LMTD Calculations Using DWSIM:

A Free and Open-Source Chemical Process Simulator

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PREFACE

The manual “LMTD Calculation using DWSIM” presents a set of LMTD calculation for co-currerent and counter current configuration for heat exchangers exercise using a free and open-source chemical process simulator “DWSIM” and can be utilized to establish process simulation laboratory as part of undergraduate chemical engineering degree or in allied degree curriculum. The problem statements are of intermediate level & **strictly focuses on LMTD calculations (Not the entire design of Heat Exchangers).**

Prerequisite

- Must know about DWSIM UI/UX.
- Flow sheeting in DWSIM
- Selection of Thermodynamic Packages.
- Manipulating variables

Thanks

Viraj Desai

P.E. O&G

Disclaimer

All the exercises are strictly restricted to learning only and not meant to be used in real world application.

PROCESS SIMULATION USING DWSIM: A FREE AND OPEN-SOURCE CHEMICAL PROCESS SIMULATOR

PREAMBLE

DWSIM is an open-source CAPE-OPEN compliant chemical process simulator. It features a Graphical User Interface (GUI), advanced thermodynamics calculations, reactions support and petroleum characterization / hypothetical component generation tools. DWSIM can simulate steady-state, vapor–liquid, vapor–liquid-liquid, solid–liquid and aqueous electrolyte equilibrium processes and has built-in thermodynamic models and unit operations (https://en.wikipedia.org/wiki/DWSIM). It is available for Windows, Linux and Mac OS.

The objective of the course is to create awareness of the open-source process simulator "DWSIM" among prospective graduates and practicing process engineers. The course will cover Intermediate aspects of create flow sheet in DWSIM and simulation of simple Pressure changing module like pipe segment

Target Audience

- Junior Interns in Process Firms
- III / Final year B. Tech. Chemical Engineering students
- M. Tech. Chemical Engineering students
- Practicing Process Engineers

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1 Background

What is Logarithmic Mean Temperature Difference?

"**Logarithmic Mean Temperature Difference** "**(LMTD)** is a logarithmic average of the temperature difference between the hot and cold feeds at each end of the heat exchanger. The larger the LMTD, the more heat is transferred.

But why is it so much important?

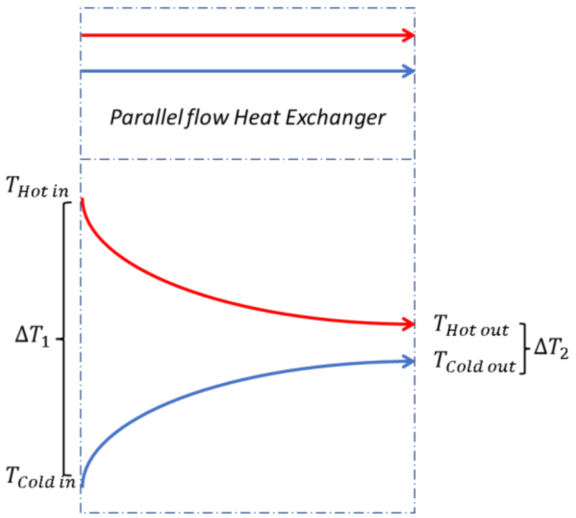
Logarithmic Mean Temperature Difference (LMTD), which is used to determine the temperature driving force for heat transfer in heat exchangers. **LMTD** is introduced due to the fact, the temperature change that takes place across the heat exchanger from the entrance to the exit is **not linear**.

