air and reduce the cooling load.

2.3 Waste heat recovery for different Indian climate zones

Waste heat recovery in different climate zones like (hot and dry, warm and humid, composite, cold, temperate) using air to air heat pipe heat exchanger and how heat transfer occurs in different climate zones. After investigation maximum energy savings in hot dry zones and minimum energy saving in cold zones using air to air heat exchanger of Indian climate zones

Hot dry zones maximum energy savings because in climate zone high temperature, low humidity and rainfall and clear sky so maximum temperature difference and given maximum heat transfer. Cold zone moderate temperature and very in winter season and high humidity in cloud so the temperature difference is minimum and minimum heat transfer.

Annual energy saving of hot n dry climate zones in Ahmedabad city 12500 Kw/hr and cold and zones in Guwati kw/hr.

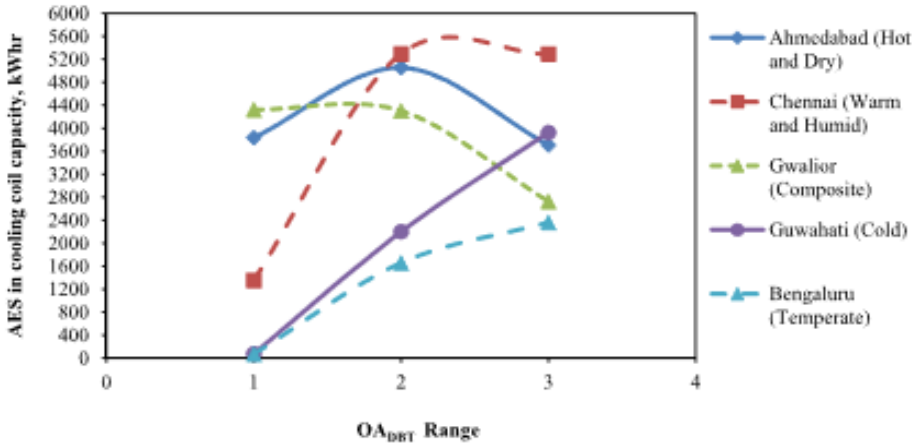

Figure 2.4: Compare analysis of energy savings **(**T.S. Jadhav et al,2015)

2.4 Waste heat recovery in steel industry

Waste heat recovery in steel industry using flat heat pipe heat exchanger. The flat heat exchanger designed to recover the waste heat recovering by radiation during the production of the steel rods in steel industry. Stainless steel material heat pipe is used and the connected with the support of the collector, header of flat heat pipe heat exchanger. The experiment results carried out two positions barrier and wire conveyer.

The radiate heat has been passing to the heat pipe wall of the evaporator to inner wall of evaporator section. The working fluid is a reaches saturation temperature, pressure fluid is vaporizing and vapor flow upper side and heat transfer occur done using of shell tube heat exchanger. A condensing the fluid and fluid condensation and back to evaporator section. This process iscontinuing occur done and transfer the heat due to radiation using flat heat pipe heat exchanger during steel road production. It is able to waste heat recovery in steel industry of 15.6 Kw. Mechanism of the flat heat pipe heat exchanger.

