Experimental Analysis of Heat Transfer rate on Plain and Biphillic Surfaces using Condensation methods

Ch. V. V. S. S. R. Krishna Murthy[1], P. Prem Kumar[2], J. Leeladhar[3], K. Tarun Teja[4], K. Satish[5], M. Demudu Babu[6], K. Mohan Rao[7], M.V.M. Patrudu[8], N. Narendra Yadav[9], V. Durga Mahesh[10].

Assistant Professor[1,2], Students of Mechanical Engineering[3,4,5,6,7,8,9,10] Department of Mechanical, N S Raju Institute of Technology, Affiliated to JNTUK, AP, INDIA

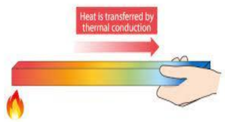
Abstract

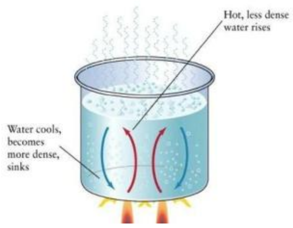
Condensation of vapour is needed in many of the Industrial applications like steam condensers, refrigeration etc. When vapour comes in contact with surface having temperature lower than saturation temperature, condensation occurs. When the condensate formed wets the surface, a film is formed over the surface and the condensation is called film wise condensation. When condensate does not wet the surface, drops are formed over the surface and condensation is called drop wise condensation. Surfaces with plain and low surface wettability lead to poor condensation process which means heat transfer rate and heat transfer coefficient is low. There are surfaces like Hydrophilic surfaces and hydrophobic pattern surfaces which help in increasing the heat transfer rate and heat transfer coefficient through material surface. By considering all the possible considerations we prepared a project which is used to find better surface for heat transfer through Biphilic surfaces by using condensation process.

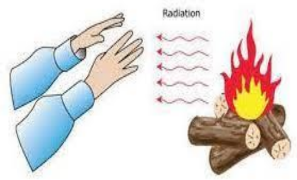
***Keywords**:* Condensation, Film Condensation, Plain Surface, Biphilic Surface, Teflon Coated Copper Tube, Teflon Coated Biphilic Copper Tube.

1. Introduction

Heat transfer is the study of the flow of heat. In chemical engineering, we have to know how to predict rates of heat transfer in a variety of process situations. For example, in mass transfer operations such as distillation, the overhead vapour has to be condensed to liquid product in a condenser, and the bottoms are boiled off into vapour in a reboiler. Often the feed stream is preheated using the bottoms product in a heat exchange. The three basic mechanisms of heat transfer. They are conduction, convection, and radiation. Conduction is an electronic/atomic mechanism of transferring energy from one place to another in solids, and a molecular mechanism of heat transfer in liquids and gases. Convection occurs when an element of fluid moves from one place to another, it brings its energy content with it, so that this is another mechanism for transferring energy from one place to another. Radiation heat transfer is ubiquitous, because all matter emits and absorbs electromagnetic radiation. The electromagnetic radiation spectrum is huge, but heat transfer is mostly concerned with a small part of it, called thermal radiation.

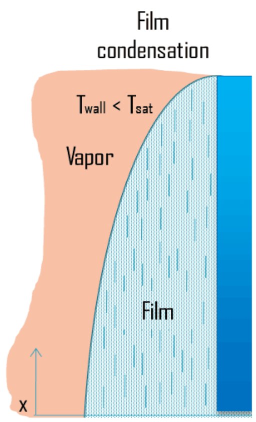


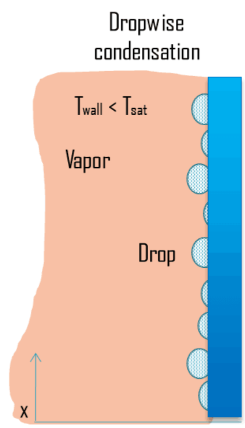




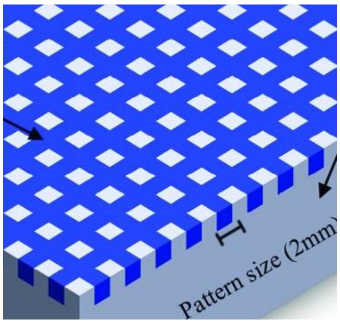
Condensation involves change of phase from the vapour state to the liquid. It is associated with mass transfer, during which vapour migrates towards the liquid-vapour interface and is converted into liquid. Condensation process is initiated by sub cooling, a temperature difference between the bulk vapour and the solid surface. Subsequently, energy in the form of the latent heat must be removed from the interfacial region either by conduction and convection through the droplet and conduction through the substrate. This chapter introduces classification and significance of various physical processes in drop wise condensation, while comparing it with the film wise form of condensation. The importance of surface wettability and equilibrium contact angle on the formation of drops is highlighted. The shape of the drop plays a central role in fixing conduction resistance, the onset of gravitational instability with respect to static equilibrium, as well as its motion over the substrate. Post instability, fresh nucleation ensures that the dropwise condensation process is intrinsically cyclic, with a characteristic timescale, area coverage, and drop size distribution.

