GUJARAT TECHNOLOGICAL UNIVERSITY

CHANDKHEDA, AHMEDABAD

L. J. INSTITUTE OF ENGINEERING AND TECHNOLOGY

A REPORT ON

IMPROVEMENT IN HEAT EXCHANGER BY USING TWISTED TUBE AND NANO FLUID

B.E. SEMESTER – VIII

(MECHANICAL ENGINEERING)

Submitted by

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Academic Year
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L.J. INSTITUTE OF ENGINEERING AND TECHNOLOGY

Department of Mechanical Engineering 2019

CERTIFICATE

Date:

This is to certify that the Project – 1. Work entitled **"IMPROVEMENT IN HEAT EXCHANGER BY USING TWISTED TUBE AND NANO FLUID"**, carried out by the group of students mentioned below under my guidance is approved for the Degree of Bachelor of Engineering in **Mechanical Engineering** (Semester - VII) of Gujarat Technological University, Ahmedabad during the academic year 2019.

List of Students:-

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<u>REPORT APPROVAL CERTIFICATE</u>

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This is to certify that the Project – 1. Work entitled **"<u>IMPROVEMENT IN</u> <u>*HEAT EXCHANGER BY USING TWISTED TUBE AND NANO FLUID*</u> "**, carried out by the group of students mentioned below is approved for the Degree of Bachelor of Engineering in **Mechanical Engineering** (Semester-VIII)of Gujarat Technological University, Ahmedabad during the academic year 2020.

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ABSTRACT

- Shell and tube heat exchanger is widely used in many application. Increased performance and efficiency are the most demanding need in today's world. Working fluid like Nano fluid with high heat transfer coefficient can be a promising alternative to the existing system. It should possess the height thermal conductivity, low viscosity, high specific heat, and stability. This paper discusses the review work on the uses of the Nano fluid to increase the performance of shell and tube heat exchanger. The effect of different material with different base fluid has been presented with different Nano particle shape on the performance of exchanger and on the thermal properties of working fluid has been presented.

- The importance of twisted shell and tube heat exchangers has increased immensely from the view point of energy conservation and environmental concerns. Heat exchanger plays a significant role in the operation of many systems such as power plants, process industries and heat recovery units. Among of all type of exchangers, shell and tube exchangers are most commonly used heat exchange equipment. A Nano fluid is a fluid containing Nano meter-sized particles, called Nano particles. These fluids are engineered colloidal suspensions of Nano particles in a base fluid.

- Nano fluids have novel properties that make them potentially useful in many applications in heat transfer, including microelectronics, fuel cells, pharmaceutical processes, and hybrid-powered engines, engine cooling/vehicle thermal management, domestic refrigerator, chiller, heat exchanger, in grinding, machining and in boiler flue gas temperature reduction. They exhibit enhanced thermal conductivity and the convective heat transfer coefficient compared to the base fluid. Knowledge of the rheological behavior of Nano fluids is found to be very critical in deciding their suitability for convective heat transfer applications. Heat transfer characteristics of Al2O3/water and TiO2/water Nano fluids were measured in a shell and tube heat exchanger under turbulent flow condition.

CHAPTER 1 : INTRODUCTION

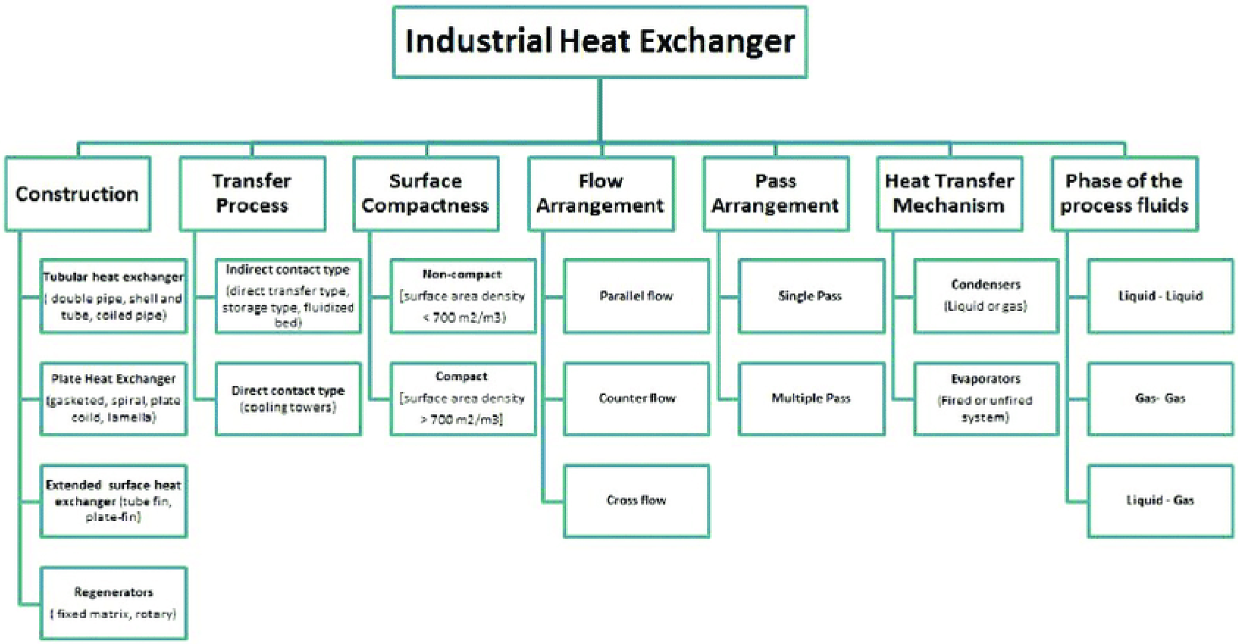
1.1 HEAT EXCHANGER

- Heat exchangers are devices used to transfer heat energy from one fluid to another. Typical heat exchangers experienced by us in our daily lives include condensers and evaporators used in air conditioning units and refrigerators. Boilers and condensers in thermal power plants are examples of large industrial heat exchangers. There are heat exchangers in our automobiles in the form of radiators and oil coolers. Heat exchangers are also abundant in chemical and process industries. Different heat exchangers are named according to their applications. For example, heat exchangers being used to condense are known as condensers; similarly heat exchangers for boiling purposes are called boilers. Performance and efficiency of heat exchangers are measured through the amount of heat transferred using least area of heat transfer and pressure drop. A better presentation of its efficiency is done by calculating over all heat transfer coefficient. Pressure drop and area required for a certain amount of heat transfer, provide an insight about the capital cost and power requirements (Running cost) of a heat exchanger. Usually, there are lots of literature and theories to design a heat exchanger according to the requirements. A good design is referred to a heat exchanger with least possible area and pressure drop to fulfill the heat transfer requirements.

Table 1 – Industries and Applications of Heat Exchangers by Type

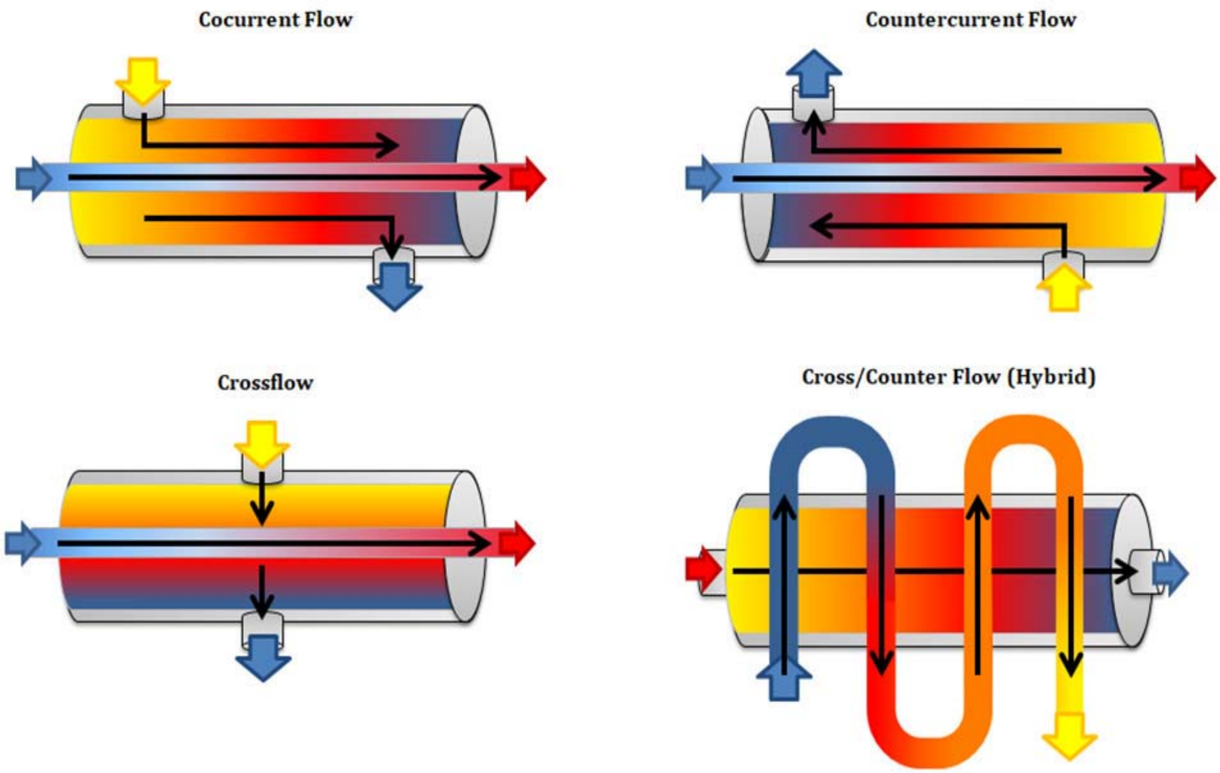
Type of Heat Exchanger	Common Industries and Applications
Shell and Tube	• Oil refining • Preheating • Oil cooling • Steam generation • Boiler blow down heat recovery • Vapor recovery systems • Industrial paint systems
Double Pipe	• Industrial cooling processes • Small heat transfer area requirements
Plate	• Cryogenic • Food processing • Chemical processing • Furnaces • Closed loop to open loop water cooling
Condensers	• Distillation and refinement processes • Power plants • Refrigeration • HVAC • Chemical processing
Evaporators/Boilers	• Distillation and refinement processes • Steam trains • Refrigeration • HVAC

1.2 CLASSIFICATION OF HEAT EXCHANGER



- Heat exchangers are typically classified according to flow arrangement ,construction, surface compactness, pass arrangement The simplest heat exchanger is one for which the hot and cold fluids move in the same or opposite directions in a concentric tube (or double-pipe) construction. In the parallel flow arrangement of Figure 1.1a, the hot and cold fluids enter at the same end, flow in the same direction, and leave at the same end. In the counter flow arrangement of Figure 1.1b, the fluids enter at opposite ends, flow in opposite directions, and leave at opposite ends.