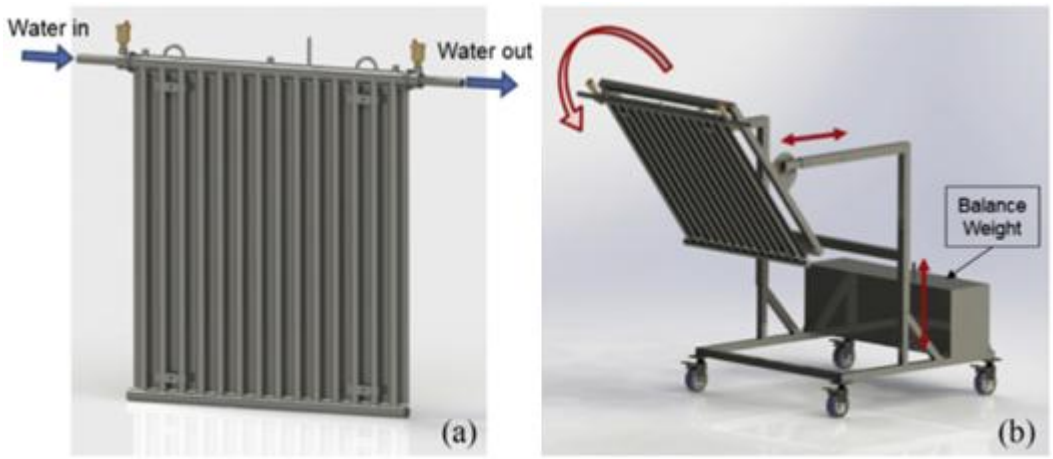

Figure 4: Mechanism of flat heat pipe heat exchanger (Amisha Chauhan et.al, 2017)

2.5 Waste heat recovery in buildings

Heat pipe heat exchanger has a used to waste heat recovery in residential and commercialusing primary agent as fluid and secondary agent water. This heat used for domestic water and heating the space.

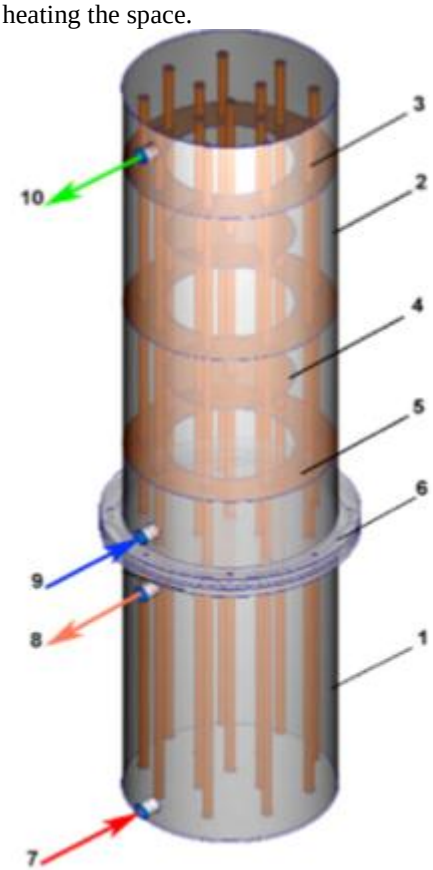

Figure 5: Mechanism of flat heat pipe heat exchanger in buildings (Andrei Burlacu et.al,2017)
1-Evaporator, 2-Condenser, 3-Heat Pipe, 4-Heat transfer ring, Type 1, 5-Heat transfer ring, Type 2, 6-Separation flange,7-Primary agent inlet, 8-Primary agent outlet, 9-Secondary agent inlet, 10-Secondary agent outlet

After CFD work we are observed When secondary agent is increased five times but normal change in secondary agent outlet temperature.

Table 1: Result data secondary agent outlet temperature (Andrei Burlacu et.al,2017)

Primary agent temperature $T_{1,in}$ [°C]	Case 1 $T_{2,out}$ [°C]	Case 2 $T_{2,out}$ [°C]	Case 3 $T_{2,out}$ [°C]	Case 4 $T_{2,out}$ [°C]	Case 5 $T_{2,out}$ [°C]
70	59.6	57.4	54.2	50.1	47.6
60	48.7	46.3	43.5	40.7	38.2

This table given a primary agent flow rate and temperature of the constant 10 (1/min) , 70ºc and secondary agent flow rate increased five times [6 to 30 (1/min)] but necessary changed in secondary agent outlet conditions.

We are observed heat pipe has been operated to high volume flow rate of secondary agent and minimum temperature of the primary agent also it could be found the introducing ring in the condenser section in which heat transfer from the heat pipe to secondary agent as water.

2.6 Waste heat recovery gravity heat pipe exchanger

Waste heat recovery from the industrial waste heat like exhaust gas, oil particles, fibre and impurities are applied thermal heat transfer gas side flow channel in blocked but heat exchanger has a failure sometimes.

So the fin tube heat exchanger introduced for waste heat recovery from the gravity. The air is the passing vertical tube of fin, inside the condenser section and dirty gas passing inside smooth surface of horizontal tubes which in the evaporator section.