When vapour comes in contact with surface having temperature lower than saturation temperature, condensation occurs. When the condensate formed wets the surface, a film is formed over the surface and the condensation is called film wise condensation. When condensate does not wet the surface, drops are formed over the surface and condensation is called drop wise condensation. In Film condensation, the condensate wets the surface and forms a liquid film on the surface that slides down under the influence of gravity. Film condensation results in low heat transfer rates as the film of condensate impedes the heat transfer. The thickness of the film formed depends on many parameters including orientation of the surface, viscosity, rate of condensation etc. The film increases a thermal resistance to heat flow between the surface and the vapour.

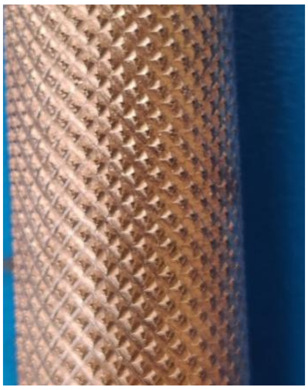


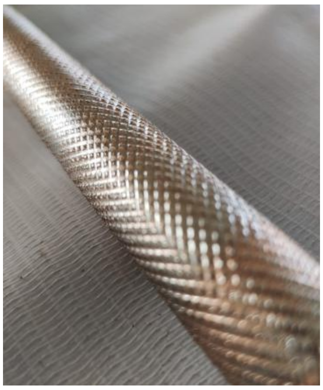


Biphilic surfaces consist of hydrophobic patterns and hydrophilic structural patterns. The hydrophilic base provides high thermal conductivity and low nucleation activation energy resulting in enhanced vapour condensation rate. Using this Biphilic surfaces, we can enhance the condensation process in which heat transfer rate and heat transfer coefficient is quite better when compared with normal plain surfaces which has smooth surface and low wettability.

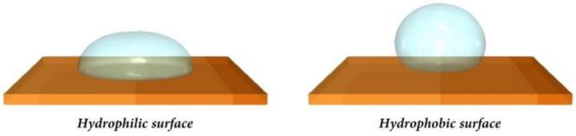


The usage of Biphilic surfaces is one of the most promising ways to simultaneously enhance heat transfer and increase critical heat fluxes during boiling and condensation processes. The concept of Biphilic surfaces is inspired by the structured pattern of banana leaf which is simpler to manufacture when compared to branched design and increases the wettability.





Hydrophilic surfaces have benefits as well. What are hydrophilic surfaces? They are high surface energy substrates that attract water and allow wetting of the surface. They typically have a droplet contact angle measurement of less than 90 degrees. Lots of surfaces tend to be more water friendly including, glass, steel, or stainless steel and many coatings and paints. **Hydrophobic surfaces** is a surface that has the ability to repel water. The term hydro phobicity was derived from two Greek words that are hydro that means water and phobic that means fear thus, hydrophobic surfaces can be define as material that tend to repel with water. A hydrophobic surface has low surface energy surface that resists wetting. Moisture contact angle measurements will classify a surface as hydrophobic when the contact angle of the water droplet exceeds 90 degrees. Exceed the 150 degree contact angle mark and the surface will be classified as super hydrophobic.



Surface Wettability is the ability of a liquid to maintain contact with a solid surface, and it is controlled by the balance between the intermolecular interactions of adhesive type (liquid to surface) and cohesive type (liquid to liquid).

1. Objectives

Understanding the process of condensation on different plain & Coated surfaces. Determination of heat transfer rate on different plain & Coated surfaces. Comparing the results of heat transfer rate on Plain and Biphilic surfaces & Coated Plain and Biphilic surfaces. Determination of better surface for condensation on plain & Coated Surfaces

2. Methods

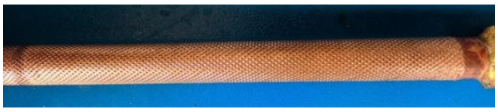
3.1 Material and its properties.

Copper is a chemical element with the symbol Cu and atomic number 29. It is soft, malleable and ductile material with very high thermal and electrical conductivity. A fresh exposed surface of pure copper has a pinkish-orange colour.

Plain Copper Tube (PCT) & Biphilic Copper Tube are used for this Experimentation and their Dimensional details are given below:

Plain Copper Tube:

Biphilic Copper Tube:



- Diameter (d) : 16 mm
- Length (l) : 300 mm

Teflon Coated Copper Tube (PCT) & Teflon Coated Biphilic Copper Tube are used for this Experimentation and their Dimensional details are given below:

Teflon Coated Copper Tube

Teflon Coated Biphilic Copper Tube:

- Diameter (d) : 16 mm
- Length (l) : 300 mm

3.2 Experimental Setup

1. This Experimental setup showing the required components including knobs, tubes etc.
2. The display shows different temperatures and different output values.
3. The base table is used to support the digital and physical components.