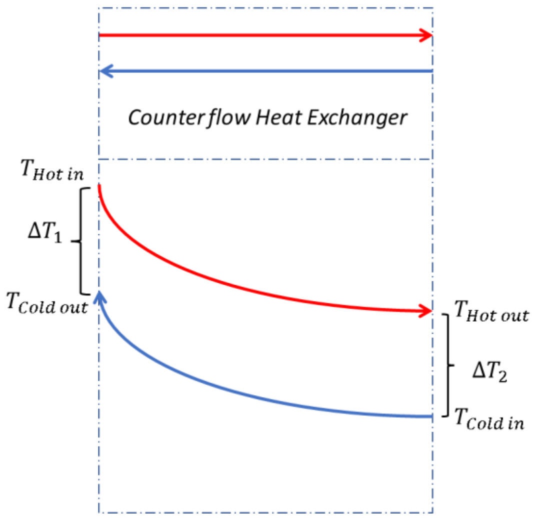
Why can't we take Arithmetic Mean Temperature Difference (AMTD)?

The temperature difference continuously varies with location (especially in counter-flow arrangement). To determine the total heat flow, either the heat flow should be summed up using elemental areas and the temperature difference at the location or more conveniently engineers can average the value of temperature difference.

$$LMTD_{Parallel} = \frac{(T_{Hot\,in} - T_{Cold\,in}) - (T_{Hot\,out} - T_{Cold\,out})}{\ln \frac{(T_{Hot\,in} - T_{Cold\,in})}{(T_{Hot\,out} - T_{Cold\,out})}}$$

$$LMTD_{Counter} = \frac{(T_{Hot\,in} - T_{Cold\,out}) - (T_{Hot\,out} - T_{Cold\,in})}{\ln \frac{(T_{Hot\,in} - T_{Cold\,out})}{(T_{Hot\,out} - T_{Cold\,in})}}$$





2 PROBLEM STATEMENT

Objective

Find the LMTD for the given configuration of heat exchangers.

Data

Co Current Arrangement
Shell Side Pressure drop = 0.25 bar
Tube Side Pressure drop = 0.3 bar
Global Heat Transfer Coeff = 1000 W/m2 K
No heat loss

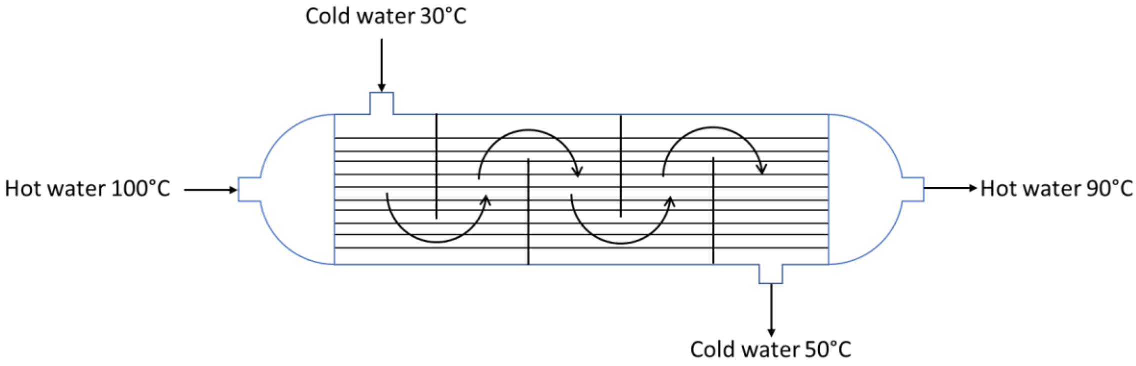


Figure 1 Problem Statement for Co Current Arrangement

Counter Current Arrangement
Shell Side Pressure drop = 0.25 bar
Tube Side Pressure drop = 0.3 bar
Global Heat Transfer Coeff = 1000 W/m2 K
No heat loss