- Alternatively, the fluids may move in cross flow (perpendicular to each other), the fluid is said to be unmixed because the fins inhibit motion in a direction (y) that is transverse to the main-flow direction (x). In this case the fluid temperature varies with x and y.



flow:

Cocurrent flow:

Cocurrent flow heat exchangers, also referred to as parallel flow heat exchangers, are heat exchanging devices in which the fluids move parallel to and in the same direction as each other. Although this configuration typically results in lower efficiencies than a counter flow arrangement, it also allows for the greatest thermal uniformity across the walls of the heat exchanger.

Countercurrent flow:

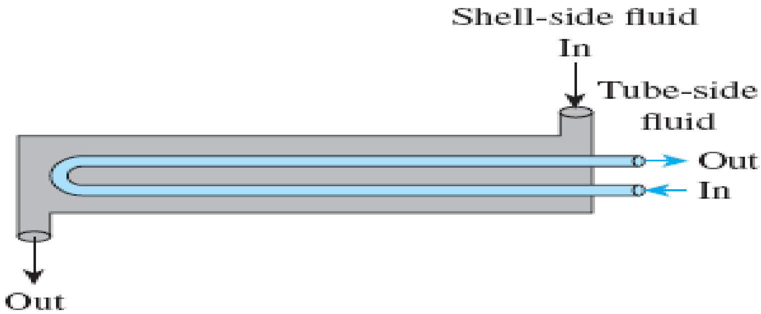
Countercurrent flow heat exchangers, also known as counter flow heat exchangers, are designed such that the fluids move anti parallel (i.e., parallel but in opposite directions) to each other within the heat exchanger. The most commonly employed of the flow configurations, a counter flow arrangement typically exhibits the highest efficiencies as it allows for the greatest amount of heat transference between fluids and, consequently, the greatest change in temperature.

Crossflow;

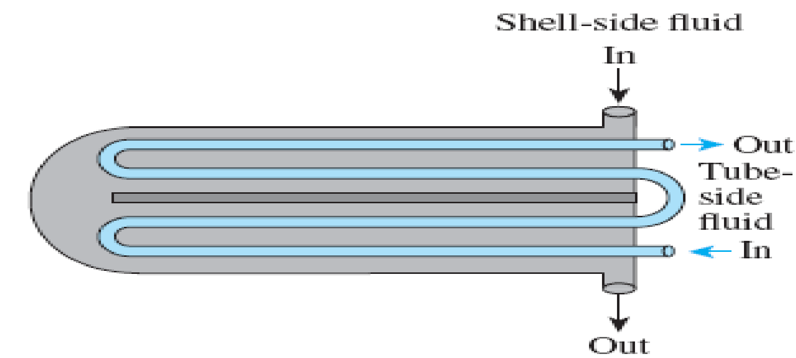
In *crossflow heat exchangers*, fluids flow perpendicularly to one another. The efficiencies of heat exchangers which employ this flow configuration fall between that of countercurrent and cocurrent heat exchangers.

Hybrid flow:

Hybrid flow heat exchangers exhibit some combination of the characteristics of the previously mentioned flow configurations. For example, heat exchanger designs can employ multiple flow passes and arrangements (e.g., both counter flow and crossflow arrangements) within a single heat exchanger. These types of heat exchangers are typically used to accommodate the limitations of an application, such as space, budget costs, or temperature and pressure requirements



(a) One-shell pass and two-tube passes



(b) Two-shell passes and four-tube passes

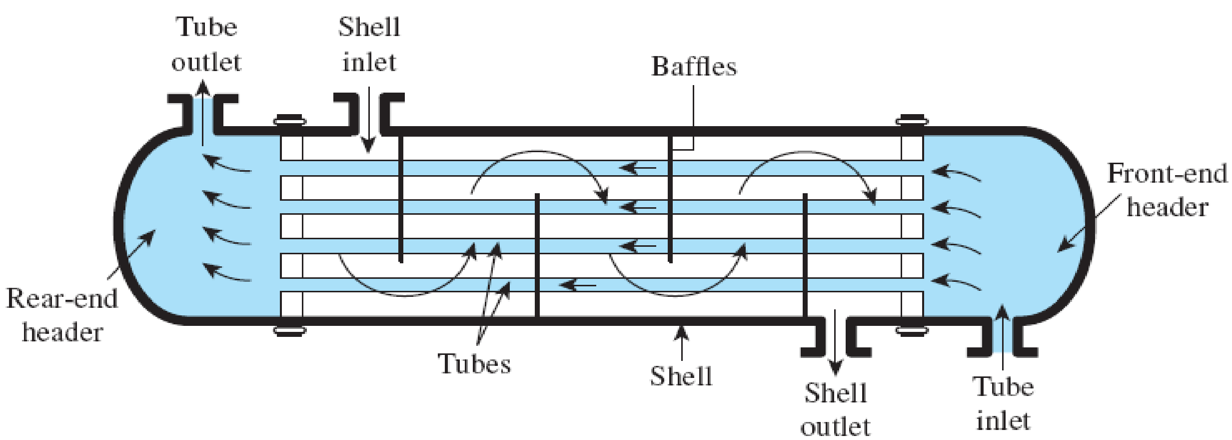


Figure 1.3 Shell and Tube Heat Exchanger with One Shell Pass and One Tube Pass (Cross-Counter flow mode of operation)

1.3 SHELL AND TUBE TYPE HEAT EXCHANGER

- A shell and tube heat exchanger is a class of heat exchanger designs. It is the most common type of heat exchanger in oil refineries and other large chemical processes, and is suited for higher-pressure applications. As its name implies, this type of heat exchanger consists of a shell (a large pressure vessel) with a bundle of tubes inside it. One fluid runs through the tubes, and another fluid flows over the tubes (through the shell) to transfer heat between the two fluids. The set of tubes is called a tube bundle, and may be composed of several types of tubes: plain, longitudinally finned, etc. They have larger ratio of heat transfer surface to volume than double pipe heat exchanger and they are easy to manufacture in large variety of sizes and flow configuration.

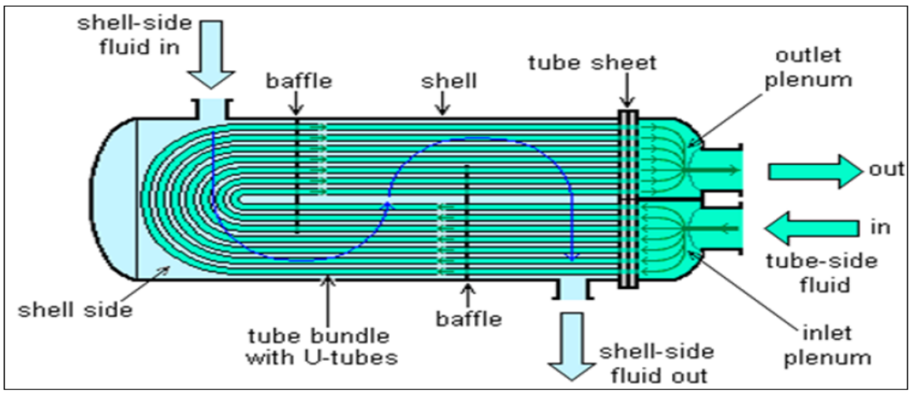


Figure 1.6 Shell and Tube Heat Exchanger [18]

- Baffles serve two important functions. They support the tubes during assembly and operation and help prevent vibration from flow induced eddies and direct the shell side fluid back and forth across the tube bundle to provide effective velocity and Heat Transfer rates. The diameter of the baffle must be slightly less than the shell inside diameter to allow assembly, but must be close enough to avoid the substantial performance penalty caused by fluid bypass around the baffles. Baffle spacing is the centerline to centerline distance between adjacent baffles. It is the most vital parameter in STHE design. The TEMA standards specify the minimum baffle spacing as one fifth of the shell inside diameter or 2 in., whichever is greater.

- **<u>The Objectives of the Study are as follows:-</u>**
- Increasing heat transfer rate.
- Reducing pressure drop at shell side and tube side
- Reducing cost.

- **<u>Problem Definition:</u>**
  The Problems are:
- Heat Transfer Rate is less.
- Pressure Drop is large at Shell side.
- Pressure Drop is large at Tube side.
- Very high cost

❖Selection

- ➢ Due to the many variables involved, selecting optimal heat exchangers is challenging. Hand calculations are possible, but many iterations are typically needed. As such, heat exchangers are most often selected via computer programs, either by system designers, who are typically engineers, or by equipment vendors.
- ➢ To select an appropriate heat exchanger, the system designers (or equipment vendors) would firstly consider the design limitations for each heat exchanger type. Though cost is often the primary criterion, several other selection criteria are important:

- High/low pressure limits
- Thermal performance
- Temperature ranges
- Product mix (liquid/liquid, particulates or high-solids liquid)
- Pressure drops across the exchanger
- Fluid flow capacity
- Cleanability, maintenance and repair
- Materials required for construction
- Ability and ease of future expansion
- Material selection, such as copper, aluminium, carbon steel, stainless steel, nickel alloys, ceramic, polymer, and titanium.

❖Monitoring and maintenance

- Online monitoring of commercial heat exchangers is done by tracking the overall heat transfer coefficient. The overall heat transfer coefficient tends to decline over time due to fouling.

- By periodically calculating the overall heat transfer coefficient from exchanger flow rates and temperatures, the owner of the heat exchanger can estimate when cleaning the heat exchanger is economically attractive.

- Integrity inspection of plate and tubular heat exchanger can be tested in situ by the conductivity or helium gas methods. These methods confirm the integrity of the plates or tubes to prevent any cross contamination and the condition of the gaskets.
- Mechanical integrity monitoring of heat exchanger tubes may be conducted through Nondestructive methods such as eddy current testing.

