**EXPERIMENT NO. 2**

*OBJECTIVE:*

To determine the effectiveness of Shell and Tube Heat Exchanger for parallel flow.

*INTRODUCTION:*

In many process industries it is a frequent necessity to heat, cool, vapourize and condense various fluid streams. Different types of heat transfer equipments are used for such purposes. Heat Exchanger is a device in which two fluid streams, one hot and another cold are brought into thermal contact in order to affect transfer of heat from hot fluid stream to the cold. It provides a relatively large area for heat transfer for a given volume of the equipment.

The simplest type of heat exchanger is a double-pipe heat exchanger in which one fluid flows through the annular space between the inner and outer pipes. In the design of heat exchanger one should take into account the following important factors:

* THE THERMAL ANALYSIS-

In this phase of design one is primarily concerned with the estimation of heat transfer area for the transfer of heat at a specified rate for the given flow rates and temperature of the fluids.

* THE MECHANICAL DESIGN-

In this phase of design one takes into account the operating temperatures, pressures, corrosive nature of the fluids, pressure drop, thermal stresses etc.

* THE DESIGN FOR THE MANUFACTURER

In this phase of design, one concentrates on the selection of the material, seals, enclosures, cost of manufacturing procedures.

*THEORY:*

The shell and tube heat exchanger is commonly used in the food and chemical process industries. This type of exchanger consists of a number of tubes in parallel enclosed in a cylindrical shell. Heat is transferred between one fluid flowing through the tubes and another fluid flowing through the cylindrical shell around the tubes.



a shell and tube heat exchanger

In this miniature exchanger, baffles inside the shell increase the velocity of the fluid and hence, the rate of heat transfer increases. The exchanger has one shell and seven tubes with two transverse baffles in the shell. The exchanger is mounted on a PVC base plate which incorporates four holes, which locate it on four studs at the left hand end of the service unit. The PVC base plate is secured to the service unit using thumb nuts. In normal operation the hot fluid from the hot water circulator enters the header at one end of the shell and passes through the bundle of stainless steel tubes. The cold fluid from the cold water supply passes through the cylindrical shell. This arrangement minimizes heat loss from the exchanger without the need for additional insulation and allows the construction of the exchanger to be viewed.

*PROCEDURE:*

* Fix the four thermometers in position.
* Start the flow on hot water side. Similarly start the flow on cold water side.
* Switch on the geyser.
* Adjust the flow rate on water side. Keep the flow rate same till steady state is achieved (i.e. temperature readings do not change with time).
* Note the temperatures and measure the flow rates.
* 4th and 5th steps are repeated for different sets of flow rate.

*CALCULATIONS :*

Mass flow rate (qm), kg/s = Volume flow rate (qv) x Density of fluid (ρ)

Heat power (Q), W = Mass flow rate (qm) x specific heat (cp) x (ΔT)

Therefore:

Heat power emitted from hot fluid Qh= qmh. Cph (T1 - T2)

Heat power absorbed by cold fluid Qc= qmc. Cpc (T4 - T3)

Heat power lost (or gained) Qf= Qh- Qc

Overall Efficiency η = Qc/Qh \* 100 %

Theoretically Qh and Qc should be equal. In practice these differ due to heat losses or gains to/

from the environment.

Sample calculation :

Mass flow rate of hot water= 49.457 \*10-3 kg/s

Inlet temperature of hot fluid = 40°C

Outlet temperature of hot fluid = 36°C

Heat lost by hot fluid =m\*Cph\*∆T

Qh=49.457\*10-3\*4180.5\*4= 0.827\*103J/s

Mass flow rate of cold water = 100.128\* 10-3 kg/s

∆T= 1°C

Cpc=4187 J/kg.K

Qc=100.128\*10-3\*4178\*1 =0.418\*10 3J/s

Ƞ= Qc/Qh = .418/.827 = 0.505

*RESULT AND DISCUSSION:*

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| HOT WATER | | | | COLD WATER | | | | ƞ |
| Mass flow rate(\*10-3) | Inlet temp.(°C) | Outlet temp.(°C) | Qh (J/s) | Mass flow rate(\*10-3) | Inlet temp.(°C) | Outlet temp.(°C) | Qc (J/s) |  |
| 49.457  40.9972  44.657 | 40  42  41 | 36  37  36.5 | 827.01  856.94  840.10 | 100.128  107.470  90.90 | 27  27  27 | 28  28  28 | 418.23  449.00  379.78 | 0.505  0.524  0.452 |

From the results obtained we can see that the effectiveness of heat exchanger obtained shows variation with change in flow rates. This can be observed that for best heat exchanger, we must have optimum condition of flow rates.

Possible sources of error are :

* leakage in apparatus
* improper working of thermometer
* blockage in thermo-wells
* wrong measurement of flow rate due to lack of proper measuring instruments.

*NOMENCLATURE:*

Ƞ : Efficiency of heat exchanger

Qf: Heat transferred between fluids

Cph : Heat capacity of hot fluid

Cpc: Heat capacity of cold fluid

qmh: mass flow rate of hot fluid

qmc: mass flow rate of cold fluid