IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X
PP. 79-82
www.iosrjournals.org

Role of Heat Pipe Heat Exchanger In Waste Heat Recovery

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Abstract : *The most of Industries using energy which is in the form of heat energy especially the steel industry using energy which is the heat energy. The need of waste heat recovery play the vital role in the contribution of reduction the production cost as well as the greenhouse gas effect .In this paper the innovative waste heat recovery system is described which is the design, manufacturing, testing of Flat Pipe Heat Exchanger. The thermal performs of FHP is studied in laboratory as well as in Industry which will give the potential of Heat Pipe Heat Exchanger in waste heat recovery. The comparison is made between actual and theoretical results .From result concluded that the Heat Pipe Heat Exchanger gives maximum contribution for waste heat recovery in industry*

Keywords: Flat Pipe Heat Exchanger, *Heat Pipe, Heat, Heat Exchanger, Waste Heat Recovery.*

I. Introduction

Iron and steel industry is the pillar industry of national economy. In the past few decades, iron and steel technology has made tremendous development. However, the steel industry is one of the most energy-intensive industries, and the 30% of total production cost is having the cost of energy and the most of energy used is heat energy.[1] Waste heat recovery in steel industry having a lot of difficulties such as space available for installing heat exchangers and matching the waste heat stream to the heat sink demand. Recovering excess heat from the processes could reduce greenhouse gas emissions and significantly reduce production costs. A significant number of investigations on waste heat recovery have been conducted over the past decade.

A large amount of hot liquid and gases is released in environment during the manufacturing processes in steel industries these waste liquid and gases having a potential of waste heat recovery especially in steel slag cooling process. Such type of large amount of liquids and gases are directly discharged to the environment without any recycled process so it will again harmful to the environmental effect so the waste heat recovery having very much importance in industrial application.[5]

Most of technologies are not able to recover enough waste heat to be a viable solution for companies. However using heat pipe based heat exchangers for waste heat recovery is a promising solution that can address this issue. Heat pipe technology is known as a high efficiency transfer method. Where heat pipes are passive thermal devices that are able to transfer large amount of heat with no moving parts, using only the phase change (liquid vapour) process. The heat pipe is composed of a shell case material and a working fluid. The system is separated in three sections, the evaporator section where heat is applied; the adiabatic section composed of liquid and vapour; and the condenser section where the vapour is condensing.