❖ Fouling

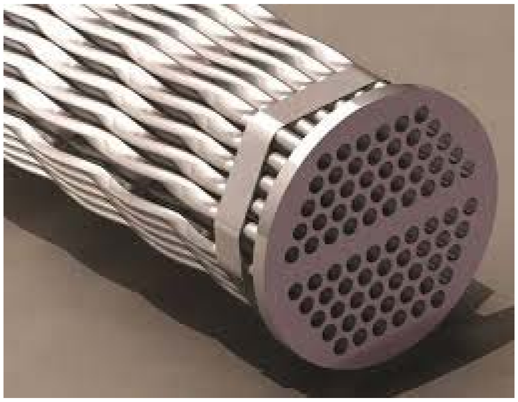
➢ Fouling occurs when impurities deposit on the heat exchange surface. Deposition of these impurities can decrease heat transfer effectiveness significantly over time and are caused by:

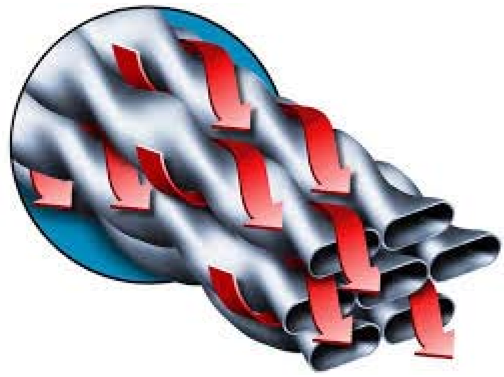
- Low wall shear stress
- Low fluid velocities
- High fluid velocities
- Reaction product solid precipitation
- Precipitation of dissolved impurities due to elevated wall temperatures

❖ Costs

- The cost of a heat exchanger includes not only the initial price of the equipment, but the installation, operational, and maintenance costs over the device’s lifespan as well. While it is necessary to choose a heat exchanger which effectively fulfills the requirements of the applications, it is also important to keep in mind the overall costs of the chosen heat exchanger to better determine whether the device is worth the investment. For example, an initially expensive, but more durable heat exchanger may result in lower maintenance costs and, consequently, less overall spend over the courses of a few years, while a cheaper heat exchanger may be initially less expensive, but require several repairs and replacements within the same period of time.

1.5 INTRODUCTION TO TWISTED SHELL AND TUBE HEAT EXCHANGER





- Heat transfer enhancement is one of the fastest growing areas of heat transfer technology. The technologies are classified into active and passive techniques depending on how the heat transfer performance is improved. A twisted tube is a typical passive technique that uses a specific geometry to induce swirl on the tube side flow.

- The helical channel formed in the inter tubular space can be looked upon as series of consecutive short sections of which the buildup of a steady velocity profile is interrupted by the constant direction change of the flow. Good transverse mixing is achieved by these interruptions, and the numerous disturbances keep the flow turbulent even at relatively low Reynolds numbers. The turbulent regime offers substantially higher convective heat transfer coefficients compared to laminar flow. By keeping the flow turbulent one secures a high heat transfer performance. These mechanisms contribute to higher heat transfer coefficients on the shell side flow.

1.6 INTRODUCTION OF NANO FLUID

- The poor thermal properties of fluids act as a main barrier to the growth of energy-efficient heat exchanger. During the past decades, many efforts have been devoted to the enhancement of heat transfer. One of the possible techniques for improving heat transfer is adding millimeter- or micrometer-sized particles in fluids. In recent years, nano-fluids have been introduced as an ideal candidate for enhancing heat transfer. As a result of the small size of nano particles, a little pressure drop is observed in the fluid. In this situation the fluid behaves like a pure fluid or single phase liquid. Various studies have been conducted on the performances of nano fluids convective heat transfer in laminar flow. They concluded that nano fluids provide heat transfer enhancement in comparison with their corresponding base fluids. Mansour et al. experimentally studied the mixed convection of water–Al_2O_3 mixture inside an inclined tube. Their results indicated that a higher particle volume concentration clearly induced a decrease of the Nusselt number for the horizontal inclination. On the other hand, they showed that for the vertical one, the Nusselt number remains nearly constant with an increase of particle volume concentration from 0 to 4%.

CHAPTER 2 : LITERATURE REVIEW

➢ Literature review basis on different tube and wall:

- S. Rozi et al. Fluid foods are often subjected to thermal treatment inside surface heat exchangers. Besides the need for high heat transfer performance, also low friction losses and easy cleaning and sanitizing properties of the surface are imperative. In food process industry these requirements are often met by the shell and tube heat exchanger equipped with helically corrugated walls. The present work concerns convective heat transfer and friction losses in helically enhanced tubes for both Newtonian and non-Newtonian fluids. For fluid foods, namely, whole milk, cloudy orange juice, apricot and apple puree, are tested in a shell and tube heat exchanger. Both fluid heating and cooling conditions are considered. The experimental outcome confirms that helically corrugated tubes are particularly effective in enhancing convective heat transfer for generalized Reynolds number ranging from about 800 to the limit of the transitional flow regimefor low values of the generalized Reynolds number (Re<800) the flow regime maintains laminar with practically negligible enhancing effects; for generalized Reynolds number values ranging from about 800 to the limit of the transitional flow regime the helical corrugation significantly enhances the overall heat transferred; in the fully developed turbulent flow regime a moderate overall heat transfer enhancement can be achieved, but with a very high pressure loss increase; for fully turbulent flow the heat transfer enhancement of the helical corrugation is higher in heating than in cooling, but the reverse appear true in the transitional flow regime.

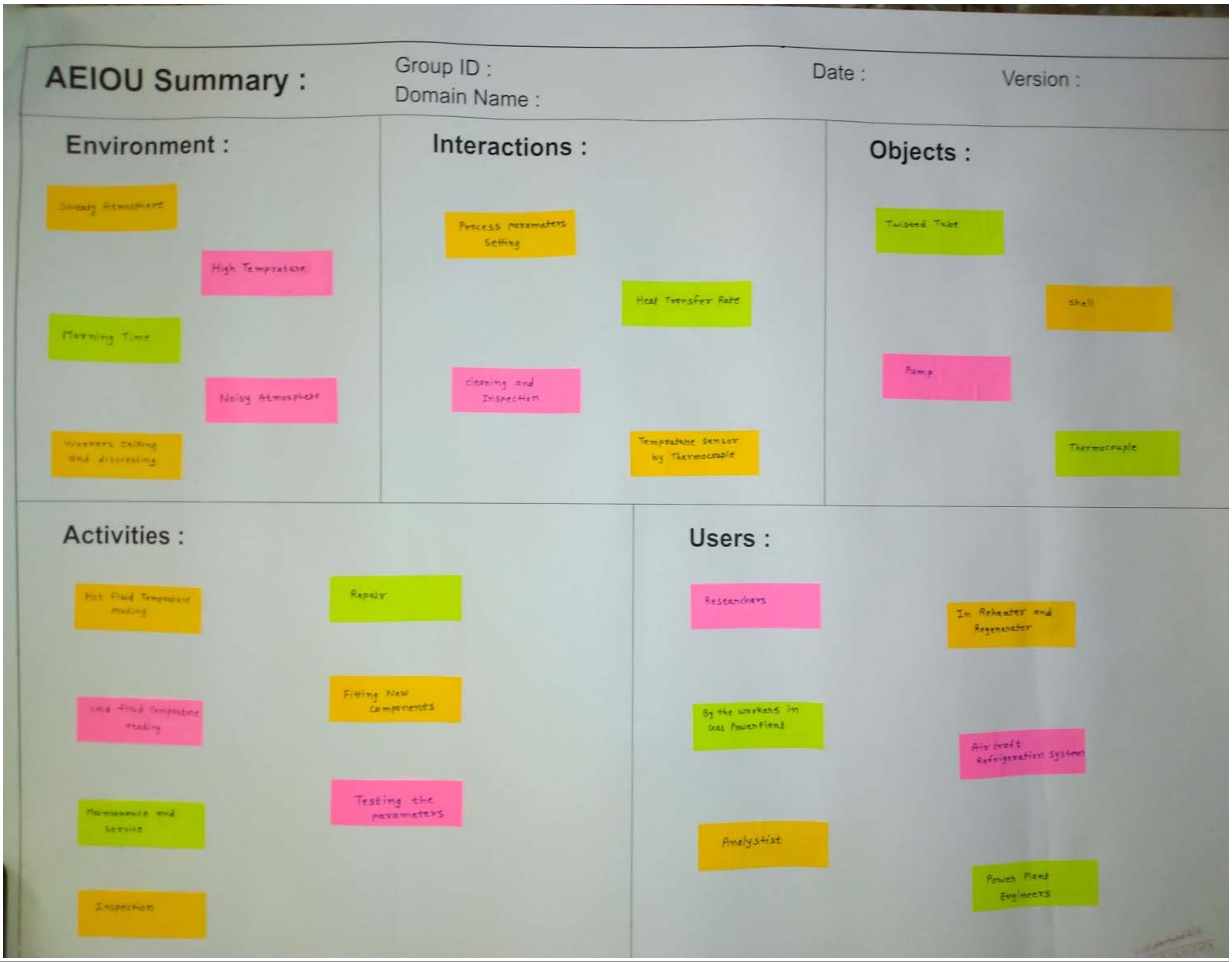
➢ Literature review basis on fluid:

- M.J. Hosseini et al. A combined experimental and numerical study has been designed to study thermal behaviour and heat transfer characteristics of Paraffin RT50 as a phase change material (PCM) during constrained melting and solidification processes inside a shell and tube heat exchanger. A series of experiments are conducted to investigate the effects of increasing the inlet temperature of the heat transfer fluid (HTF) on the charging and discharging processes of the PCM. The computations are based on an iterative, finite-volume numerical procedure that incorporates a single-domain enthalpy formulation for simulation of the phase change phenomenon. The molten front at various times of process has been studied through a numerical simulation. The experimental results show that by increasing the inlet HTF temperature from TH = 70 °C to 75 and 80 °C, theoretical efficiency in charging discharging processes rises from 81.1% to 88.4% and from 79.7% to 81.4% respectively.