4. The condenser chamber is fitted to the front panel of the Experimental setup.
5. Condenser chamber has three valves. They are
    - Steam inlet valve
    - Water outlet valve
    - Condensate outlet valve
6. The water inlet is connected to one side of the copper tube and water outlet is connected to other side of the copper tube.
7. Boiler is placed on the bottom of the base table with separate water inlet for it.
8. Boiler is provided with pressure gauge, pressure relief valve, steam outlet pipe connection, water inlet and outlet connection.
9. This Setup consists of two Switches. They are.
    - Mains ON
    - Boiler ON
10. Mains ON is the main switch for all the components like Thermocouples, Indicator panel and Boiler.
11. Source voltage is connected to Mains ON through 3-pin Plug.
12. Boiler ON is the separate switch which is used to supply power to the Boiler unit in order to generate steam.
13. A fuse is providing in the circuit to prevent the damage caused by the excessive voltage.
14. In order to change the copper tube inside condenser chamber, it is provided with Bolt and Nut arrangement. Unscrewing them slowly, opens the condenser chamber easily and new surface tube will be placed and fitted easily.

3.3 Experimental Setup Specification:

Test section size (For Both Plain & Biphilic)

Copper tube diameter	:	16 mm
Copper tube length	:	300 mm
Digital Temperature Indicator	:	0 – 200 ^{o}C
Water measurement	:	1 to 30 cc/sec
Maximum steam pressure	:	0.8-1.5 Kg / cm^{2}

Components of Experimental Setup:


Condenser chamber


Steam Boiler


Pressure relief valve


Rotameter

Thermocouple

Temperature indicator

Selector Switch

Pressure gauge

3.4 Experiment Procedure

Ensure that the pipes connected to condenser chamber inlet and outlet tightly to avoid leakages.

1. Fill water slowly into the water tank and steam generator upto the required level.
2. Switch on the power supply and switch on Mains ON.
3. Switch on Boiler ON and wait for pressure reaches to 0.1 – 0.2 kg/cm^2.
4. Once the steam is generated follow the steps below.
5. Open the inlet valve and allow the cold fluid to flow through the condenser.
6. Adjust the flow rate of cold fluid to minimum (say 5 cc/sec).
7. Open the steam inlet through valve and keep steam pressure constant with the help of pressure gauge (say 0.2 kg/cm^2) throughout the experiment.
8. After cold fluid temperature becomes steady state, note down the inlet temperature, out let temperature, flow rate of cold fluid, chamber temperature and copper tube surface temperature.
9. Keeping steam pressure constant take 3 – 5 readings for different cold fluid flow rate from minimum to maximum.
10. Repeat the experiment at another constant steam pressure Say (0.4kg/cm^2).
11. Repeat the same procedure for Coated plain and Biphilic surface tube with different mass flow rates and different steam pressure.

Condensation on Plain copper tube

Condensation on Biphilic copper tube

Condensation on Teflon plain copper tube

Condensation on Teflon Coated Biphilic copper tube

3.5 Calculations:

Thermocouple Position:

- Water inlet temperature – T1
- Water outlet temperature – T2
- Copper specimen chamber steam temperature – T3
- Copper tube surface temperature –T4

3.5.A Plain Copper Tube Readings:

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Temperatures (^0C)			
			T_1	T_2	T_3	T_4
1.	0.2	5	29	34	78	57
2.	0.2	7.5	29	33	77	59
3.	0.2	15	29	31	75	58
4.	0.4	5	28	34	81	62
5.	0.4	7.5	29	34	81	61
6.	0.4	15	28	31	79	59
7.	0.6	5	28	36	82	64
8.	0.6	7.5	28	34	81	63
9.	0.6	15	29	33	80	61

Calculations of 4th reading for Plain Copper Tube :

1. Mass flow rate of water (m_w) = 5 cc/sec = $5 * 10^{-3}$ kg / sec
2. Heat carried away by the water, $(Q)_{Plain}$ = $m_w c_p (T_2 - T_1)$

= $5 * 10^{-3} \times 4.187 \times (34-28)$

= **125.61 Watts**

Where, Specific heat of water (c_p) = 4.187 KJ / Kg - ^0C

$$3.\ LMTD = \frac{(T_4 - T_1) - (T_4 - T_2)}{\ln[(T_4 - T_1)/(T_4 - T_2)]} = \frac{(62-28) - (62-34)}{\ln[(62-28)/(62-34)]}$$

$$= \mathbf{30.90\ ^{o}C}$$

4. Experimental heat transfer coefficient (U) = Q / A * (LMTD)

= 125.61 / 0.015 x 30.90

= **271 W / m² - °c**

Where,

Surface area of the plain copper tube (A) = π x d x L

= π x 0.016 x 0.3

= 0.015 m^2

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Heat Transfer Rate (Q) (watts)	LMTD (°c)	Overall heat transfer coefficient (U)
1.	0.2	5	104.6	25.41	274.43
2.	0.2	7.5	125.6	27.95	299.58
3.	0.2	15	125.6	27.98	299.26
4.	0.4	5	125.61	30.90	271.0
5.	0.4	7.5	157.01	29.42	355.78
6.	0.4	15	188.4	29.47	426.19
7.	0.6	5	167.4	31.83	350.61
8.	0.6	7.5	188.4	31.90	393.73
9.	0.6	15	251.2	29.95	559.25

