

Shell & Tube Heat Exchanger- An Exergy Study

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ABSTRACT: The most critical issue nowadays is energy usage. The energy measurement only results in energy use and device energy losses. It does not have details on the equipment's internal inefficiency. As added to the process or a whole facility, the exergy study indicates that the beneficial function capacity. Exergy-based analyses are very convenient methods for assessing the performance of energy conversion systems. Exergy is the maximum work that can be obtained from a system. Exergy-based analyses help determine the irreversibility (entropy generation) and how a source can be used effectively. In this study a shell and tube heat exchanger were taken for the study purpose. The Water inlet temperature 30°C & refreshment water outlet temperature is 45°C and 0.5 bar pressure was maintained.

KEYWORDS: Exergy, Shell & Tube type heat exchanger, Efficiency

I. INTRODUCTION

A heat exchanger is an effective heat transfer system from one medium to another. There are media that may be isolated by a concrete wall to stop mixing or in close contact. They are commonly used as room heating, ventilation, air conditioning, plantations, chemical factory, petrochemicals, petroleum refining, gas manufacturing and wastewater treatment plants. An internal combustion engine, through which a circulating fluid called the engine coolant passes through the radiator coils and air flows along the coils, which cool the coolant and heat inbound air.

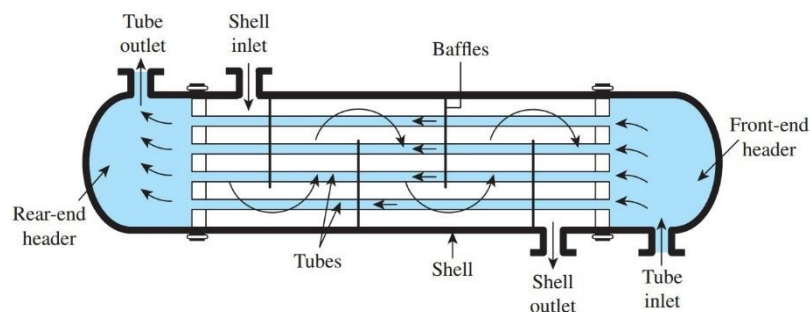


Fig. 1: Shell and Tube type Heat Exchanger

It is the most common form of heat exchanger for petroleum refineries and other large chemical process factories and is ideal for higher pressure applications. This form of heat exchanger is a shell (a large pressure vessel) with a pack of tubes within the shell as its name suggests. One fluid runs through the tubes and another fluid runs through the tubes (by the shell) to pass heat between or between the two fluids. The group of tubes is called a bundle of tubes and may be

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made of different tubes such as a single, longitudinal, etc. Exergy analysis is a powerful tool for developing, evaluating, and improving an energy conversion system. The growing energy supply and demand have created an interest toward the plant equipment efficiency and the optimization of existing thermal power plants. At present, most of the power plants are going to be designed by the energetic performance criterion which is based on the first law of thermodynamics. Energy losses taking place in a system can be easily determined by using exergy analysis. The exergy concept has gained considerable interest in the thermodynamic analysis of thermal processes and plant systems since it has been seen that the first law analysis has been insufficient from an energy performance standpoint. The system energy balance is not sufficient for the possible finding of the system imperfections. The types of applications of exergy methods to energy systems are extremely varied and include the following sub grouped as (a) utility, (b) industrial, (c) residential-commercial, and (d) transportation. Application of the exergy analysis may be applied predominantly among industrial energy systems. [1][2][3][4].

II. METHODOLOGY FOR EXERGY ANALYSIS

Exergy is defined as the amount of work (= entropy-free energy) a system can perform when it is brought into thermodynamic equilibrium with its environment. Following the method from the reference text for validating the exergy analysis.

$$EX = (H - H_0) - T_0(S - S_0)$$

H = Enthalpy of system.

S = Entropy of system.

T = Temperature of system.

