KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY

COLLEGE OF ENGINEERING

DEPARTMENT OF MECHANICAL AND CHEMICAL ENGINEERING

ME 396

MECHANICAL ENGINEERING LABORATORY

GROUP M



**HEAT TRANSFER EXPERIMENT USING HEAT EXCHANGER**

**LAB TECHNICIAN:**

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**HEAT EXCHANGER**

**INTRODUCTION**

Heat exchangers are devices that are used as a surface for thermal heat transfer between fluids. The

experiments carried out investigated the performance of three main heat exchangers: double pipe,

shell-and-tube and plate heat exchangers. Each heat exchanger was tested under two different flow

arrangements: parallel (co-current) flow and counter current flow. Aside from flow distribution cold

mass flow rates were varied to evaluate the effect on heat exchanger performance. The data

collected from each experiment was used to calculate the overall heat transfer coefficient, which

was then used as a basis to compare the performance between each heat exchanger. In general, the

results showed that in steady state operation the overall heat transfer coefficient increased as the

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Heat exchangers are devices that are used as a surface for thermal heat transfer between fluids .Heat exchangers transfer heat between two or more fluids and are used in both cooling and heating processes. The fluids may be separated by a solid wall to prevent mixing or they may be in direct contact. They are widely used in space heating, refrigeration, air conditioning, power stations, chemical plants, petrochemical plants, petroleum refineries, natural-gas processing, and sewage treatment.

There are three primary classifications of heat exchangers according to their flow arrangement. In parallel-flow heat exchangers, the two fluids enter the exchanger at the same end, and travel in parallel to one another to the other side. In counter-flow heat exchangers the fluids enter the exchanger from opposite ends.

**Mode of Operation**

Heat transfer in a heat exchanger usually involves convection in each fluid and conduction through the wall separating the two fluids. Radiation heat transfer between the exchanger and the environment can usually be neglected unless the exchanger is not insulated and its external surfaces are very hot. In the analysis of heat exchangers, it is convenient to work with an overall heat transfer coefficient U that accounts for the contribution of all these effects on heat transfer. In the analysis of heat exchangers, it is usually convenient to work with the logarithmic mean temperature difference LMTD which is an equivalent mean temperature difference between the two fluids for the entire heat exchanger.

For this experiment, we considered the Double pipe heat exchangers.

**Aim Of Experiment**  The experiment was conducted to characterize the heat exchanger for air to water heat transfer.

**Apparatus**

The apparatus consists of two double pipe units which are fitted with thermocouples. One unit has a fouling coating on the outside of the inner pipe. Air is supplied from a blower gun unit, covered by its own booklet. Both pipe units are connected to a cooling water supply which is fitted with a flow meter on the inlet. The flow meter has a digital display reading in liters/minute. A valve square is used to select parallel or counter flow and each pipe unit has a shut-off valve.

Thermocouples are fitted to the various parts of the exchanger and linked to a selector unit with a digital readout.

Location Clean tube Fouled tube

Water, left-hand end 1 7

Air inlet 2 8

Pipe surface left-hand 3 9

Pipe surface right-hand 4 10

Air outlet 5 11

Water, right-hand end 6 12

**Procedure**

Select a tube to test, the clean one is at the rear and the front tube has the fouling coating. Do not exceed a wall temperature of 80°c or the fouling coating, thermocouples and adhesive bonding may be damaged. Set the cooling water flowing. Then start the hot air blower. Monitor the thermocouples at the tube inlet, both air and pipe surface 2, 3 or 8, 9 as appropriate. Allow conditions to stabilize. Then for a range of water flow-rates note the flow-rates and the thermocouple readings. Allow sufficient time for readings to stabilize after each adjustment of water flow.

Try parallel and counter flow and compare your temperatures with the profiles. Then evaluate the various non-dimensional numbers outlined in the theory section and the following pages.

**CLEAN TUBE – PARALLEL FLOW**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| LEVEL OF WATER IN TANK | FLOW RATE  TIME/ s | TEMPERATURE oC | | | | | | | |
| 1 | 2 | 3 | | 4 | 5 | 6 | |
| 1/5 | 12.36 | 21 | 160 | | 26 | 22 | 46 | | 23 |
| 2/5 | 12.00 | 17 | 152 | | 23 | 21 | 49 | | 25 |
| 3/5 | 11.84 | 20 | 151 | | 30 | 25 | 46 | | 23 |
| 4/5 | 11.74 | 18 | 153 | | 39 | 23 | 48 | | 21 |
| 5/5 | 11.70 | 17 | 156 | | 25 | 13 | 44 | | 32 |