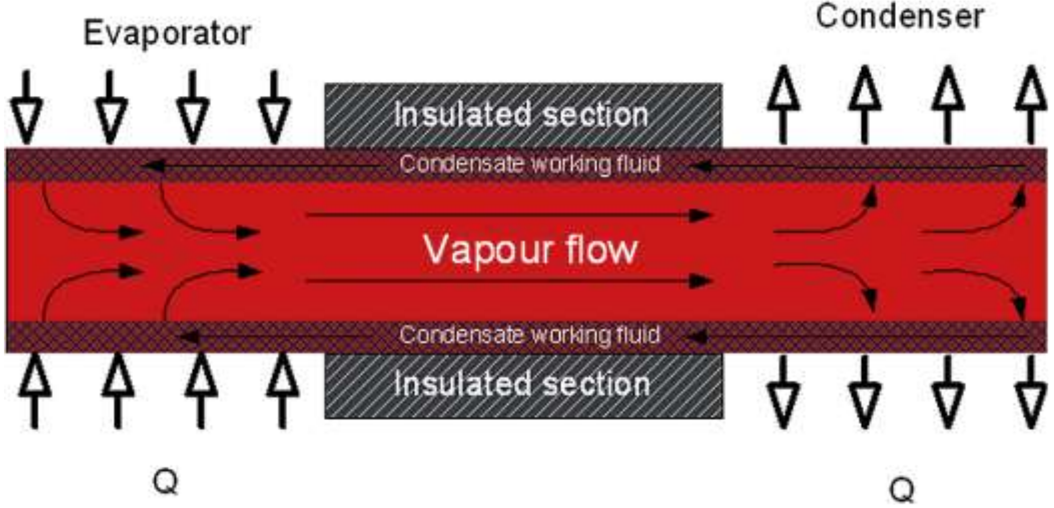

Fig.1 Heat Pipe

In fig.1 shows the heat pipe concept when heat is applied on the evaporator section, the working fluid vaporizes. The vapour then travels through the adiabatic section to the condenser. The latent heat of the vapour is then transferred to the condenser surrounding which causes the condensation of the working fluid. Flat heat pipes are able to transport high heat flux and thermal management is feasible of FHP that's why this devices are used in number of applications such as solar applications when it combined with PV cell it will produce electricity as well as the thermal heat simultaneously.

II. Design of FHP

For waste heat recovery FHP is designed from thermal heat source at temperature greater than 500°C FHP absorbed heat mainly by radiation and passed it to the evaporator by the wall conduction. When the working fluid reaches the saturation temperature, it vaporizes and flows upwards to the condenser. The heat is then transferred to the cooling fluid via shell and tube heat exchanger system, which condenses the working fluid. Finally, the condensate flows back to the evaporator section under gravity.

The prototype of the flat heat pipe illustrated in fig 2 (a) consists of 14 stainless steel pipes with a length of 1 m linked by a bottom header and a shell and tube heat exchanger at the top. The shell and tube heat exchanger consists of 8 stainless steel smooth tubes within a stainless steel shell. A stainless steel sheet is fixed at

the back of the evaporator section to increase the overall heat transfer area. The overall dimensions of the flat heat pipe are 1 m height by 1 m width. A stand has been designed and manufactured to hold the system in place as shown in fig.2 (b). This allows the system to be tested at different inclinations and heights.

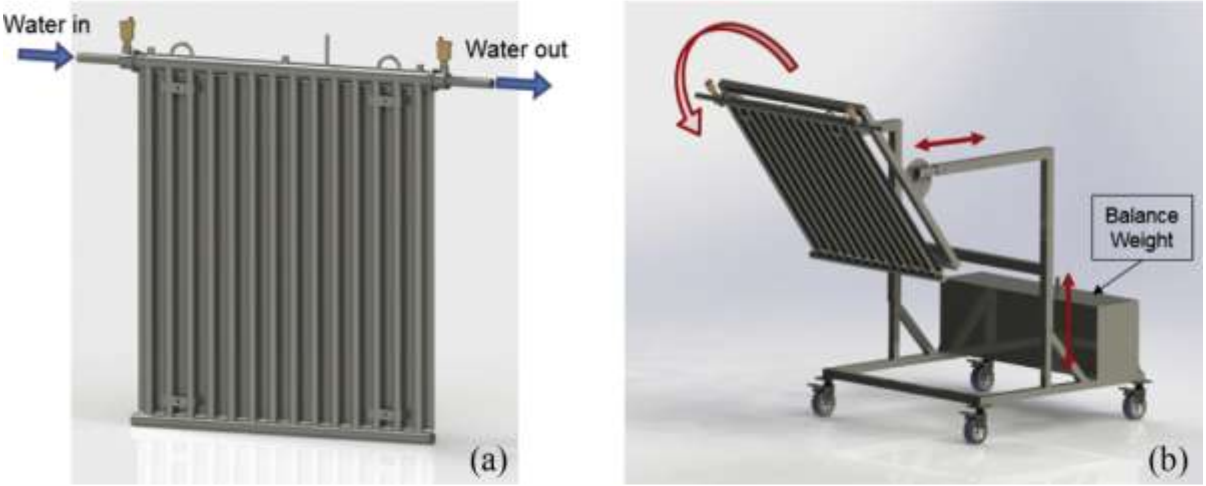

Fig2 Mechanical Design Of FHP

III. Testing Of Fhp

Two tests were conducted at the same water flow rate. Test 1 was performed at a heater temperature of 500 _C, which was measured by a laser pyrometer, while test 2 was performed at a heater temperature of 580 _C. The experimental conditions are given in Table.1 Experimental conditions.