(1) Exergy Analysis

$$E = mv[cpv[(tv_1 - tv_2) - t_0 \ln(tv_1/tv_2)] + hfg - t_0 \cdot sfg] - (mc \cdot cpc) \cdot [(tc_2 - tc_1) - t_0 \ln(tc_2/tc_1)]$$

(2) Efficiency

$$\eta_{ex} = \frac{[(tc_2 - tc_1) - t_0 \ln(tc_2/tc_1)] \cdot [mv \cdot [cpv[(tv_1 - tv_2) - t_0 \ln(tv_1/tv_2)] + hfg - t_0 \cdot sfg]]}{mv(e_2 - e_1)}$$

Where,

$$mv(e_2 - e_1) = [mv \cdot [cpv[(tv_1 - tv_2) - t_0 \ln(tv_1/tv_2)] + hfg - t_0 \cdot sfg]]$$

$$mc(e_{v1} - e_{v2}) = [(tc_2 - tc_1) - t_0 \ln(tc_2/tc_1)]$$

Specification

cpv = Specific heat of vapour, kJ/kg K

cpc = Specific heat of water, kJ/kg K

mv = Mass flow rate of vapour kg/s

mc = Mass flow rate of cooling water kg/s

tv₁ = Inlet vapour temperature K

tv₂ = Outlet vapour temperature K

tc₁ = Inlet cooling water temperature K

tc₂ = Outlet cooling water temperature K

t₀ = Environment temperature

E = Exergy rate, kW

η_{ex} = Exergy efficiency

hfg = Enthalpy of Condensation kJ/kg

sfg = Entropy of Condensation kJ/kg

The benefits of exergy analysis are numerous compared to energy analysis. Some of the more significant are Exergy efficiencies are always the measures of the approach to true ideality and provide more meaningful information when assessing the performance of energy systems. Also, exergy losses clearly identify the locations, causes, and sources of deviations from ideality in a system. Exergy methods can help evaluate the thermodynamic values of the product energy forms in complex systems with multiple products (e.g., cogeneration and trigeneration plants). Exergy-based methods can be used to improve economic and environmental assessments. Exergy can improve understanding of terms like

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energy conservation and energy crisis. Exergy methods can help in optimization activities. There has been an increasing interest in using energy and exergy modeling techniques for energy utilization assessments in order to attain energy and financial savings. [5][6][7][8]

III. RESULT OBTAINED

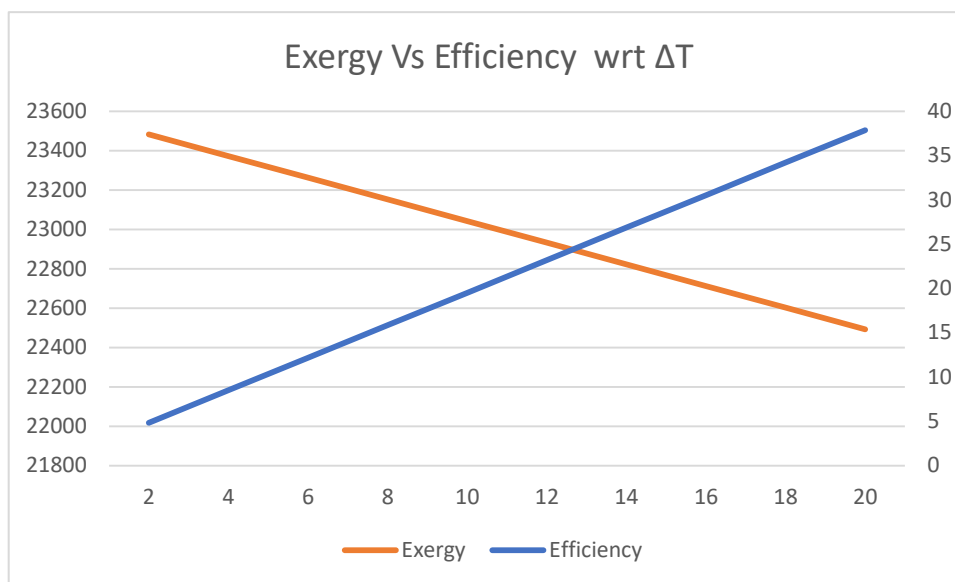


Fig. 2 Exergy Vs Efficiency with respect to ΔT

As the change in temperature was observed in the heat exchanger the exergy curve was linear in downstream and also the efficiency curve in upstream. The first law analysis shows major energy loss that has been found to occur in pipes.

IV. CONCLUSION

At refreshing water inlet temperature of 30°C & cooling outlet temperature is 40°C at 0.5 bar pressures, the exergy is 23483.0 kW at a temporary efficiency of 4.85% was observed initially and finally the exergy is 2249.23 kW at a temporary efficiency of 37.885% was observed. Finally, there is a need for further work to develop a methodology for optimizing the exergy and to relate the overall efficiency to the rational efficiencies of its components or subsystems to include in some significant new conceptual developments and beneficial interpretations. An exergy method of optimization gives logical solution improving the power production opportunities in thermal and nuclear power plants.

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