3.5.B. Biphilic Copper Tube Readings :

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Temperatures (°C)			
			T_1	T_2	T_3	T_4
1.	0.2	5	26	35	85	75
2.	0.2	7.5	27	32	83	69
3.	0.2	15	26	29	80	60
4.	0.4	5	27	35	90	60
5.	0.4	7.5	27	33	88	63

6.	0.4	15	27	31	86	61
7.	0.6	5	26	36	90	74
8.	0.6	7.5	25	32	90	63
9.	0.6	15	26	31	86	55

Calculations of 4th reading for Biphilic Copper Tube :

1. Mass flow rate of water (m_w) = 5 cc/sec = $5 * 10^{-3}$ kg / sec

2. Heat carried away by the water, $(Q)_{Plain}$ = $m_w c_p (T_2 - T_1)$

= $5 * 10^{-3}$ x 4.187 x (35-27)

= **167.48 Watts**

Where, Specific heat of water (c_p) = 4.187 KJ / Kg - ^{0}C

3. LMTD = $\frac{(T_4 - T_1) - (T_4 - T_2)}{\ln [(T_4-T_1) / (T_4-T_2)]}$ = $\frac{(60-27) - (60-35)}{\ln [(60-27) / (60-35)]}$

= **34.84 ^{0}C**

4. Experimental heat transfer coefficient (U) = Q / A * (LMTD)

= 167.48 / 0.015 x 34.84

= **320.47 W / m^2- ^{o}c**

Where, Surface area of the plain copper tube (A) = π x d x L

= π x 0.016 x 0.3

= 0.015 m^2

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Heat Transfer Rate (Q) (watts)	LMTD (^{o}c)	Overall heat transfer coefficient (U)
1.	0.2	5	146.5	44.34	220.26
2.	0.2	7.5	157.01	39.44	265.39
3.	0.2	15	188.4	32.47	386.81
4.	0.4	5	167.48	34.84	320.47
5.	0.4	7.5	188.4	32.90	381.67
6.	0.4	15	251.22	31.95	524.19
7.	0.6	5	209.35	42.80	326.05
8.	0.6	7.5	219.81	34.38	426.22
9.	0.6	15	314.02	26.42	791.79

3.6.A. Teflon Coated Copper Tube Readings:

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Temperatures (^0C)			
			T_1	T_2	T_3	T_4
1.	0.1	5	29	34	80	70
2.	0.1	7.5	29	33	79	63
3.	0.1	15	29	31	78	60
4.	0.3	5	31	37	82	74
5.	0.3	7.5	30	37	81	73
6.	0.3	15	30	35	77	71
7.	0.5	5	30	43	82	77
8.	0.5	7.5	30	41	82	76
9.	0.5	15	29	38	81	74

Calculations of 4th reading for Teflon Coated Copper Tube :

1. Mass flow rate of water (m_w) = 5 cc/sec = $5 * 10^{-3}$ kg / sec
2. Heat carried away by the water, $(Q)_{Plain}$ = $m_w c_p (T_2 – T_1)$

$= 5 * 10^{-3} \times 4.187 \times (37-30)$

= **167.4 Watts**

Where,

Specific heat of water (c_p) = 4.187 KJ / Kg - ^0C

$$3.\ \text{LMTD} = \frac{(T_4 - T_1) - (T_4 - T_2)}{\ln [(T_4-T_1) / (T_4-T_2)]} = \frac{(74-30) - (74-37)}{\ln [(74-30) / (74-37)]}$$

= **39.92^oC**

4. Experimental heat transfer coefficient (U) = Q / A * (LMTD)

= 167.4 / 0.015 x 39.92

= **279.55 $W / m^2 – {}^oc$**

Where, Surface area of the plain copper tube (A) = π x d x L

= π x 0.016 x 0.3

= $0.015\ m^2$

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Heat Transfer Rate (Q) (watts)	LMTD (^oc)	Overall heat transfer coefficient (U)
1.	0.1	5	104.6	38.44	181.40
2.	0.1	7.5	125.6	31.95	262.07
3.	0.1	15	188.4	29.98	418.94
4.	0.3	5	167.4	39.92	279.55
5.	0.3	7.5	219.8	39.39	372.0
6.	0.3	15	314.02	38.44	544.60
7.	0.5	5	272.1	40.14	451.91
8.	0.5	7.5	345.4	40.24	572.23
9.	0.5	15	565.2	40.33	934.91

3.6.B. Teflon Coated Biphilic Copper Tube Readings :

Sl No.	Steam Pressure (kg/cm^2)	Water flow Rate (cc/sec)	Temperatures (^0C)			
			T_1	T_2	T_3	T_4
1.	0.1	5	30	37	79	74
2.	0.1	7.5	30	36	79	71
3.	0.1	15	30	35	79	69
4.	0.3	5	30	39	81	78
5.	0.3	7.5	30	38	81	76
6.	0.3	15	30	36	80	74
7.	0.5	5	29	43	84	82
8.	0.5	7.5	29	42	83	81
9.	0.5	15	29	40	81	78