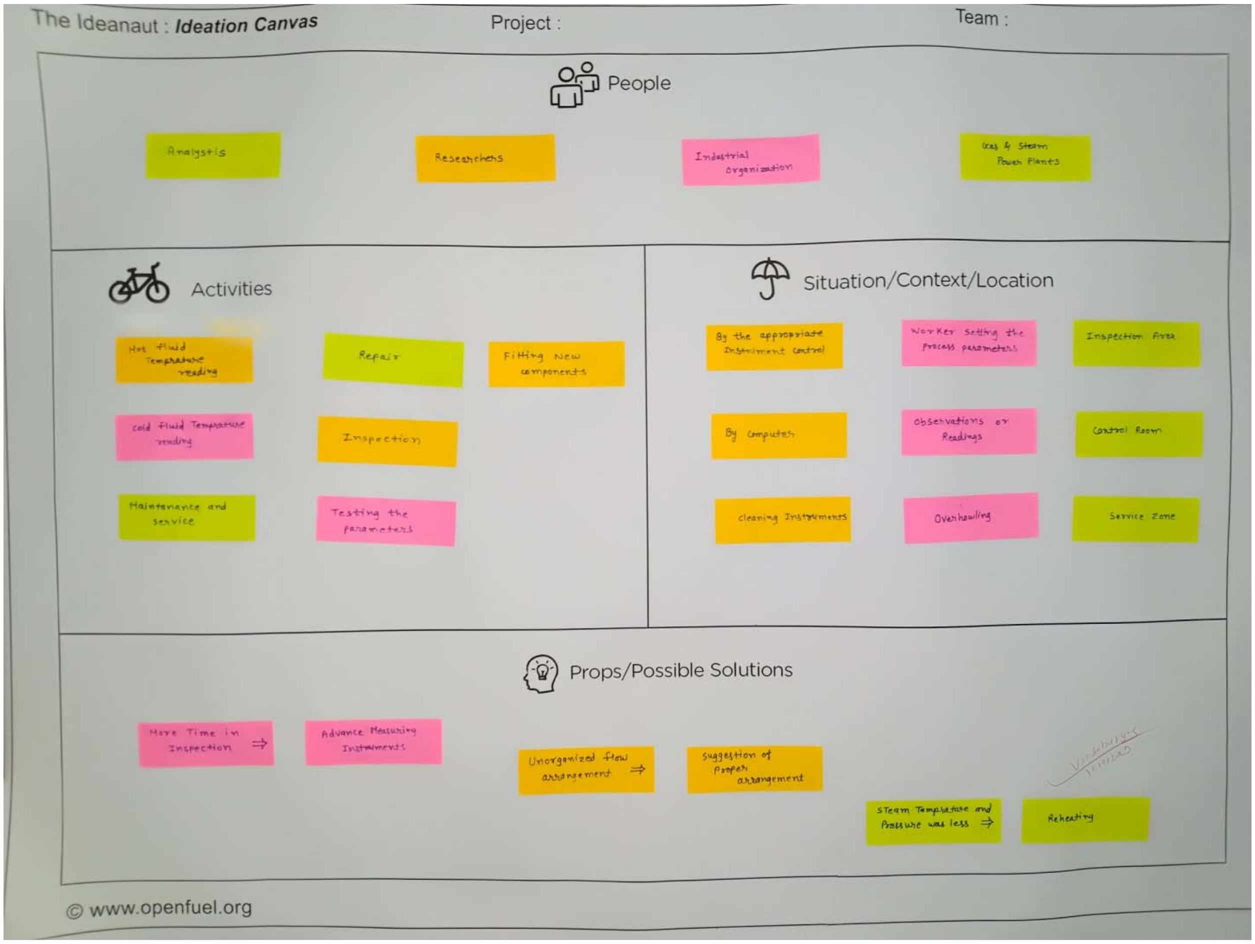
- The method of heat transfer in the PCM is a combination of convection and conduction, but in the melting process, initially, heat transfer is dominated by conduction and after, considering melting and solidification pattern of phase change, it is obvious that convection governs the heat transfer phenomena. The rate of heat transfer and consequently the time for complete melting process are directly related to the inlet water temperature. The present study demonstrates that by increasing the inlet HTF temperature to 80 °C, the total melting time decreases to 37%.It is observed that by increasing the inlet HTF temperature from Th = 70 °C to 80 °C, theoretical efficiency of the heat exchanger in charging and discharging processes rise from 81.1% to 88.4% and 79.7% to 81.4% respectively .

CHAPTER 3 PROJECT SHEETS

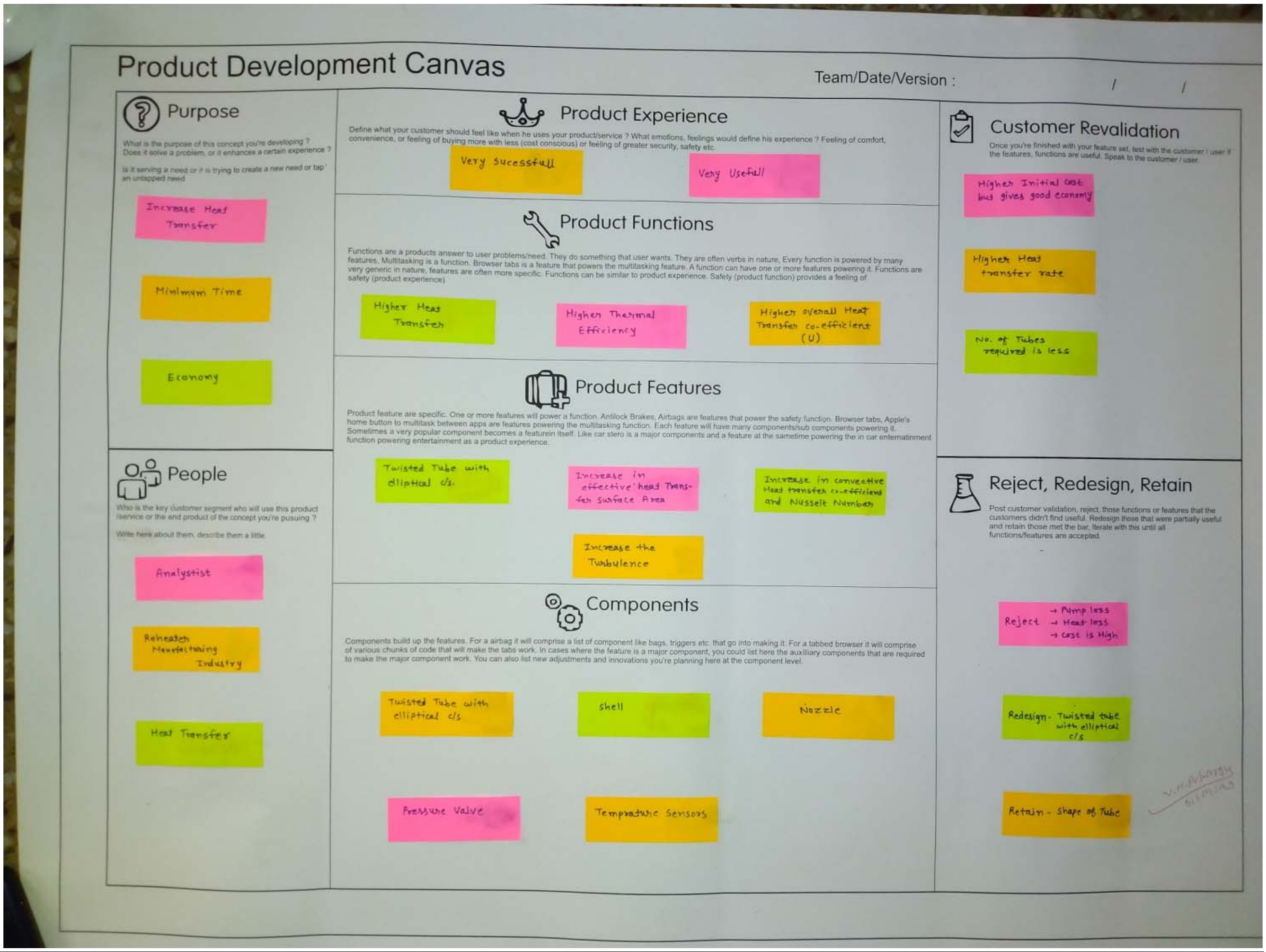
3.1 AEIOU SHEET



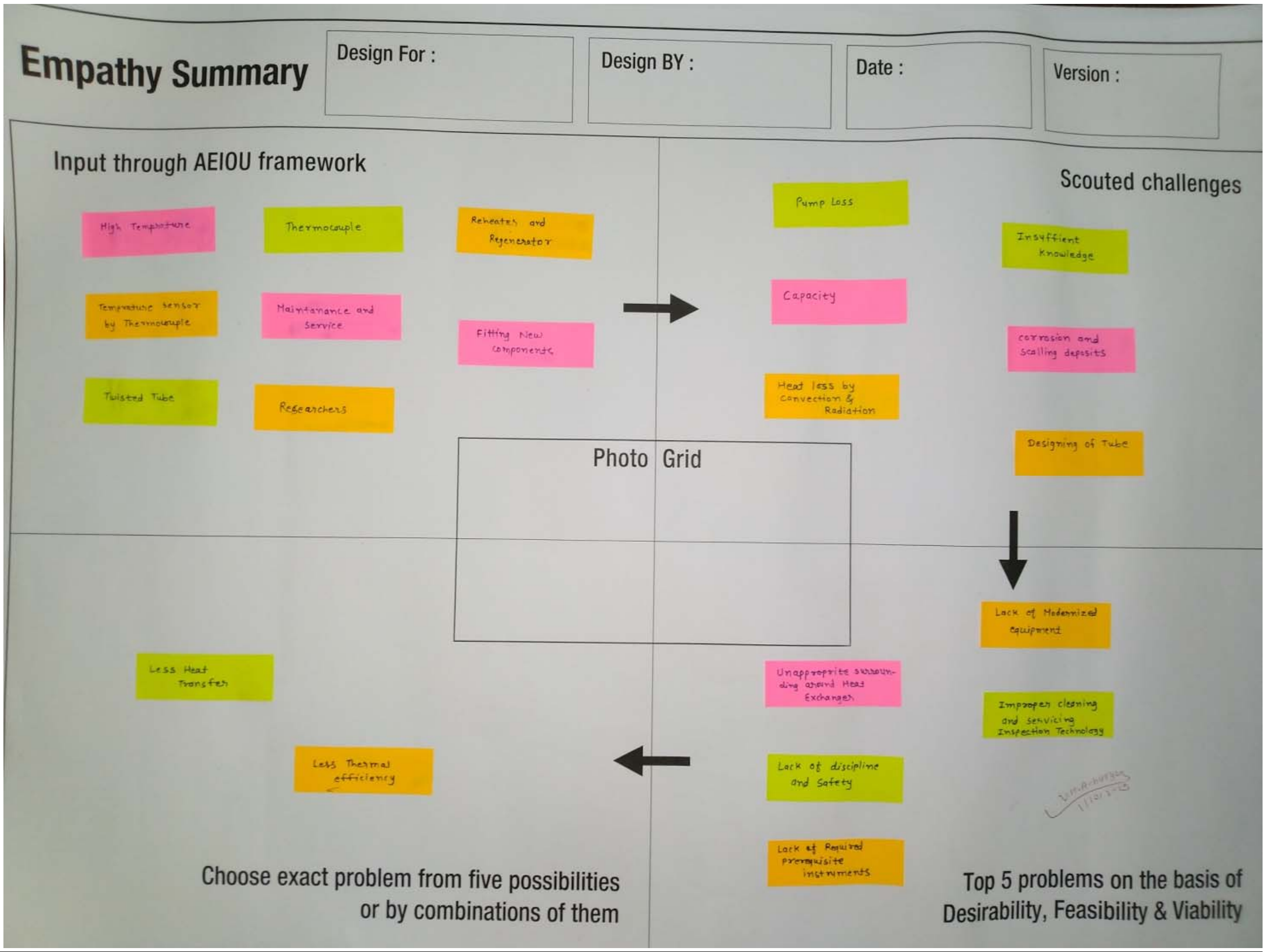
<u>**3.2 IDEATION CANVAS**</u>



3.3 PRODUCT DEVELOPMENT CANVAS



3.4 EMPATHY MAPPING



CHAPTER 4 DESIGN OF HEAT EXCHANGER

Nomenclature

A	Tube cross section area, m2
Cp	Specific heat capacity, kJ/kgK
D	Diameter of the tube, m
h	Heat transfer coefficient, W/m2K
k	Thermal conductivity, W/mK
L	Length of the tube, m
Nu	Nusselt number
Pe	Peclet number
Pr	Prandtl number
Re	Reynolds number
T	Temperature, K
u	Mean fluid velocity, m2/s