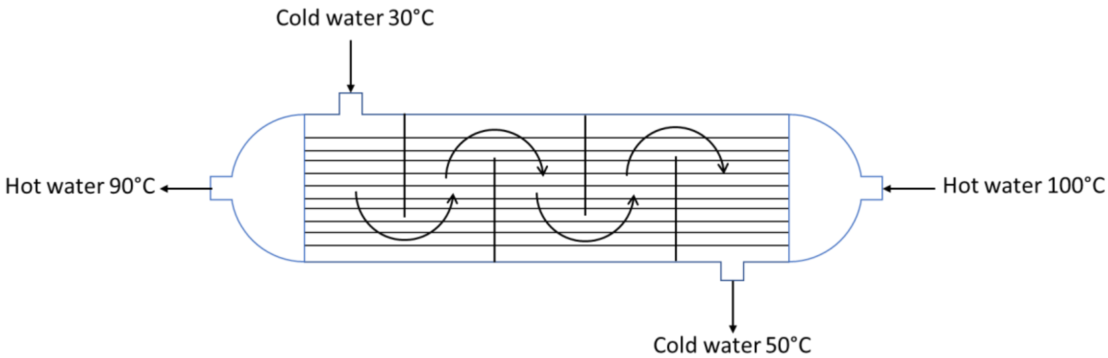


Figure 2 Problem Sratement for Counter Currnet Arrangement

DWSIM Blocks Used

- Heat Exchangers
- Material Stream

Procedure

1. Start a new DWSIM Simulation (DWSIM VER 8.2 - CLASSIC UI). Click on “New steady state Simulation” as a template for new simulation
2. The simulation configuration window will be opened. It shows a specification page. Add components required to solve the problem statement. In the present case, add water. Ensure all components are added from the same property database. For instance, in this case, both components are added from “ChemSep” database.
3. Specify the thermodynamic package as Stea m table (IAPWA-IF97).
4. Customize the system of units for the simulation and click “Next”.
5. The flow sheeting section of simulation window will be opened. First, let provide input and output streams for the unit operation to be performed. Drag and drop two Material streams available at the right, in the object palette. Rename them stream as “Cold water In” and “Hot water In” for inlet streams and “Cold water out” and “Hot water Out” for outlet streams.
6. On clicking the “Cold water In” and “Hot water In” stream, general information about the stream will be displayed on the left side of screen. Specify the feed compositions, temperature, and pressure for the inlet streams. Once credentials are specified for the inlet streams, the color of stream turns blue.

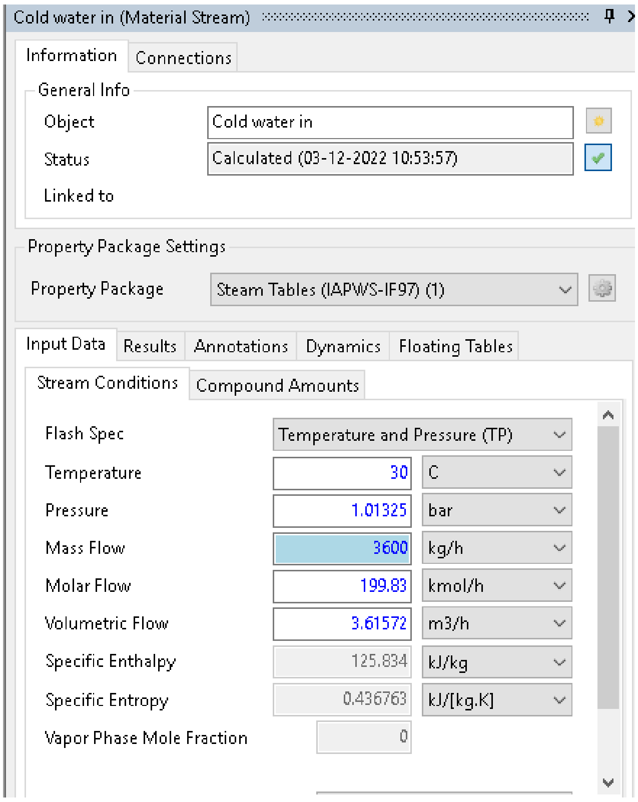


Figure 3 Cold Water Inlet Stream Specs

7. On clicking the “Hot water In” stream, general information about the stream will be displayed on the left side of screen. Specify the feed compositions, temperature, and pressure for the inlet streams. Once credentials are specified for the inlet streams, the color of stream turns blue.