Calculations of 4th reading for Teflon Coated Biphilic Copper Tube :

1. Mass flow rate of water (m_w) = 5 cc/sec = $5 * 10^{-3}$ kg / sec
2. Heat carried away by the water, $(Q)_{Plain}$ = $m_w c_p (T_2 - T_1)$

$= 5 * 10^{-3} \times 4.187 \times (39-30)$

= **188.4 Watts**

Where,

Specific heat of water (c_p) = 4.187 KJ / Kg - ^0C

$(T_4 - T_1) - (T_4 - T_2)$ (78-30) - (78-39)

3. LMTD = -------------------------- = -------------------------

$\ln [(T_4-T_1) / (T_4-T_2)]$ $\ln [(78-30) / (78-39)]$

= **43.34 ^{0}C**

4. Experimental heat transfer coefficient (U) = Q / A * (LMTD)

= 188.4 / 0.015 x 43.34

= **289.8 W / m^2- ^{o}c**

Where,

Surface area of the plain copper tube (A) = π x d x L

= π x 0.016 x 0.3

= 0.015 m^2

Sl No.	**Steam Pressure (kg/cm^2)**	**Water flow Rate (cc/sec)**	**Heat Transfer Rate (Q) (watts)**	**LMTD (^{o}c)**	**Overall heat transfer coefficient (U)**
1.	0.1	5	146.5	40.39	241.8
2.	0.1	7.5	188.4	37.92	331.22
3.	0.1	15	314.0	36.44	574.46
4.	0.3	5	188.4	43.34	289.8
5.	0.3	7.5	251.2	41.87	399.96
6.	0.3	15	376.8	40.92	613.88
7.	0.5	5	293.09	45.64	428.11
8.	0.5	7.5	408.23	45.18	602.37
9.	0.5	15	690.08	43.26	1063.46

4. Results

The below are the Experiment Results of **Heat Transfer rate** (Q) at the Steam Pressures of 0.2, 0.4, 0.6 (kg / cm^2) with different mass flow rates of **plain and Biphilic surface copper tube.**

Pressure	**Flow Rate(cc/sec)**	**Plain Surface (Watts)**	**Biphilic Surface (Watts)**
0.2 Kg/cm^2	5	104.6	146.5
	7.5	125.6	157.01
	15	125.6	188.4

Pressure	Flow Rate(cc/sec)	Plain Surface (Watts)	Biphilic Surface (Watts)
0.4 Kg/cm^2	5	125.61	167.48
	7.5	157.01	188.4
	15	188.4	251.22

Pressure	Flow Rate(cc/sec)	Plain Surface (Watts)	Biphilic Surface (Watts)
0.6 Kg/cm^2	5	167.4	209.35
	7.5	188.4	219.81
	15	251.2	209.35

The below are the Experiment Results of **Heat Transfer Coefficient** (U) at the Steam Pressures of 0.2, 0.4, 0.6 (kg / cm^2) with different mass flow rates of **plain and Biphilic surface copper tube.**

Pressure	Flow Rate(cc/sec)	Plain Surface (W/m^2-^{0}c)	Biphilic Surface (W/m^2-^{0}c)
0.2 Kg/cm^2	5	274.43	220.26
	7.5	299.58	265.39
	15	299.26	386.81

Pressure	Flow Rate(cc/sec)	Plain Surface (W/m^2-^{0}c)	Biphilic Surface (W/m^2-^{0}c)
0.4 Kg/cm^2	5	271.0	320.47
	7.5	355.78	381.67
	15	426.19	524.19

Pressure	Flow Rate(cc/sec)	Plain Surface (W/m^2-^{0}c)	Biphilic Surface (W/m^2-^{0}c)
0.6 Kg/cm^2	5	350.61	326.05
	7.5	393.73	426.22
	15	559.15	791.79

The below are the Experiment Results of **Heat Transfer rate** (Q) at the Steam Pressures of 0.1, 0.3, 0.5 (kg / cm^2) with different mass flow rates of **Teflon coated plain and Biphilic surface copper tube.**

Pressure	**Flow Rate(cc/sec)**	**Plain Surface (Watts)**	**Biphilic Surface (Watts)**
0.1 Kg/cm^2	5	104.6	146.5
	7.5	125.6	188.4
	15	188.4	314.0

Pressure	**Flow Rate(cc/sec)**	**Plain Surface (Watts)**	**Biphilic Surface (Watts)**
0.3 Kg/cm^2	5	167.4	188.4
	7.5	219.8	251.2
	15	314.02	376.8

Pressure	**Flow Rate(cc/sec)**	**Plain Surface (Watts)**	**Biphilic Surface (Watts)**
0.5 Kg/cm^2	5	272.1	293.09
	7.5	345.4	408.23
	15	565.2	690.08

