Waste Heat Recovery using the Plate Heat Exchanger

Rohit Prabhakarrao Sarode[1] Prof Pravinkumar Wankhade[2]
[1]Researcher [2]Professor
[1,2]Department of Mechanical Engineering
[1,2]G H Raisoni School of Science and Technology, Amravati, Maharashtra, India

Abstract— The price of energy is one of the big problems in front of the Industrial sector and many Companies. This problem increases continuously year by year. Therefore Industrial sections and companies searching for a new best method for lower their energy use. This research paper presents a comprehensive review of the waste heat recovery method by using the Plate heat exchanger. Using this waste recovery technique can significantly reduce industrial energy consumption and also help to handle the toxic and dangerous waste generated from various industrial processes. As a result, this dangerous waste cannot be released into the atmosphere directly and must be destroyed by burning first. Instead of disposing of these burning waste gases, waste heat recovery technique is able to reuse them in a way that can help to reduce energy consumption and also aids in reusing Dangerous emission. This waste heat technique is very useful to the generated extra heat source and this extra heat source is beneficial to replace or supplement heat for several industrial purposes.

Keywords: Waste heat recovery, Plate heat exchanger, Energy Saving, Global warming

I. INTRODUCTION

With trends in Energy prices increased within the past decades, as well as growing concern about engineering Industries have been challenged to reduce greenhouse gas emissions and also improving the energy efficiency of their site.

In this regard, very beneficial to waste heat recovery techniques in industrial areas and also has been key as one of the major areas of research regards to reducing energy consumption, handing dangerous and toxic gases i.e., lower harmful emissions and also improve production and operating efficiency.

Industrial wastes gases have the potential to generated additional heat source but this wastes heat is a by-product of industrial processes, not the primary function of generating waste heat in industrial processes. Therefore this heat is wasted and dumped into the environment, so these very high-temperature gases mixed with the environment result in increased greenhouse gas emission. The main sources of waste heat include high-temperature combustion gases dumped to the environment, many heated products of existing industrial processes and also heat transfer from hot equipment surfaces [1]. To overcome this problem, one of the best methods is a waste heat recovery because high-temperature gases instead of discharged to the atmosphere is passing through heat recovery equipment. Therefore it is helpful to reduce environmental impact by reducing emission which may help to control global warming.

The quantity of waste heat available can be calculated using the following Equation.

$$Q = \rho \times V \times CP \times \Delta T$$

Where, Q (J) is the amount heat, V is the flow rate (m3/s), ρ is density of the flue gas (kg/m3), Cp is the specific heat of the substance at constant pressure (J/kg .K) and ΔT is the difference in substance temperature (K) between the final highest temperature at outlet (Tout) and the initial temperature at inlet (Tin) of system.

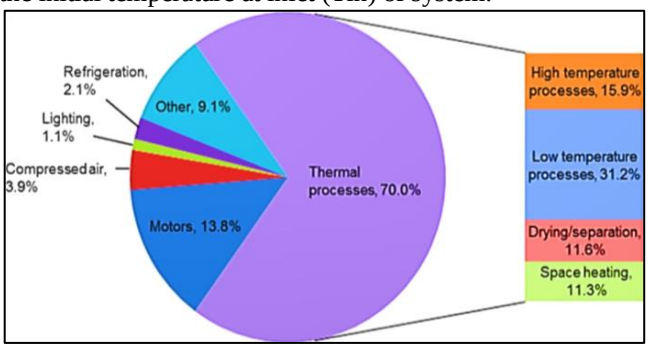

Fig. 1: 2016 Energy Consumption in the UK Manufacturing Industry [2].

Heat loss can be classified on the basis of the temperature range i.e., High temperature, low temperature, and medium temperature grades. Heat recovery (WHR) techniques are available for every range of waste heat. High-temperature Recovery i.e., WHR consists of recovering waste heat at greater than 400 °C temperature usually this heat comes from the direct combustion process. The Medium temperature range is 100-400 °C and the low-temperature range is less than 100 °C temperature. In medium range temperature heat comes from the exhaust of combustion units and in the low-temperature heat from the product, parts, surface and the equipment of process units [3].