Greek symbols

α	Thermal diffusivity, m2/s
ε	Roughness, m
μ	Viscosity, Pa s
ρ	Density, kg/m3
υ	Kinematics viscosity, m2/s
ϕ	Nanoparticle volume fraction

Subscripts

b	Bulk
nf	Nanofluid
w	Water
p	Solid nanoparticle
exp.	Obtained experimentally
ν	Laminar sublayer
in	Inlet
out	Outlet

Appendix I

Nomenclature

• A0/Ai	Ratio of Outside to inside Surface of Tubing
• As	Bundle Cross Flow Area at the Centre of Shell (m2)
• B	Baffle Spacing
• C	Clearance between adjacent tubes (mm)
• De	Equivalent Diameter (mm)
• Ds	Shell inside Diameter (mm)
• Do	Outside Diameter of Tube (mm)
• Gs	Mass Flow Density (kg/m2 s)
• Ho	Film Coefficient of shell side fluid (W/m2K)
• Hi	Film Coefficient of Tube Side Fluid (W/m2K)
• k	Thermal conductivity (W/m K)
• L	Length of Tube (mm)
• Nb	No. of Baffle
• Nt	No. of Tube
• Nu	Nusselt Number
• ΔPs	Shell Side Pressure Drop (Pa)
• Pt	Tube pitch (mm)
• Q	Total Heat Transferred (J/s or W)
• Th1	Shell Side inlet Temperature (Hot Fluid) (ºC)
• Th2	Shell Side outlet Temperature (ºC)
• Tc1	Tube Side inlet Temperature (Cold Fluid) (ºC)
• Tc2	Tube Side outlet Temperature (ºC)

4.1 DESIGN OF HEAT EXCHANGER

Components Of Shell And Tube Type Heat Exchanger :

Part	Parameter	Value
Shell	Shell Material	Mild Steel
	Shell Length	735 mm
	Shell OD	100 mm
	Shell ID	84mm
Tube	Tube Material	Aluminium
	Tube OD	15 mm
	Tube ID	13 mm
	Tube Length	837.5 mm
Tube Sheet	Material	Mild Steel
	Size	100 mm
	No. of tube sheet	2
Baffle	Baffle material	Mild steel
	Baffle cut	25%
	Baffle thickness	2 mm
	No. of Baffles	2
Shell Cover	Each Size	100 mm
	No. of shell cover	3

- ***Model Description***

The shell and tube heat exchanger consists of the following components:

• Shell
• U Tubes
• Straight baffles (25% cut segmental baffles)

- ***Specifications of Shell and Tube***

A single shell and 2 pass tube heat exchanger is selected for analysis purpose.
The specifications of heat exchanger are given below Tables

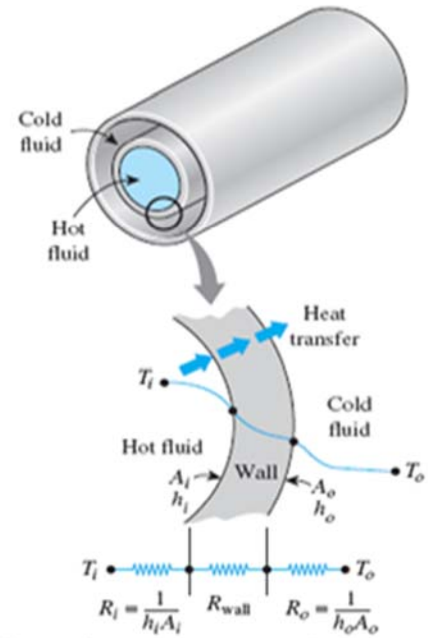
➢ Nano fluid preparation

- Preparing stable suspension of nano particles in the base liquid was the first step in applying nano fluids for the heat transfer enhancement. In this study, TiO2 nano particles with an average diameter of about 30 nm were prepared at Sharif University Physics laboratory. Thermo-physical properties of these nano particles calculated at 65 °C . Nano fluid was obtained by dispersing TiO2 nano particles in de ionized water as a base fluid. The nano fluid with five different nano particle volume concentrations (0.05%, 0.1%, 0.15%, 0.20%, and 0.25%) was prepared and utilized to study the heat transfer enhancement.

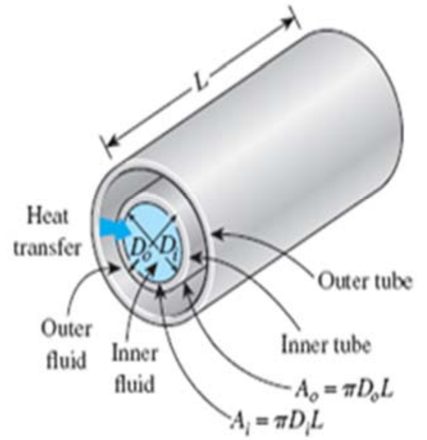
Researcher	**Nanoparticle and base fluid**	**Size**	**Flow type**	**Nanoparticle concentration**	**Results**
Sajadi and Kazemi	TiO_2-water	30 nm	Turbulent	0.05, 0.1, 0.15, 0.20, and 0.25%	Enhancement in heat transfer coefficient was about 22%
Hussein et al.	TiO_2-water	-	Laminar	1–2% by volume	Maximum enhancement of nusselt number for TiO_2 obtained is 11%.
Tiwari et al.	Al_2O_3-water	45 nm	Laminar	1.5 % by volume	For Al_2O_3 the maximum enhancement in heat transfer coefficient at optimum volume concentration are about 26.3

4.2 EQUATION USED IN CALCULATION

THE OVERALL HEAT TRANSFER COEFFICIENT



Thermal resistance network associated with heat transfer in a double-pipe heat exchanger



The two heat transfer surface areas associated with a double-pipe heat exchanger (for thin tubes, Di = Do and thus Ai = Ao)

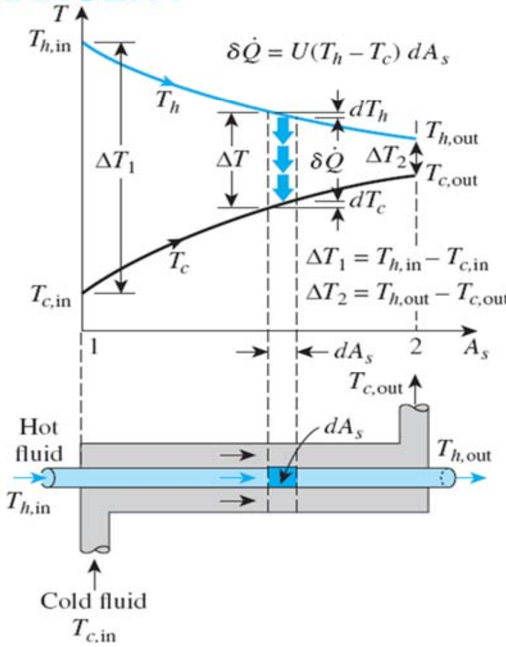
$$R = R_{\text{total}} = R_i + R_{\text{wall}} + R_o = \frac{1}{h_i A_i} + \frac{\ln (D_o/D_i)}{2\pi k L} + \frac{1}{h_o A_o}$$

$$\dot{Q} = \frac{\Delta T}{R} = U A_s \Delta T = U_i A_i \Delta T = U_o A_o \Delta T$$

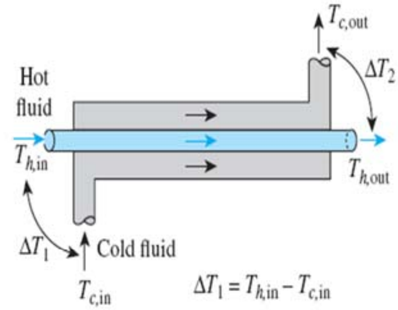
$$\frac{1}{UA_s} = \frac{1}{U_i A_i} = \frac{1}{U_o A_o} = R = \frac{1}{h_i A_i} + R_{\text{wall}} + \frac{1}{h_o A_o}$$

$$\frac{1}{U} \approx \frac{1}{h_i} + \frac{1}{h_o}$$

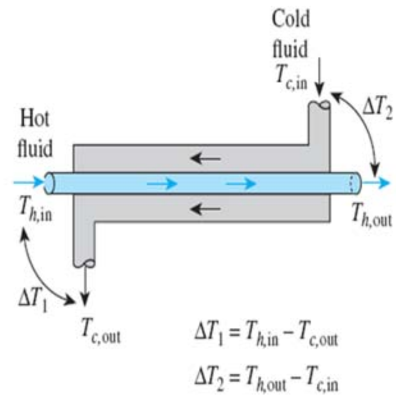
EQUATIONS OF LMTD FOR PARALLEL FLOW AND COUNTER FLOW HEAT EXCHANGER :



Variation of the fluid temperatures in a parallel-flow double-pipe heat exchanger.



(*a*) Parallel-flow heat exchangers



(*b*) Counter-flow heat exchangers

The ΔT_1 and ΔT_2 expressions in parallel-flow and counter-flow heat exchangers.