Table 1

Test 1	conditions
Heater Temperature	500°C
Heater Power	25kw
FHP inclination angle	12.5°
Water flow	25L/min
Water inlet temp	10.6°C

IV. Industrial Test

The flat heat pipe was tested on a production line during the cooling process of steel wires. The total length of the production linewas 70m. The FHPwas placed 5.75mfromthe beginning of the production line, at the hottest point of the cooling zone. Temperatures were again measured using K type thermocouples; although for these tests the number of thermocouples on the heat pipes was increased from five to nine, as shown in fig 4

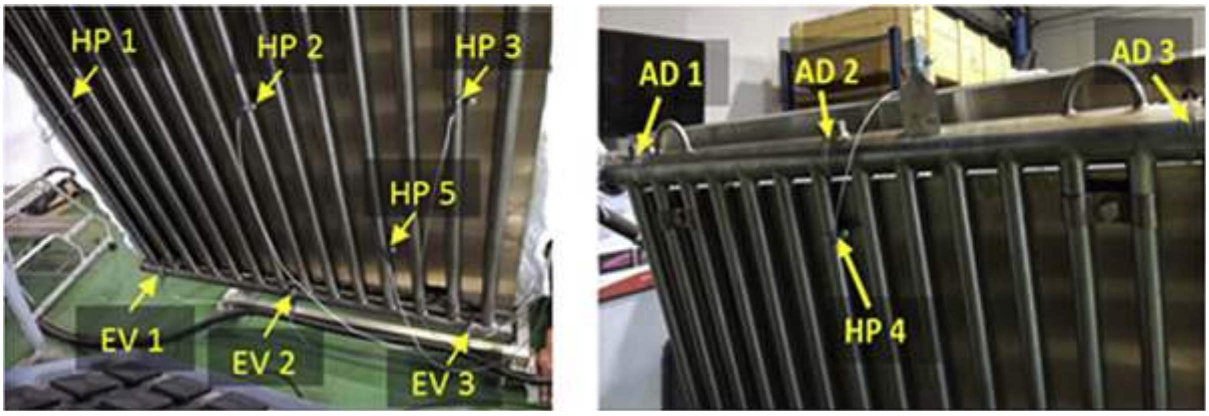

Fig.4 Thermocouple positions

V. Results And Discussion

The surface temperature of the FHP during test 1 varied between 63.5 _C and 80.3 _C. It was observed that the

temperature of thermocouple HP 4 was the highest due to is position which reflected a maximum temperature of 80.3 _C during test 1. The surface temperatures of the flat heat pipe varied between 64.4 _C and 85.4 _C in test 2. It can be observed from the results that the temperatures of the thermocouples HP 1e3 were nearly the

same. Thermocouple HP 5 had the lowest temperature value. This temperature could be explained by a false junction along the thermocouple or an incorrect installation. The back panel temperature was 102.7 _C and 92 _C in test 1 and test 2, respectively. The back panel temperature was higher than the pipe temperatures since the thermal conductivity of the stainless steel sheet is relatively low