The below are the Experiment Results of **Heat Transfer Coefficient** (U) at the Steam Pressures of 0.1, 0.3, 0.6 (kg / cm^2) with different mass flow rates of **Teflon coated plain and Biphilic surface copper tube.**

Pressure	**Flow Rate(cc/sec)**	**Plain Surface (W/m^2-^{0}c)**	**Biphilic Surface (W/m^2-^{0}c)**
0.1 Kg/cm^2	5	181.40	241.8
	7.5	262.07	331.22
	15	418.94	574.46

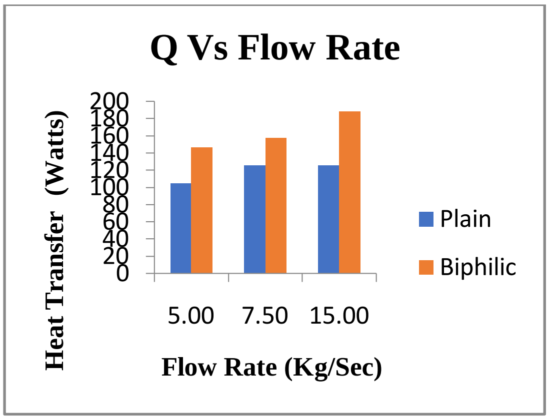
Pressure	**Flow Rate(cc/sec)**	**Plain Surface (W/m^2-^{0}c)**	**Biphilic Surface (W/m^2-^{0}c)**
0.3 Kg/cm^2	5	279.55	289.8
	7.5	372.0	399.96

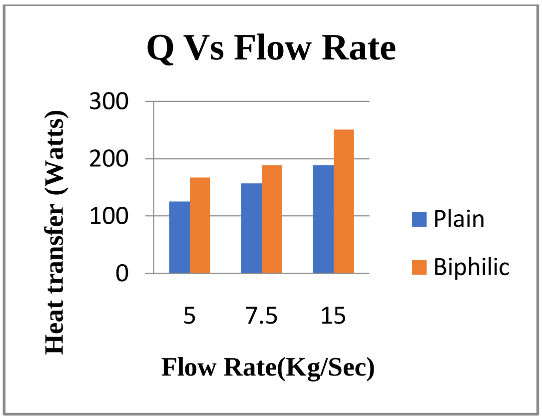
	15	544.60	613.88

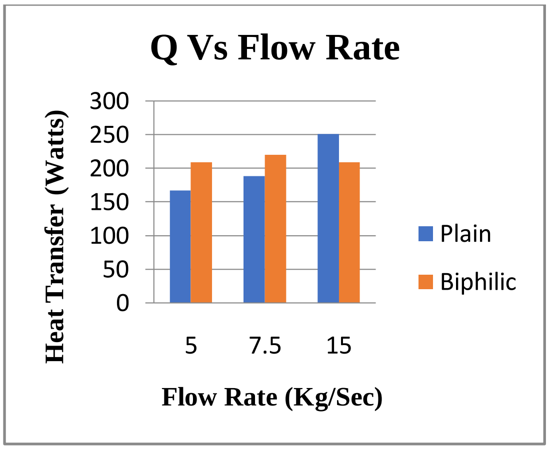
Pressure	Flow Rate(cc/sec)	Plain Surface (W/m^2-^{0}c)	Biphilic Surface (W/m^2-^{0}c)
0.5 Kg/cm^2	5	451.91	428.11
	7.5	572.23	602.37
	15	934.91	1063.46

4.1 Graphical Comparison of Results of Plain and Biphilic surface copper tube.

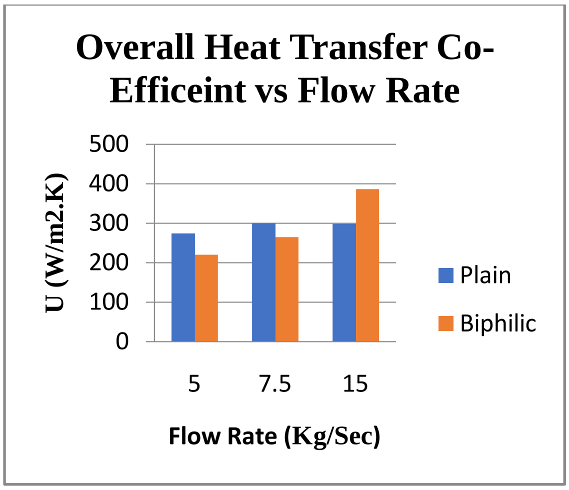
Comparison of Experimental Results of **Heat Transfer rate** (Q) at the Steam Pressures of 0.2, 0.4, 0.6 (kg / cm^2) with different mass flow rates of Copper Plain and Biphilic surface copper tube