EQUTIONS :

$$\dot{Q} = \dot{m}c_{pc}(T_{c,\text{ out}} - T_{c,\text{ in}})$$

$$\dot{Q} = \dot{m}_h c_{ph}(T_{h,\text{ in}} - T_{h,\text{ out}})$$

$$C_h = \dot{m}_h c_{ph} \text{ and } C_c = \dot{m}_c c_{pc}$$

$$\dot{Q} = C_c(T_{c,\text{ out}} - T_{c,\text{ in}})$$

$$\dot{Q} = C_h(T_{h,\text{ in}} - T_{h,\text{ out}})$$

$$\dot{Q} = UA_s\, \Delta T_m$$

$$\delta\dot{Q} = \dot{m}_c c_{pc}\, dT_c$$

$$\dot{Q} = UA_s\, \Delta T_{\text{lm}}$$

$$\Delta T_{\text{lm}} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)}$$

THE EFFECTIVENESS NTU

A second kind of problem encountered in heat exchanger analysis is the determination of the heat transfer rate and the outlet temperatures of the hot and cold fluids for prescribed fluid mass flow rates and inlet temperatures when the type and size of the heat exchanger are specified. The heat transfer surface area of the heat exchanger in this case is known, but the outlet temperatures are not. Here the task is to determine the heat transfer performance of a specified heat exchanger or to determine if a heat exchanger available in storage will do the job.

$$\varepsilon = \frac{\dot{Q}}{\dot{Q}_{\max}} = \frac{\text{Actual heat transfer rate}}{\text{Maximum possible heat transfer rate}}$$

$$\dot{Q} = C_c(T_{c,\,\text{out}} - T_{c,\,\text{in}}) = C_h(T_{h,\,\text{in}} - T_{h,\,\text{out}})$$

To determine the maximum possible heat transfer rate in a heat exchanger, we first recognize that the maximum temperature difference in a heat exchanger is the difference between the inlet temperatures of the hot and cold fluids. That is,

$$\Delta T_{\max} = T_{h,\,\text{in}} - T_{c,\,\text{in}}$$

The heat transfer in a heat exchanger will reach its maximum value when (1) the cold fluid is heated to the inlet temperature of the hot fluid or (2) the hot fluid is cooled to the inlet temperature of the cold fluid. These two limiting conditions will not be reached simultaneously unless the heat capacity Rates of the hot and cold fluids are identical (i.e., Cc = Ch). When Cc ≠ Ch, which is usually the case, the fluid with the smaller heat capacity rate will experience a larger temperature change, and thus it will be the first to experience the maximum temperature, at which point the heat transfer will come to a halt.

$$\dot{Q}_{\max} = C_{\min}(T_{h,\,\text{in}} - T_{c,\,\text{in}})$$

$$\dot{Q} = \varepsilon \dot{Q}_{max} = \varepsilon C_{min}(T_{h,\,in} - T_{c,\,in})$$

where

if $C_c = C_{min}$: $$\varepsilon = \frac{\dot{Q}}{\dot{Q}_{max}} = \frac{C_c(T_{c,out} - T_{c,in})}{C_c(T_{h,in} - T_{c,in})} = \frac{T_{c,out} - T_{c,in}}{T_{h,in} - T_{c,in}}$$

if $C_h = C_{min}$: $$\varepsilon = \frac{\dot{Q}}{\dot{Q}_{max}} = \frac{C_h(T_{h,in} - T_{h,out})}{C_h(T_{h,in} - T_{c,in})} = \frac{T_{h,in} - T_{h,out}}{T_{h,in} - T_{c,in}}$$

Effectiveness relations of the heat exchangers typically involve the dimensionless group UAs/Cmin. This quantity is called the number of transfer units NTU and is expressed as

$$\mathrm{NTU} = \frac{UA_s}{C_{min}} = \frac{UA_s}{(\dot{m}c_p)_{min}}$$

where U is the overall heat transfer coefficient and As is the heat transfer surface area of the heat exchanger. Note that NTU is proportional to As. Therefore, for specified values of U and Cmin, the value of NTU is a measure of the heat transfer surface area As. Thus, the larger the NTU, the larger the heat exchanger. In heat exchanger analysis, it is also convenient to define another dimensionless quantity called the capacity ratio c as

$$c = \frac{C_{min}}{C_{max}}$$

It can be shown that the effectiveness of a heat exchanger is a function of the number of transfer units NTU and the capacity ratio c. That is,

$$\varepsilon = \text{function}\ (UA_s/C_{min},\ C_{min}/C_{max}) = \text{function}\ (\mathrm{NTU},\ c)$$

4.3 EXPERIMENTAL READING AND CALCULATION OF TEMPERATURE:

TUBE SIDE				SHELL SIDE		
Sr no.	Mass flow rate(kg/s)	Inlet Temp. Th1 °C	Outlet Temp Th2 °C	Mass flow rare Mc	Inlet Temp Tc1 °C	Outlet Temp Tc2 °C
1	0.04083	55	49.3	0.03083	37.5	44
2	0.04083	55	49	0.04166	37.25	43
3	0.04083	55.3	48.7	0.05833	37.4	42
4	0.04083	55	47.8	0.666	37.4	41.5

- Result for Heat Transfer Rate and Effectiveness

			Heat Transfer Rate			
Sr No.	Mass Flow Rate mc (kg/s)	LMTD ºC	Hot Water Qh (W)	Cold Water Qc (W)	Average Q (W)	Effectiveness ε (%
1	0.03083	11.39	973.14	837.33	905.23	32.22
2	0.04166	11.87	1024.35	1000.91	1012.6	34.41
3	0.05833	12.27	1126.8 1	1124.1 1	1123.95	37.22
4	0.0666	11.88	1229.23	1140.95	1185.09	40.32

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Sample Calculation

$T_{h_1} = 55°C \quad T_{h_2} = 49.3°C$

$T_{c_1} = 37.5°C \quad T_{c_2} = 44°C$

$m_h = 0.04083 \quad m_c = 0.03083$

$$LMTD = \frac{[T_{h_1} - T_{c_2}] - [T_{h_2} - T_{c_1}]}{\ln\left[\frac{T_{h_1} - T_{c_2}}{T_{h_2} - T_{c_1}}\right]}$$

$$= \frac{(55-44) - (49.3 - 37.5)}{\ln\left(\frac{55-44}{49.3-37.5}\right)}$$

$$LMTD = 11.39°C$$

Heat Transfer Rate

$$Q_h = m_h \times (T_{h_1} - T_{h_2}) \times C_{ph}$$

$$Q_h = 0.04083 \times (55 - 49.3) \times 4181.4$$

$$Q_h = 973.14 W$$

$$Q_c = m_c \times (T_{c_2} - T_{c_1}) \times C_{pc}$$

$$= 0.03083 \times (44 - 37.5) \times 4178.5$$

$$Q_c = 837.33 W$$

$$Q = \frac{Q_h + Q_c}{2}$$

$$Q = \frac{973.14 + 837.33}{2}$$

$$Q = 905.23 W$$

Effectiveness of Heat Exchanger

$$E = \frac{Q}{Q_{max}}$$

$$E = \frac{C_h (T_{h_1} - T_{h_2})}{C_{min}(T_{h_1} - T_{c_1})} = \frac{C_c (T_{c_2} - T_{c_1})}{C_{min}(T_{h_1} - T_{c_1})}$$

$$E = \frac{4181.4\ (55 - 49.3)}{4181.4\ (55.25 - 37.5)}$$

$$E = 32\%$$

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Calculation of Shell side heat Transfer Coefficient

$$A_s = \frac{D_s \times C \times B}{P_t}$$

$$= \frac{0.084 \times 0.00375 \times 0.042}{0.01875}$$

$$= 0.0007056 \ m^2$$

$$G_s = \frac{m_c}{A_s}$$

$$= \frac{0.0308\,3}{0.0007056}$$

$$G_s = 40.78 \ \frac{kg}{s m^2}$$

$$D_e = 4 \ \frac{P_t^2 - \frac{\pi}{4} d_o^2}{\pi d_o^2}$$

$$D_e = 0.01484 \ m$$

$$Re_s = \frac{D_e \times G_s}{\mu}$$

$$= \frac{0.14 \times 40.78}{0.0006532}$$

$$Re_s = 926.4$$

Nusselt number

$$Nu = 0.36 \left[\frac{D_e \times G_s}{\mu}\right]^{0.55} \times \left[\frac{\mu C_p}{K}\right]^{0.33} \times \left(\frac{\mu_b}{\mu_w}\right)^{0.14}$$

$$Nu = 0.36 \times 42.83 \times 1.63 \times 1.02$$

$$Nu = 25.478$$

Shell side heat Transfer Coefficient

$$h_o = \frac{Nu \times K}{D_e} = \frac{25.478 \times 0.6305}{0.01484}$$

$$\boxed{h_o = 1082.5 \ \frac{W}{m^2 \times S}}$$

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Overall heat Transfer Coefficient

$$U = \frac{1}{\frac{d_o}{d_i \times h_i} + \frac{d_o \times \ln \frac{d_o}{d_i}}{2K} + \frac{1}{h_o}}$$

$$U = \frac{1}{\frac{0.015}{0.013 \times 889.67} + \frac{0.015 \times \ln \frac{0.015}{0.013}}{2 \times 237} + \frac{1}{1082.5}}$$

$$U = 450.79 \ \frac{W}{m^2 \times {}^\circ C}$$

Pressure drop

$$\Delta P_s = \frac{f \times G_s^2 \times (N_b + 1) \times D_s}{2 \times \rho \times \phi_s \times D_e}$$

$$f = \exp\left(0.576 - 0.19 \ln(Re_s)\right)$$

$$f = 0.49$$

$$\Delta P_s = \frac{0.49 \times (40.78)^2 \times (3+1) \times 0.084}{2 \times 992.22 \times 1.0218 \times 14.084}$$

$$\Delta P_s = 6.82 \ Pa$$

CHAPTER 5 PROPERTIES OF NANO FLUID

5.1 PROPERTIES OF NANO FLUID

- **Thermo physical Properties of the Nanofluid**
- Thermo Physical properties of the Al2O3-water nanofluid are calculated by using Pak and Cho correlations are shown in below Table 5.1 & 5.2.

Table 5.1 Physical properties of nanoparticles :

Particle	Size(nm)	Density(kg/m^3)	Thermal Conductivity (W/mK)	Specific Heat (J/kg)
Al_2O_3	25	3970	46	750

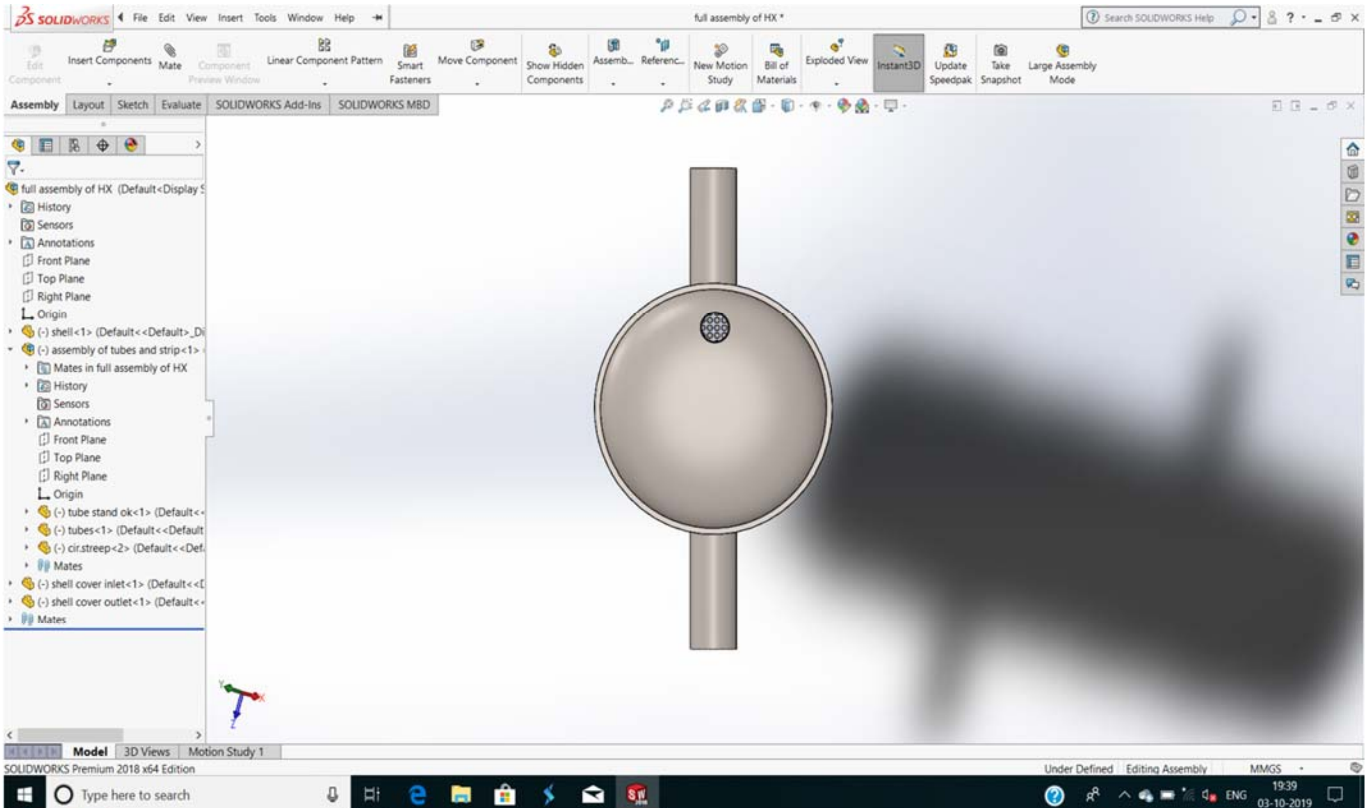
Table 5.2 Tube Side cold fluid (Al2O3-H2O nanofluid) Properties: Nanofluid properties are calculated using Pak & Cho correlations :