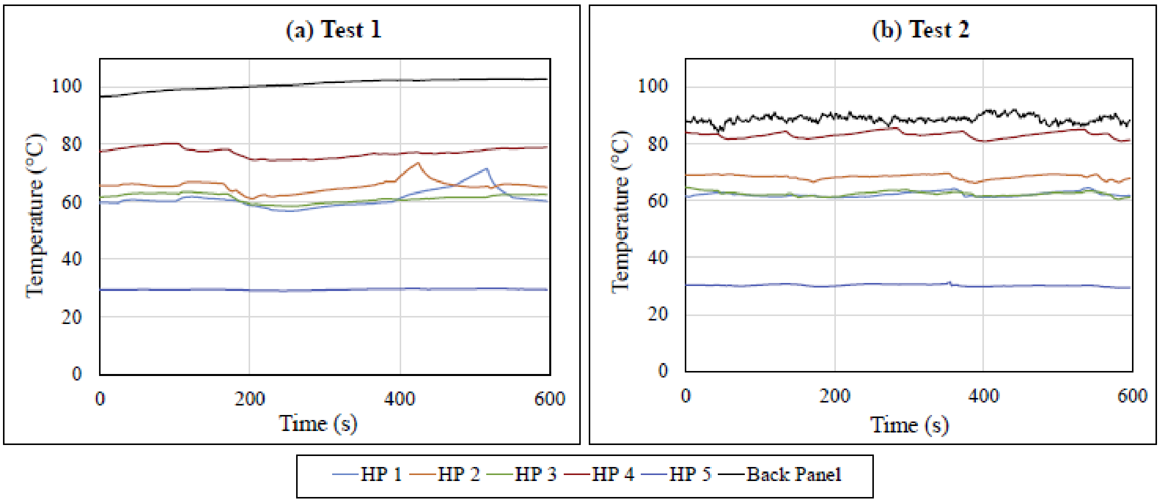

fig 5 . FHP surface Temperature.

In test 1 the average temperature of the bottom header was 59.6 _C, while the average temperature of the thermocouples placed on the top header which represents the adiabatic section varied between 38.5 _C and 53.3 _C with an average of 43.8 _C. In test 2 the thermocouples on the bottom collector showed an average temperature of 63 _C while the average temperature of the thermocouples placed on the adiabatic section was 41.3 _C. The bottom header temperature in test 2 was higher than for test 1 as result of the higher temperature of the heaters.

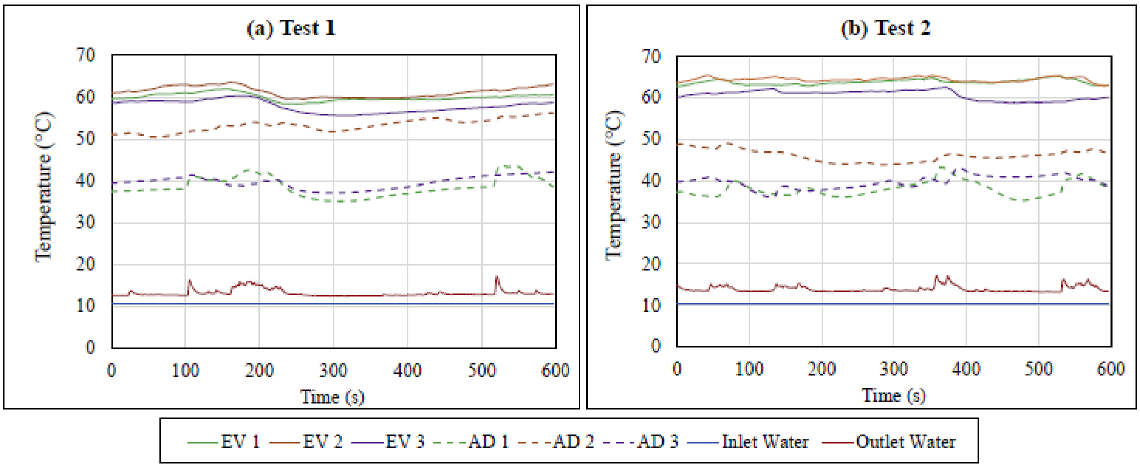

Fig.6 FHP bottom header, adiabatic, water inlet, water outlet temperatures

VI.   Conclusion

A FHP for heat recovery in industrial application is tested in laboratory as well as in industry also the thermal performance of FHP is investigated .The rate of heat recovery in laboratory is about 5kw .In industry this recovery is about 10kw since production line are long. From results it can be concluded that the FHP is most promising device for waste heat recovery in industry but with many challenges such as the high temperature source and limited available space on sites. More experiments should be carried out to investigate the performance of the FHP with various surface temperatures and for different inclination angles and water flow rates.

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