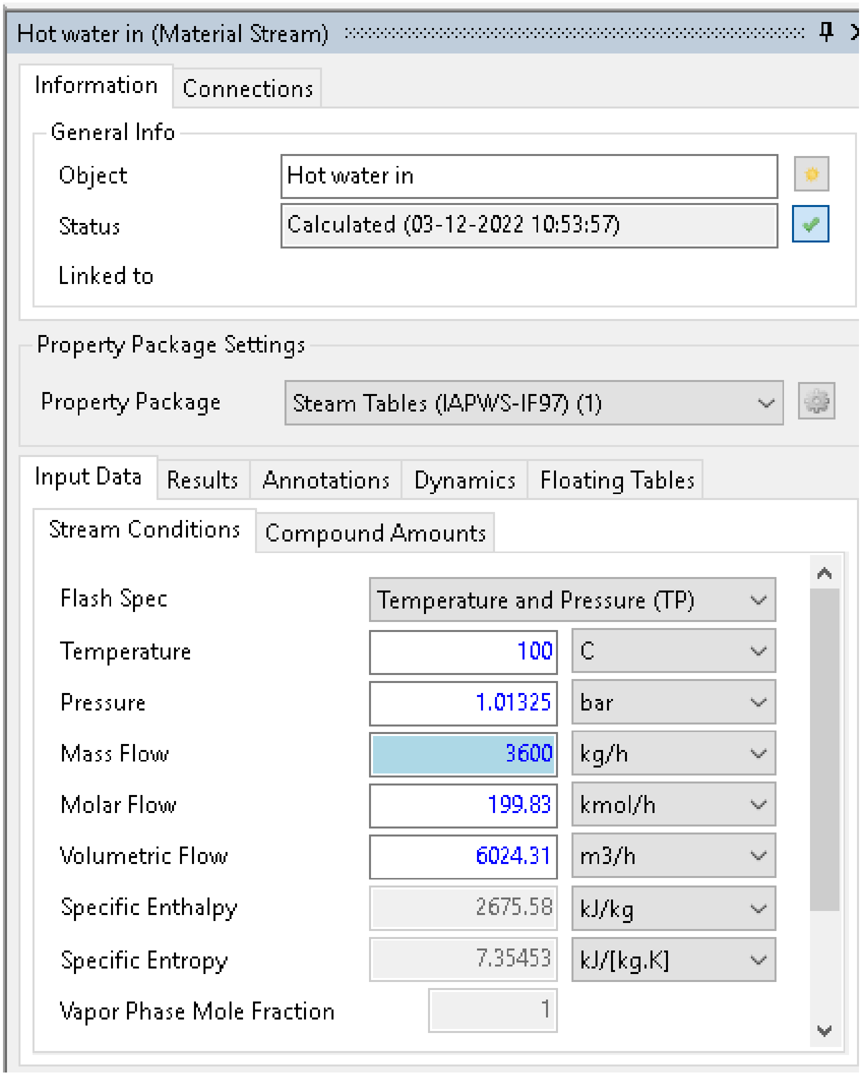


Figure 4 Hot Water Inlet Stream Specs

8. Below the Unit Operation tab on left, locate the Heat Exchanger block. Drag and drop into the flow sheet. Rename it as “Co Current HE”