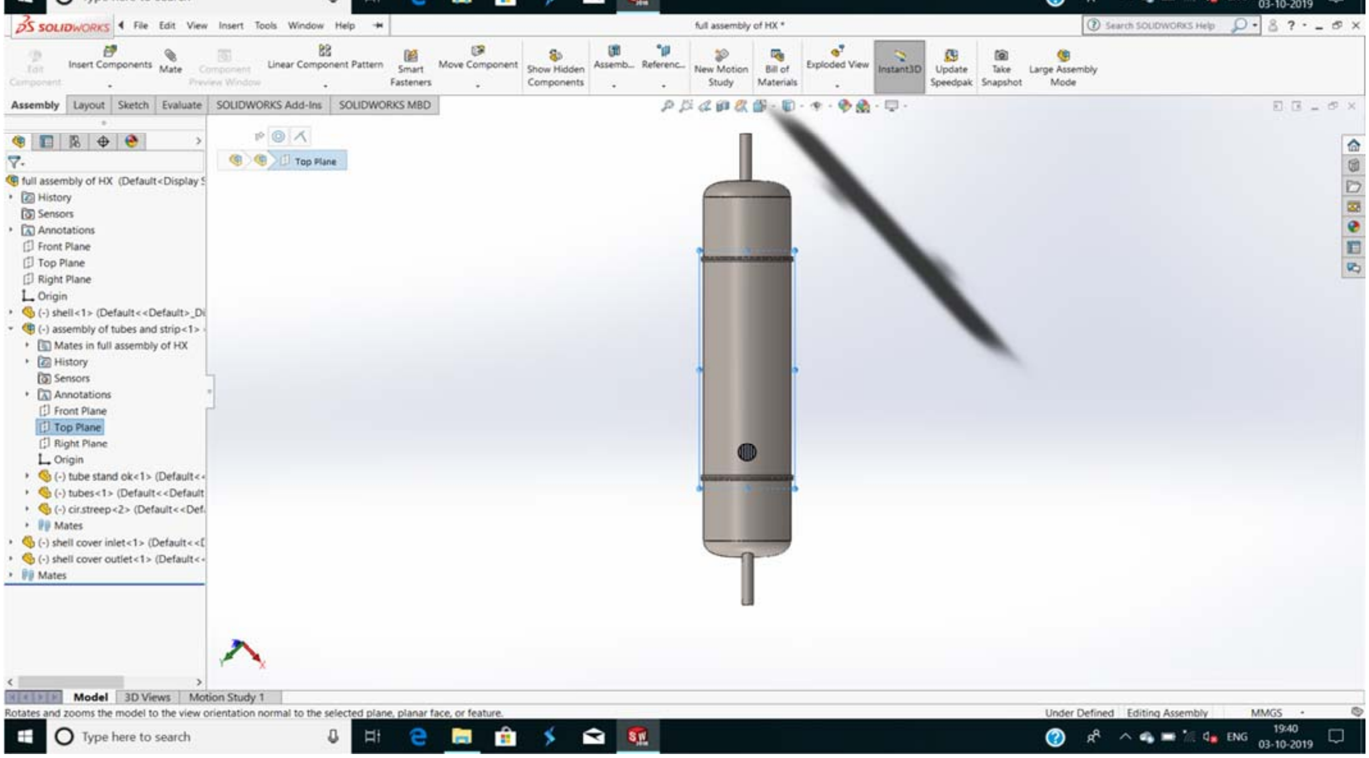
Sr. No.	Volume Fraction	Thermal Conductivity (W/m-K)	Density (kg/m^3)	Dynamic Viscosity (Ns/m^3)	Specific Heat (J/kg-K)
1	0.3%	0.622	1003.76	0.000795	4143.51
2	0.5%	0.628	1009.17	0.000799	4119.51
3	0.75%	0.633	1015.93	0.000804	4089.87
4	1%	0.641	1022.69	0.000810	4060.62
5	2%	0.664	1049.73	0.000829	3885.36

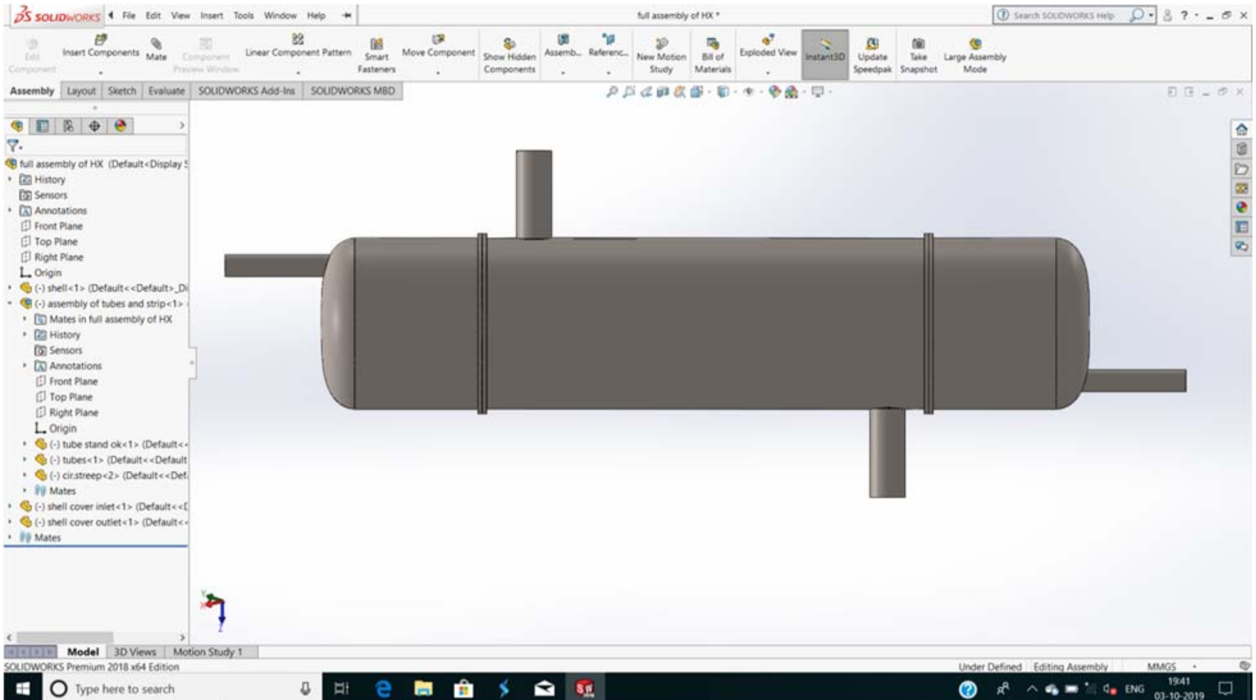
Thermo-physical Properties of TiO_2 nanoparticles:

Mean Diameter	Density (kg/m^3)	Thermal Conductivity (KJ/kg-K)	Specific Heat (W/m-K)
30	4170	11.8	711