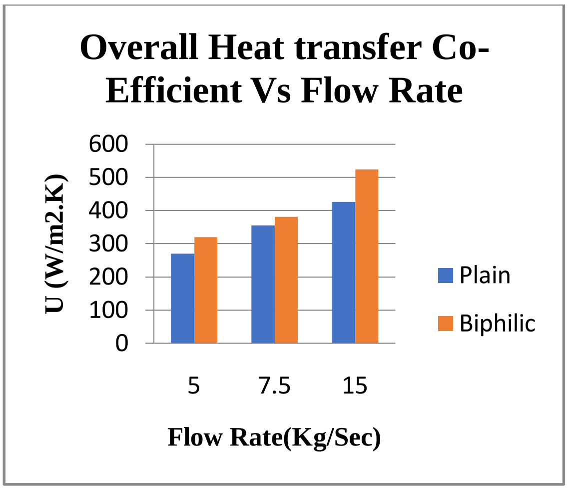


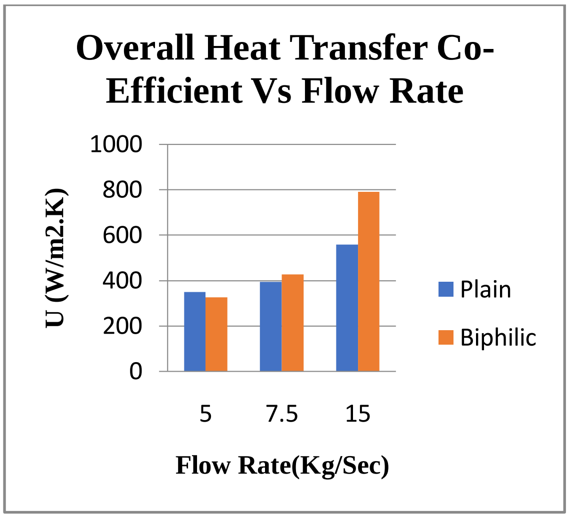




Comparison of Experimental Results of **Overall Heat Transfer Coefficient** (U) at the Steam Pressures of 0.2, 0.4, 0.6 (Kg / cm^2) with different mass flow of Plain and Biphilic surface copper tube.