Figure 5 Heat Exchanger

9. Under specification for Co Current HE, add the data as follows.

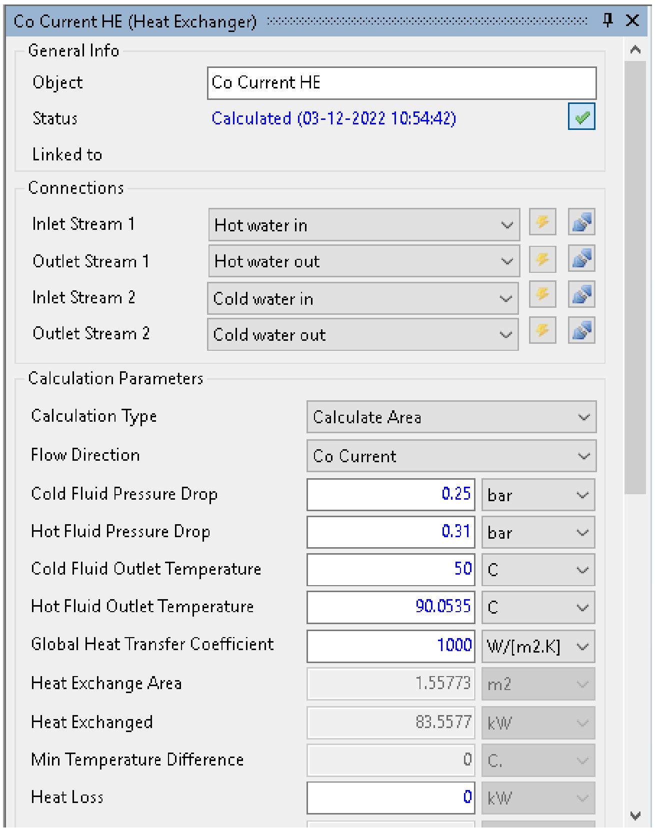


Figure 6 Co Current HE Specs

10. Click on the Enable Multiple Select as shown in the image

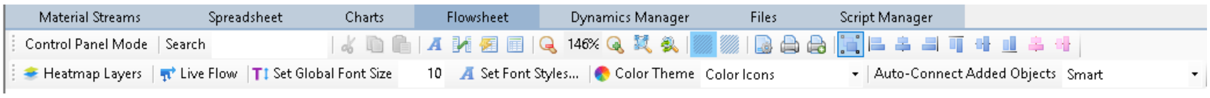


Figure 7 Multiple Select Mode

11. Select all the blocks, and right click and make a clone of the existing model

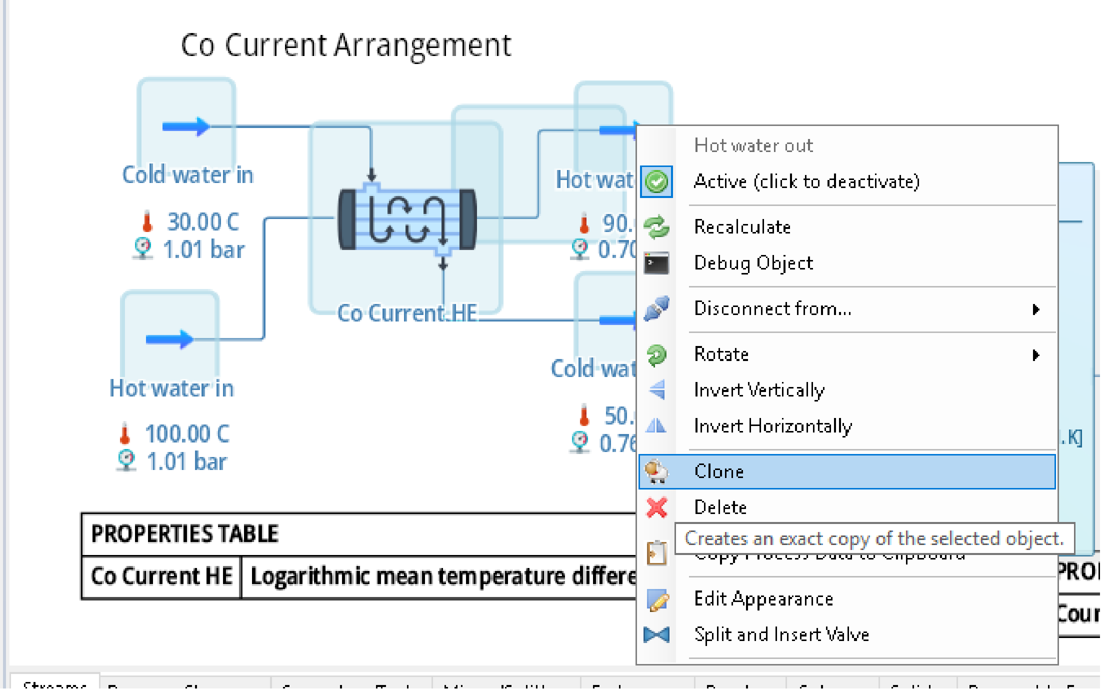


Figure 8 Cloning the model

12. Rename the cloned heat exchanger as "Counter Current HE". And make sure to select the flow direction as counter current in the model as shown in the image.