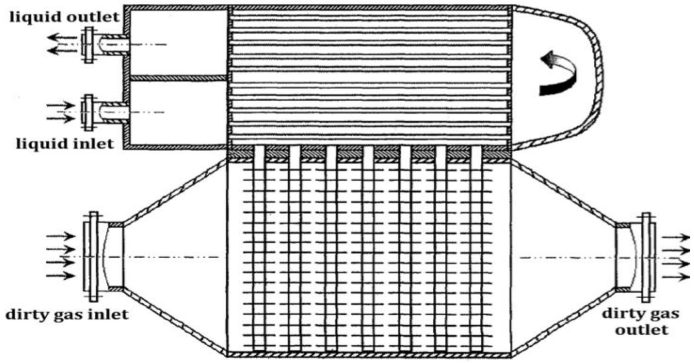

Figure 6: Mechanism of gravity heat pipe heat exchanger (En tian et.al,2016)

After experiment waste heat recovery from gravity (dirty gas, oil, impurities). Clean air passing isanin fin tubed and hot dirty exhaust gas passing in the shell and tube heat exchanger. The operations would be done up to Three month continuous ofrecovery dirty waste gas show new type heat pipe heat exchanger 15 % natural gas without blockage gas.

3. Conclusions

Heat pipe heat exchanger is an excellent device used for waste heat recovery in air conditioning system, space heating and electronics cooling.

Now day, energy shortage is biggest problem of any problem any developing country. Energy is produced by fossil fuel its harmful environment so all country moves turned renewable energy source to produce energy. So the new concept of heat pipe heat exchanger using waste heat recovered by different Indian climate zones (composite, hot and dry, warm and humid, cold).

How fluid behaviour in sonic limit and entrainment limit, viscous limit and boiling limit in design of heat pipe and how fluid selected for desired application to produce required capillarity force to transferred liquid condenser to evaporator. Otherwise evaporator dry when required capillarity force not produced and heat pipe is failure.

Design Flat heat pipe heat exchanger using waste heat recovery during hot road manufacturing process in industrial plant capacity of 15.6 kw.

Air to air heat transfer using heat pipe heat exchanger for waste heat recovering but gas to gas heat transfer not using heat pipe heat exchanger so introduced new concept of fin tube heat exchanger and without blockage of 15% natural gas produces.

References

[1] S.H. Noie-Baghban, G.R. Majideian waste heat recovery using heat pipe heat exchanger for surgery rooms in hospital, applied thermal engineering 20 (2000).
[2] T.S. Jadhav, M.M. Lele, theoretical energy saving analysis of air conditioning system using heat pipe heat exchanger for Indian climate zones, engineering science and technology an international journal (2015).
[3] Faghri, Amin, 1995. Heat Pipe Science and Technology. US: Taylor &Francis
[4] Hussam Jouhara, SulaimanAlma mound, Experimental investigation on a flat heat pipe heat exchanger for waste heat recovery in steel industry, energy Procedia (2017).
[5] Andrei Burlacu, Gavrilsosoi, Energy efficient heat pipe heat exchanger for waste heat recovery in buildings, Procedia manufacturing (2018).
[6] H. Mroue, J.b. Ramos, experimental and numerical investigation of an air to air water heat pipe heat exchanger, applied thermal engineering (2015).
[7] En Tian, Ya-Ling Research on a new type waste heat recovery gravity heat pipe exchanger, Applied Energy (2017).
[8] Mostafa A. abd, MousaM. Monamed, heat pipe heat exchanger for heat recovery in air conditioning, Applied Thermal Engineering (2017).
[9] Joao Ramos, Alex Chong, HusaamJouhara, Experimental and numerical investigation of a cross flow air to water heat pipe based heat exchanger used in waste heat recovery (2016).
[10] Revy d. knew p. Heat pipes: theory design and applications fifth ed. Buttterwerth-heinenmann;2008
[11] Meena P. Ritadech s. pooms –ad N, Closed-loop oscillating heat pipe with check valves air preheater for reducing relative humidity in drying system. Applied energy-2007