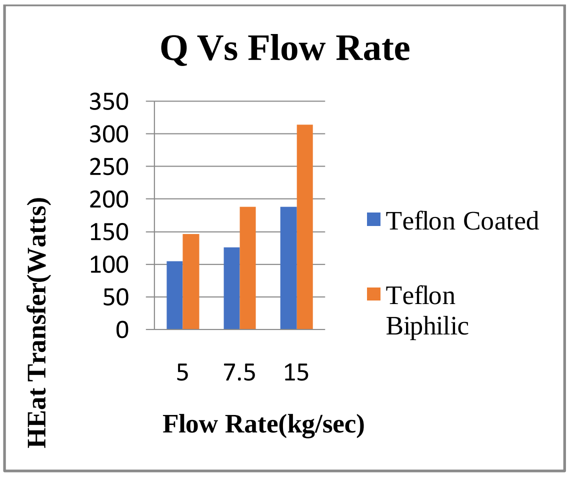


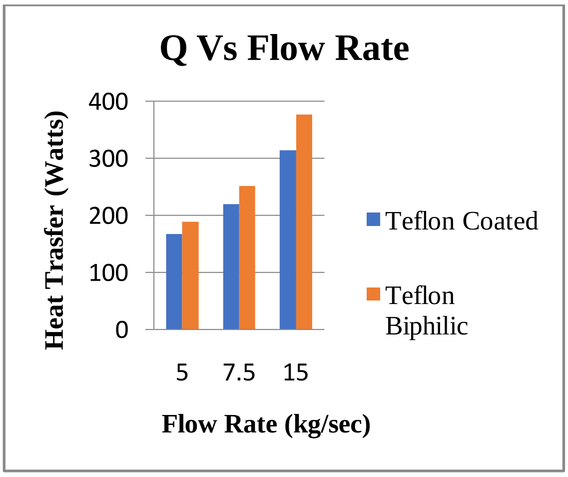


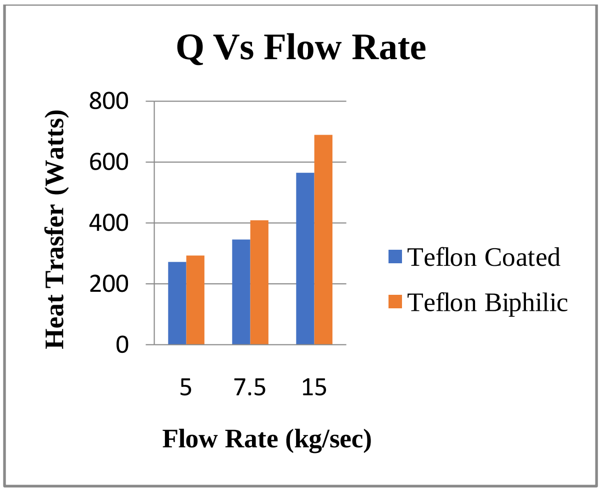


4.2 Graphical Comparison of Results of Teflon coated plain and Teflon coated Biphilic surface copper tube.

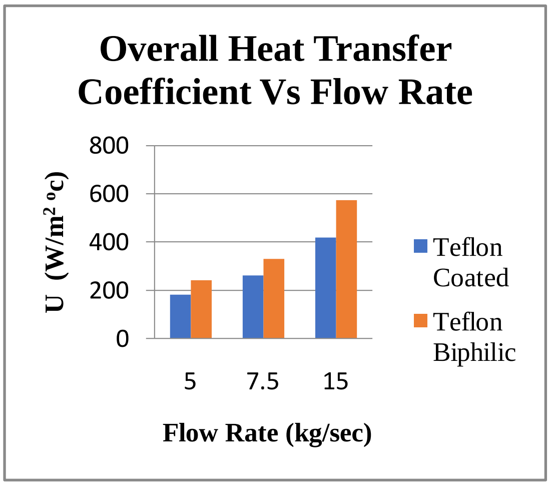
Comparison of Experimental Results of **Heat Transfer rate** (Q) at the Steam Pressures of 0.1, 0.3, 0.5 (kg / cm^2) with different mass flow rates of Teflon coated plain and Teflon Biphilic surface tube.

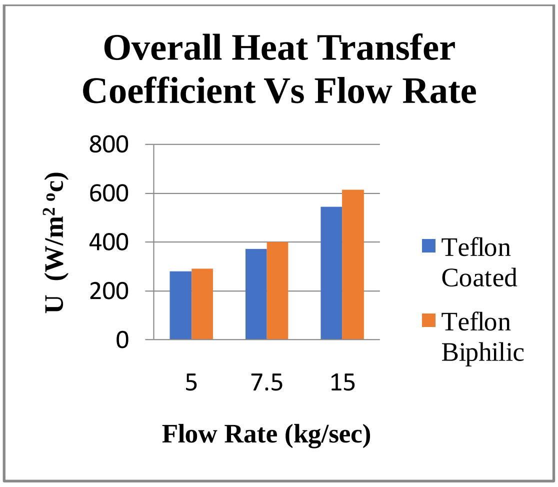


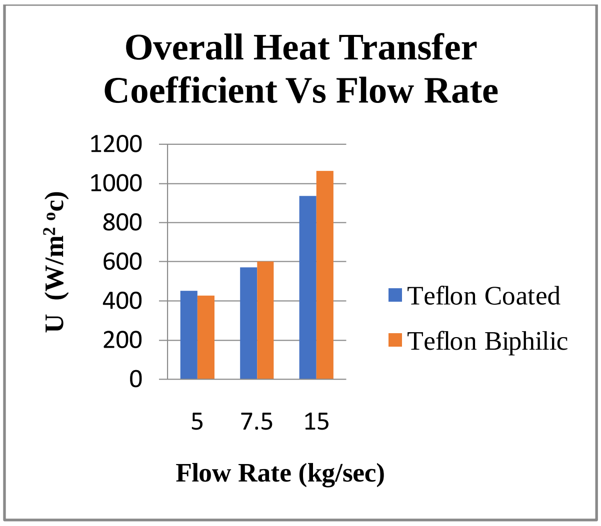




Comparison of Experimental Results of **Overall Heat Transfer Coefficient** (U) at the Steam Pressures of 0.1, 0.3, 0.5 (Kg / cm^2) with different mass flow rates of Teflon coated plain and Teflon Biphilic surface tube.







5. Discussion

Comparison of Experimental Heat Transfer rate and Overall Heat Transfer Coefficient values of Plain & Biphilic and Teflon Coated plain & Biphilic Surface tube are shown through Graphical

Representation in Results. By Comparing the results between Plain and Biphilic surfaces, it is observed that the Heat Transfer rate and Overall Heat Transfer Coefficient by Biphilic Copper surface tube are increased when compared with Copper Plain surface tube under same Steam Pressure and Flow rates condition. For a given specimen with constant area and Heat transfer coefficient, the larger the LMTD, the more heat is transferred from steam to water through Biphilic Copper Tube.

References

[1]. CP Kothandaraman, S Subramanyan. Heat and Mass Transfer Data Book, Ninth Edition.
[2]. R.K. Rajput. A Textbook of Heat and Mass Transfer, Fifth Edition.
[3]. Yunus, A. Cengel, Afshin J. Ghajar, Heat and Mass Transfer Fundamental and Applications.
[4]. Fuqiang Chu, Xiao Yan, Nenad Miljkovic. How Superhydrophobic Grooves Drive Single-Droplet Jumping. Langmuir 2022.
[5]. CunjingLv, Pengfei Hao, Xiwen Zhang, and Feng He. Dewetting Transitions of Dropwise Condensation on Nanotexture-Enhanced Superhydrophobic Surfaces. ACS Nano 2015
[6]. McAdams, William H. Heat Transition. Third ed., McGraw-Hill Book Co., Inc.,
[7]. Yu Tang, Xiaolong Yang, Yimin Li, Yao Lu, Di Zhu. Robust Micro-Nanostructured Superhydrophobic Surfaces for Long-Term Dropwise Condensation. Nano Letters 2021.