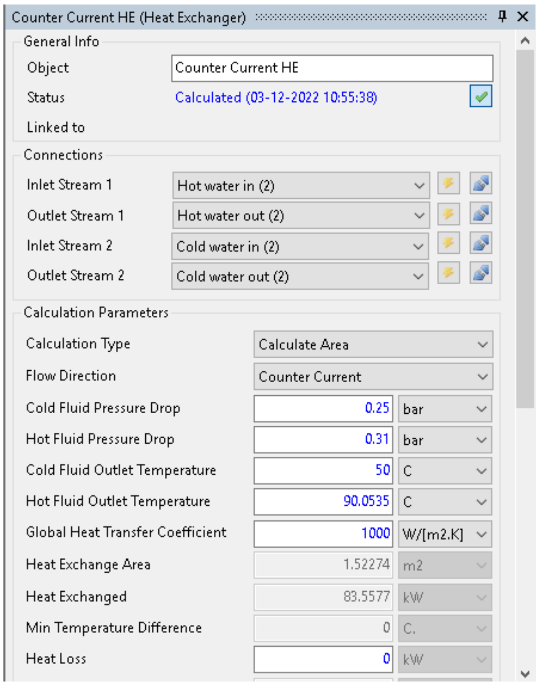


Figure 9 Counter Current HE Specs

13. Click on the property table to add the properties of “Co Current HE” & “Counter Current HE”. Double Click on the property table and select LMTD for both the HEs.

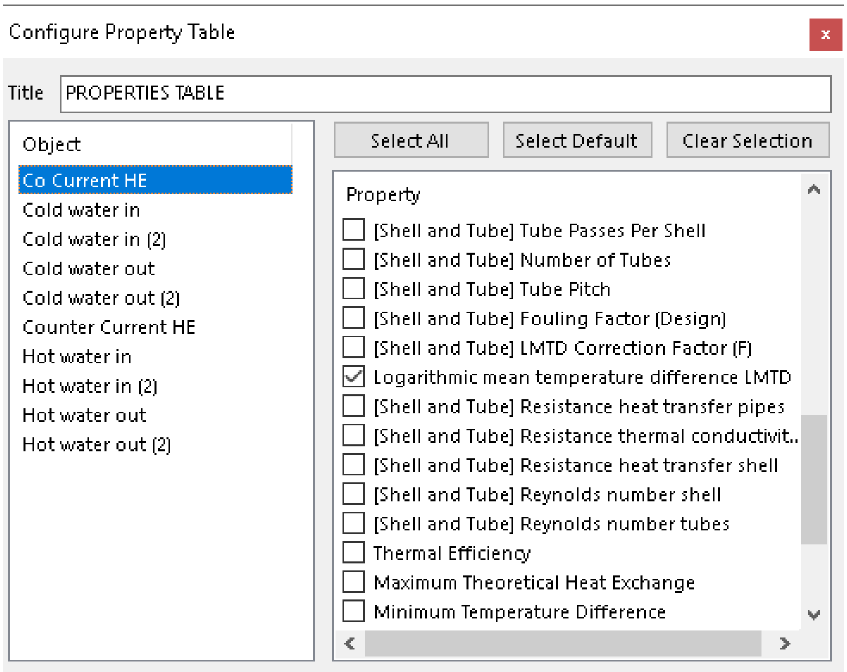
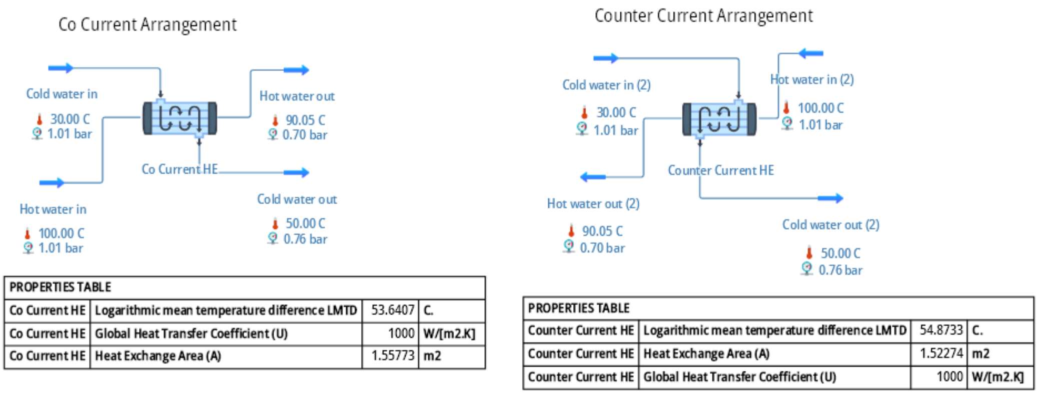