CHAPTER 6 DESIGN OF HEAT EXCHANGER IN SOLIDWORKS



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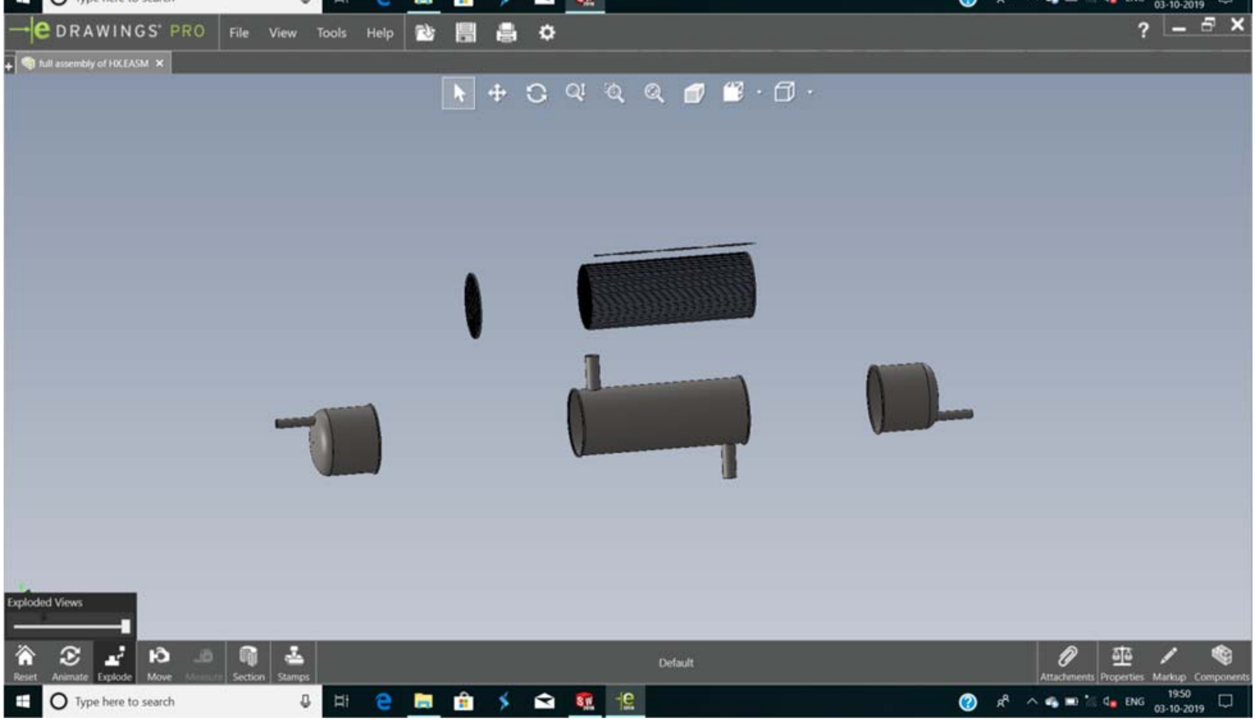
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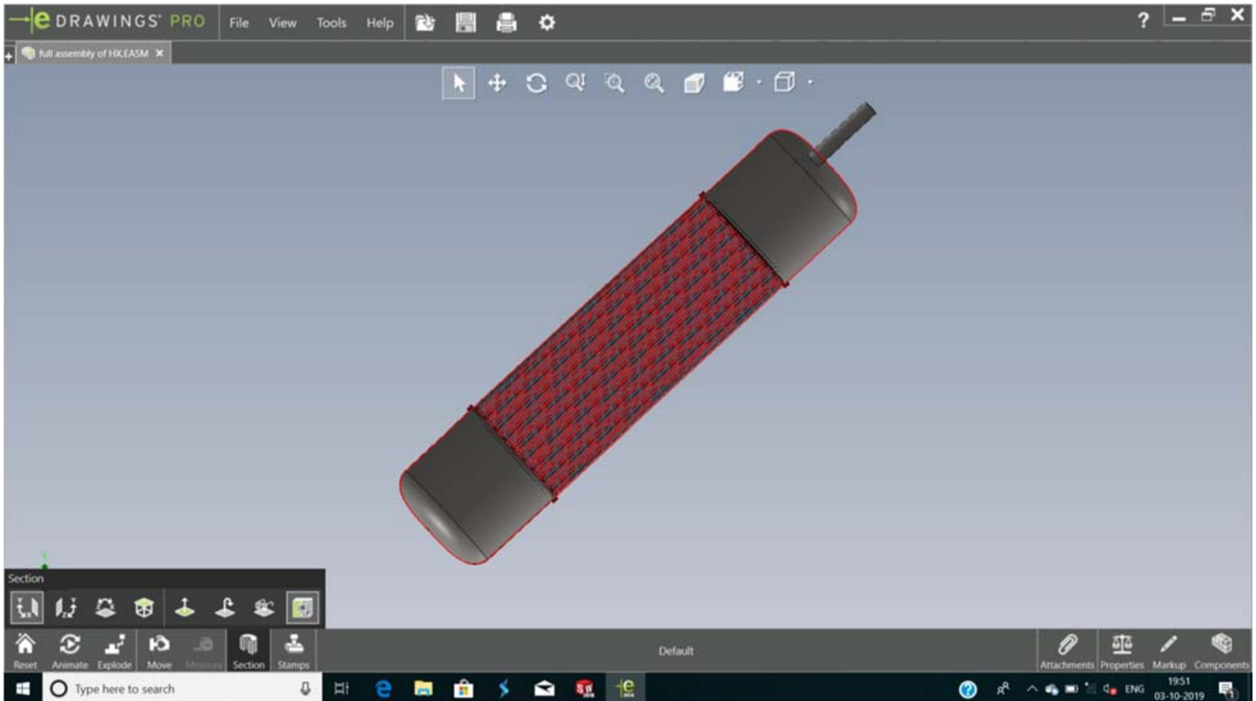
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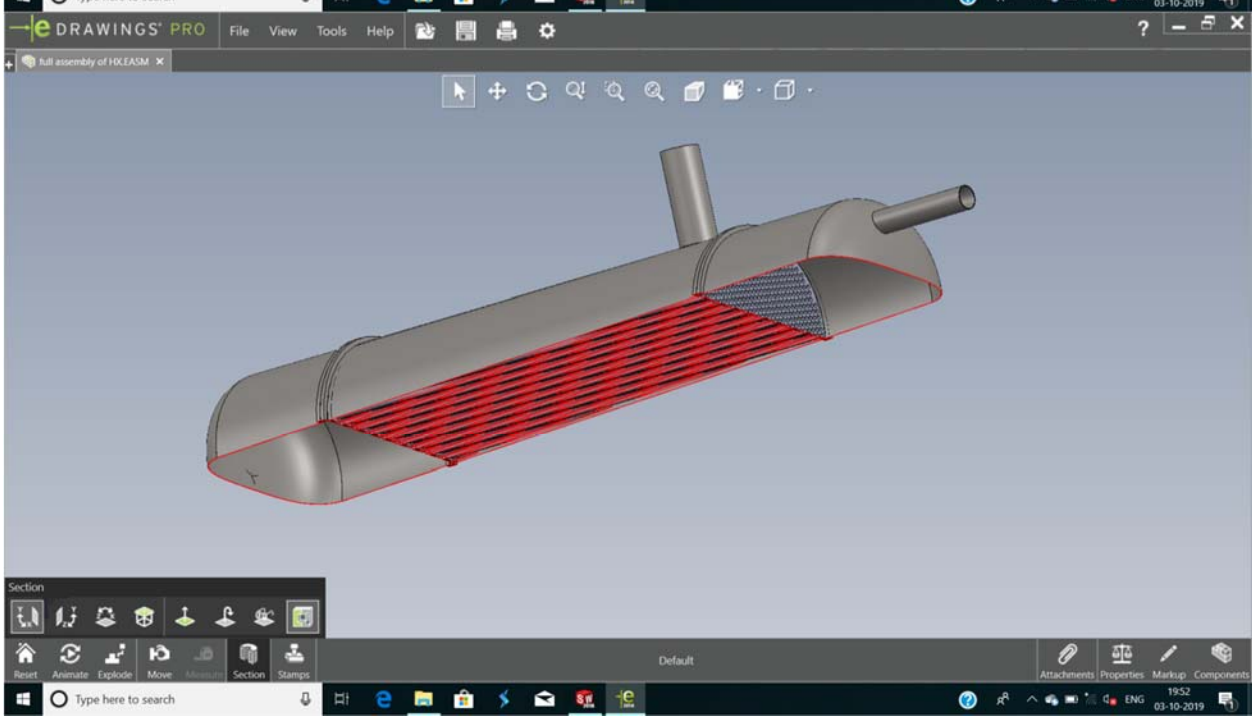
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REFERENCE

https://www.sciencedirect.com/science/article/abs/pii/S1359431119330364

https://www.sciencedirect.com/science/article/pii/S221478531830395X

https://www.sciencedirect.com/science/article/pii/S2214157X13000075

www.sciencedirect.com/A CFD Investigation of Heat TransferEnhancement of Shelland Tube Heat Exchanger Using Al2o3-Water Nanofluid

www.materialstoday.com/proceedings

www.ijesrt.com › July-2018PDF
numerical investigations for performance improvement in shell and tube heat exchanger

www.elsevier.com/locate/ichmt/Investigation of turbulent convective heat transfer and pressure drop of TiO2/waternanofluid in circular tube

EXPERIMENTAL SET-UP & PROCEDURE:

An experimental apparatus was built to study the flow and convective heat transfer features in a tube. the experimental system mainly includes a reservoir tank, a pump, a flow loop, a test section, a cooler and a steam supplier tank. The transparent plastic reservoir tank with capacity of 6 L was manufactured to reserve the nano fluid and monitor the sedimentation rate and the height of nano fluid. The test section is a straight copper tube with the inner diameter, thickness and length of about 5, 0.675 and 1800 mm, respectively. Five K-type thermocouples were mounted on the copper tube wall at equal intervals to measure the wall temperature. Two other K-type thermocouples were inserted at the entrance and exit of the test section to measure the bulk temperature. The first 50 cm of the copper tube was thermally isolated from its beginning using fiberglass to minimize the heat loss and to guarantee hydro-dynamically fully-developed condition. The flow rate was controlled with two adjusting valves, one at the end of the test section and the other at the by-pass line. The cooler includes a shell and tube heat exchanger which was used to reduce the temperature of the nano fluid at the inlet of the test section. The 50-liter steam supplier tank contains water as well as a 8KW element heater to generate fully saturated vapor. The next 120 cm of test section is surrounded by saturated vapor to reach constant water temperature. In order to minimize the heat loss from the steam tank supplier to the surrounding area, the whole tank was thermally isolated with a fiberglass cover. A differential pressure transducer (manufactured by Endress Hauser) with an uncertainty of ±1 Pa was employed for measuring the pressure loss along the test section tube. A 1-liter glass vessel with a drain valve was utilized to calculate the flow rate. A stopwatch with accuracy of ±0.01 s was employed to measure the time required for filling the vessel.

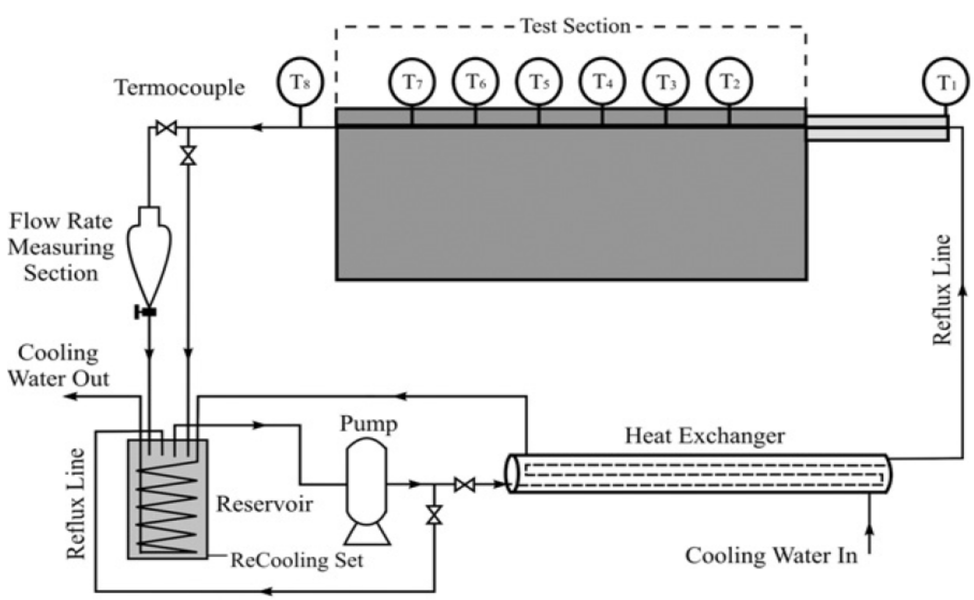

Fig. Experimental Set-up

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