This paper focuses on waste heat recovery using a plate heat exchanger. The main objective of this paper is improving energy efficiency by recovering waste heat generated by an industrial process and at the same time also focus on reducing environmental impact by reducing emissions is directly helpful to control global warming.

II. LITERATURE REVIEW

Waste heat recovery methods include capturing heat from a process that normally would be wasted, as an additional heat source and this heat is distributing such equipment or process that is commonly used as an effective and environmentally friendly way to save heat energy. Currently, huge investments are being made to dispose of waste heat on the atmosphere in the form of extremely high stacks for disposal of cooling towers, fin-fan coolers, and flue gases. The waste heat recovery method has the potential to attenuate these costs and to scale back environmental impact alongside several other benefits [4]. At present, nearly 20 to 50 % of industrial energy input is lost as waste heat. This waste heat is within the sort of high-temperature exhaust gases, cooling tower and lots of heat loss from hot

equipment surfaces and many heated products in industrial plants [1].

The amount of energy that is available to be used is defined by its exergy. This energy factor means exergy that can be used to carry out work within a system. In addition, most of the 'waste' energy available in the system lies in it the nature of the heat, which is generally less exergy than stored For example chemical or electrical energy. According to 2016 energy consumption in UK manufacturing industry by types of data from the department of business [fig 1], energy and industrial strategy, 70 % of the UK industrial demand is from the thermal process of which 15.9 % is classified as high-temperature process and almost 31.2 % is classified as low-temperature process heat and remaining are Drying/ separation and space heating [2]. According to these data, it is proved that the potential of industrial waste heat saving is huge. Techniques for using waste heat from industry can be classified as passive or active technology. It depends on whether the heat is used directly at the same temperature or at a lower temperature level or whether the energy is converted to another form of energy or to a higher temperature [Fig. 2].The active application of waste heat technique is categorized into three types on the basis of waste heat provide heat, cold or power i.e., Waste Heat to Heat (WHTH), Waste Heat to Cold (WHTC), or Waste Heat To Power (WHTP). Heat exchanger and thermal energy storage are the two most effective passive technologies. This passive technology can be used for reproducing, recovering and reusing wastes heat within an industry to create an additional heat source [3].

In this paper, we concentrated on an approach towards the most dominant passive technology of waste heat recovery i.e. Heat exchanger.

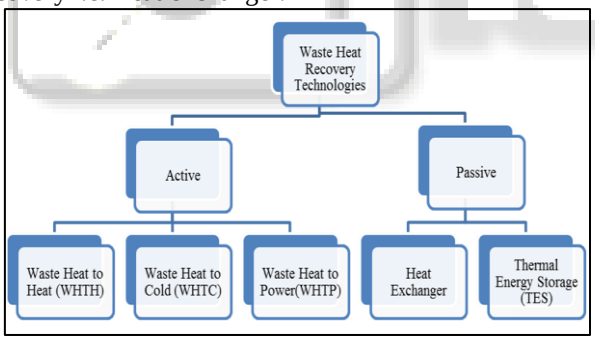

Fig. 2: Categorization of waste heat recovery technologies [3].

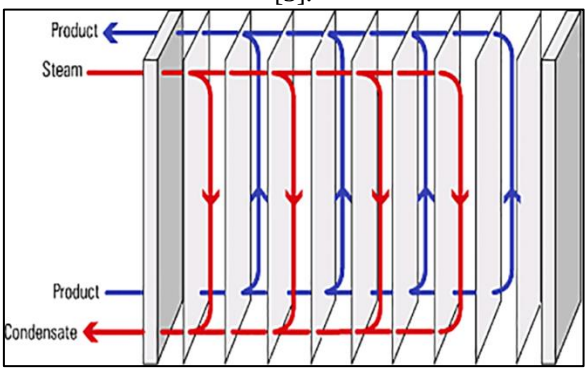

Fig. 3: Schematic arrangement of a plate heat exchanger.