Figure 10 Property Tables

14. Run the simulation by pressing “Solve flow sheet” button on the top corner of the screen.



PROPERTIES TABLE			
Co Current HE	Logarithmic mean temperature difference LMTD	53.6407	C.
Co Current HE	Global Heat Transfer Coefficient (U)	1000	W/[m2.K]
Co Current HE	Heat Exchange Area (A)	1.55773	m2

PROPERTIES TABLE			
Counter Current HE	Logarithmic mean temperature difference LMTD	54.8733	C.
Counter Current HE	Heat Exchange Area (A)	1.52274	m2
Counter Current HE	Global Heat Transfer Coefficient (U)	1000	W/[m2.K]

Figure 11 Flow Sheet

3 Manual Calculations in Smath Studio

$$T_{Hot\_in} := 100\ °C$$

$$T_{Hot\_Out} := 90\ °C$$

$$T_{Cold\_in} := 30\ °C$$

$$T_{Cold\_Out} := 50\ °C$$

$$\Delta T_1 := T_{Hot\_in} - T_{Cold\_in} = 70\ K$$

$$\Delta T_2 := T_{Hot\_Out} - T_{Cold\_Out} = 40\ K$$

$$LMTD_{Parallel} := \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = 53.6082\ K$$

Figure 12 LMTD Calculation for Parallel Configuration

$$T_{Hot\_in} := 100\ °C$$

$$T_{Hot\_Out} := 90\ °C$$

$$T_{Cold\_in} := 30\ °C$$

$$T_{Cold\_Out} := 50\ °C$$

$$\Delta T_1 := T_{Hot\_in} - T_{Cold\_Out} = 50\ K$$

$$\Delta T_2 := T_{Hot\_Out} - T_{Cold\_in} = 60\ K$$

$$LMTD_{Counter} := \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = 54.8481\ K$$

Figure 13 LMTD Calculation for Counter Configuration

[LMTD Calculation file]

4 RESULTS OF DWSIM

Co Current Heat Exchanger Results

Property	Value	Units
Maximum Heat Exchange	2549.78	kW
Thermal Efficiency	3.27705	%
Log Mean Temperature Difference (LMTD)	53.6407	C.
LMTD Correction Factor (Shell and Tube)	1	

Counter Current Heat Exchanger Results

Property	Value	Units
Maximum Heat Exchange	2549.78	kW
Thermal Efficiency	3.27705	%
Log Mean Temperature Difference (LMTD)	54.8733	C.
LMTD Correction Factor (Shell and Tube)	1	

5 REFERENCES

1. EnggCyclopedia
2. Thermal Engineering