**CLEAN TUBE – COUNTER FLOW**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| LEVEL OF WATER IN TANK | FLOW RATE TIME/ s | TEMPERATURE oC | | | | | | | |
| 1 | 2 | 3 | | 4 | 5 | 6 | |
| 5/5 | 12.22 | 19 | 154 | | 32 | 15 | 46 | | 17 |
| 4/5 | 11.95 | 26 | 155 | | 26 | 28 | 48 | | 47 |
| 3/5 | 11.66 | 19 | 104 | | 65 | 17 | 22 | | 51 |
| 2/5 | 11.75 | 22 | 154 | | 105 | 18 | 36 | | 35 |
| 1/5 | 12.21 | 23 | 157 | | 48 | 19 | 38 | | 28 |

**FOULED TUBE – PARALLEL FLOW**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| LEVEL OF WATER IN TANK | FLOW RATE TIME/ s | TEMPERATURE oC | | | | | | | |
| 7 | 8 | 9 | | 10 | 11 | 12 | |
| 1/5 | 18.68 | 13 | 36 | | 20 | 16 | 29 | | 843 |
| 2/5 | 18.07 | 14 | 35 | | 24 | 16 | 21 | | 540 |
| 3/5 | 18.24 | 13 | 29 | | 23 | 41 | 37 | | 129 |
| 4/5 | 18.45 | 13 | 37 | | 15 | 14 | 17 | | 262 |
| 5/5 | 18.65 | 14 | 35 | | 15 | 15 | 25 | | 263 |

**FOULED TUBE – COUNTER FLOW**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| LEVEL OF WATER IN TANK | FLOW RATE TIME/ s | TEMPERATURE oC | | | | | | | |
| 7 | 8 | 9 | | 10 | 11 | 12 | |
| 5/5 | 18.32 | 23 | 40 | | 25 | 19 | 16 | | 672 |
| 4/5 | 18.11 | 17 | 40 | | 25 | 22 | 23 | | 1022 |
| 3/5 | 18.10 | 15 | 33 | | 18 | 17 | 15 | | 121 |
| 2/5 | 18.46 | 15 | 22 | | 16 | 21 | 17 | | 639 |
| 1/5 | 19.18 | 14 | 24 | | 31 | 19 | 16 | | 296 |

**RESULTS**

Parallel and counter flow for both clean and fouled tube

T*a*1= temperature of hot air at inlet

T*a*2 = temperature of hot air at outlet

T*L*1= temperature of water

T*L*2 = temperature of water at right hand end



For parallel flow For counter flow

**  **

** **

Volume of flask to fill (V) *=* 1 ml*=*10-3 *m3*

Flow rate Q 

Water velocity in the annulus is given by:

Water velocityum

The flow rate is given by the meter and should be converted into liters per seconds.(divide by 60). A is the area of the annular passage.

D1 = outside diameter of the inner tube =22.0mm=0.022m

D2 = inside diameter of the outer tube = 26.3mm=0.0263m

DE = D2 - D1 = 0.0263-0.022=0.0043

DE – the equivalent diameter for the annular passage.

Area **

The various properties of water are evaluated at the average values of the flow rate Q and ∆Tlm as shown in the table below:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Tube  Flow type | Temp    average | Water rate  *Q=L/s*  average | Flow velocity  *Um (m/s)*  *um* | Density ρ  ( | Specific  heat  *cp*  (*J/kgK*) | Thermal Conductivity *k* | Dynamic  viscosity  υ (*m2/s*) | Prandtl  Number *Pr* |
| Clean tube  Parallel flow  Counter flow  Fouled tube  Parallel flow  Counter flow | 50.73  58.97  38.77  40.15 | 0.0838  0.0836  0.0543  0.0542 | 5.7719  5.757  5.68  5.77 | 991.50  989.55  996.27  996.15 | 4180.02  4181.29  4179.05  4178.97 | 0.6357  0.6406  0.62  0.6205 | 0.0597  0.6406  0.075  0.0743 | 3.897  3.616  5.04  4.991 |

**Clean tube analysis**

**Parallel flow**



**



*Nu = 0.023 Re0.8 Pr 0.4 =*





*Nu *



**Counter flow**



**



*Nu = 0.023 Re0.8 Pr 0.4 =*





*Nu *

**Fouled tube analysis**

**Parallel flow**



**



*Nu = 0.023 Re0.8 Pr 0.4 =*





*Nu *



**Counter flow**



**



*Nu = 0.023 Re0.8 Pr 0.4 =*





*Nu *



**Conclusion**

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