III. PLATE HEAT EXCHANGER

A plate heat exchanger is one type of heat exchanger that uses metal plates to transfer heat from one fluid to another [fig 3]. This has a major advantage over a traditional heat exchanger is fluids are spread over a very large surface means much more heat transfer area [5]. Similarly, other advantages of plate heat exchange are Great adaptability, Compact structure, Small size and low consumable, Easy to remove, wash and repair. It has a major plus point is High heat transfer coefficient and low metal consumption, making heat transfer more effective.

In plate heat exchanger includes plates are semi-welded, welded or brazed together are totally dependent on the application of the heat exchanger. In these types of a heat exchanger, hot fluid flows in alternating chambers in one direction and cold fluid flows in other alternate chambers but flowing opposite to the hot fluid direction [6]. Mainly plate heat exchanger refers either single pass [fig 4] or multiple pass [fig 5] arrangement as shown in the figure.
Most of the researchers discussed the heat performance analysis of the plate heat exchanger is used and developed for a variety of purposes and also developed both numerical and experimental correlations.

Tambe Shahanwaj, Pandhare Nitin, et al.[7] in their paper they primarily focused on the thermal design of plate heat exchanger for one pass one arrangement system and these researchers also analysed overall heat transfer coefficient and effectiveness. In this experimental system includes water- water heat transfer.

Anil Kumar Khandale and Ravi Vishwakarma [8] present out performance evaluation of heat transfer enhancement by a corrugated plate heat exchanger. These researchers have investigated the heat transfer characteristic of commercial plate heat exchanger using performing experiments by different geometrical Configuration.

Roberto Cipollone, Giuseppe Bianchi, et al. [9] carried out experimental performances of an evaporator for small scale waste heat recovery applications. This performance based on bottoming Organic Rankine Cycles with the use of a plate heat exchanger in an experiment. Using a heat recovery steam generator can be improved when a plate heat exchanger is used as the component to superheat the working fluid of the system.

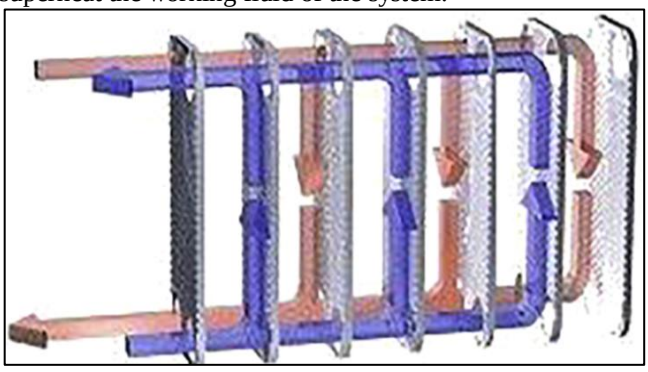

Fig. 4: Single-pass configuration of plate heat exchanger [10].

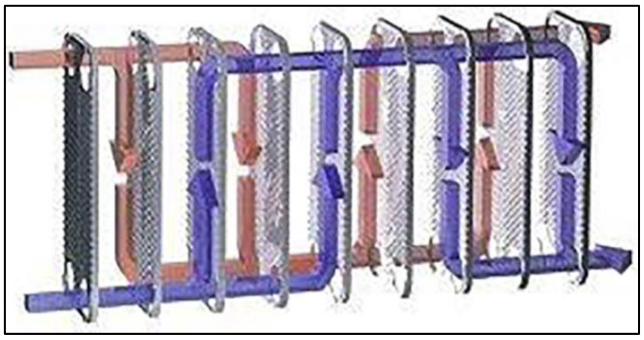

Fig. 5: Multi-pass configuration of plate heat exchanger [10].

IV. CONCLUSION

In conclusion, many industrial processes generated waste heat and this waste heat is dumped in the environment. This improper management of waste heat originates from a lot of problems in front of industries and the environment. One of the solutions to overcome this problem is a waste heat recovery because of the Waste heat recovery method collecting and re-using of the lost heat of industrial processes that can be used to generate additional heat sources and also reduces industrial energy consumption. Heat loss in the form of a high-temperature grade, medium-temperature grade, and low-temperature grade and waste heat recovery systems are correspondingly introduced for each range of waste heat.

In this regard, a comprehensive review is presented for the waste heat recovery used in industrial processes. It was investigated that, one of the dominated method of waste heat recovery using the plate heat exchanger. Plate heat exchanger offers a cost-effective way to capture heat from industrial processes and utilized at the diverse industrial processes. Also, concluded that plate heat exchanger offers high temperature and pressure limits and is used to heat transfer from one fluid to another with a high heat transfer area. Waste heat recovery methods using a plate heat exchanger are a highly attractive investment in the industrial area because it has a very good source of energy-savings and High-temperature waste gases in an industrial process are dumped to the plate heat exchanger results in reducing emissions which may very helpful to control the global warming.

ACKNOWLEDGMENT

I would like to express my special appreciation and thanks to my advisor Professor Pravinkumar Wankhade, you have been a tremendous mentor for me. I would like to thank you for encouraging my first research and for allowing me to grow as a research scientist. I wish to express my senior thanks to Professor Yogesh Deshmukh, HOD of mechanical engineering, for providing me with all the necessary facilities.

I take this opportunity to express my gratitude to all those people who have been directly and indirectly with me during this completion of a research paper.

REFERENCES

[1] I. Johnson, W.T. Choate, A. Davidson, “Waste Heat Recovery: Technology and Opportunities in U.S. Industry”, BCS Incorporate, Washington, D.C., 2008.
[2] Elliot Woolley, Yang Luo, Alessandro Simeone, “Industrial waste heat recovery: A systematic approach”, Sustainable Energy Technologies and Assessments 29 (2018), 50-59.
[3] S. Bruckner, S. Liu, M. Laia, M. Radspieler, L.F. Cabeza, L. Eberhard, “Industrial waste heat recovery technologies: an economic analysis of heat transformation technologies”, Applied Energy 151 (1) (2015) 157–167.
[4] C. Reddy, S. Naidu, Waste Heat Recovery Methods and Technologies, University of Singapore, 1 1 2013. [Online]. Available: http://www.chemengonline.com/waste-heat-recovery-methods-and technologies/? Printmode=1. [Accessed 02 01 2020].
[5] K. Sreejith, B. Varghese, D. Das, D. Devassy, K. Harikrishnan,” G.K. Sharath, Design and cost optimization of plate heat exchanger”, Res. Inventy: Int. J. Eng. Sci. 4 (10) (2014) 43–48.
[6] Reza Aghayari, Heydar Maddah, Fatemeh Ashori, A. Hakiminejad, M. Aghili, “Effect of nanoparticles on heat transfer in mini double-pipe heat exchangers in turbulent flow”, Heat Mass Transfer 51 (2015) 301–306.
[7] Tambe Shahanwaj K, Pandhare Nitin T, Bardeskar S.J, Khandekar S.B, “Experimental Investigation of performance of Plate Heat Exchanger for water as working fluid”, International Journal of Research in Engineering and Technology, vol.4, Issue 3, 2015.
[8] Anil kumar Khandale and R. Vishwakarma, “Performance Evaluation of Heat Transfer Enhancement by Corrugated Plate Heat Exchanger, International Journal of Mechanical Engineering Research and Technology”, Vol.1, No.1, 2015.
[9] R. Cipollone, G. Bianchi, D. D. Battista, F. Fatigati, Experimental and numerical analyses on a plate heat exchanger with phase change for waste heat recovery at off-design conditions, in Journal of Physics: Conference Series 655, L'Aquila, 2015
[10] SEC Heat Exchangers, SEC Brazed Plate Heat Exchangers (BPHE). [Online]. Available: http://www.brazedplate.com/. [Accessed 15 12 2019].

