

Bi-Weekly Report 3

Team number: 1

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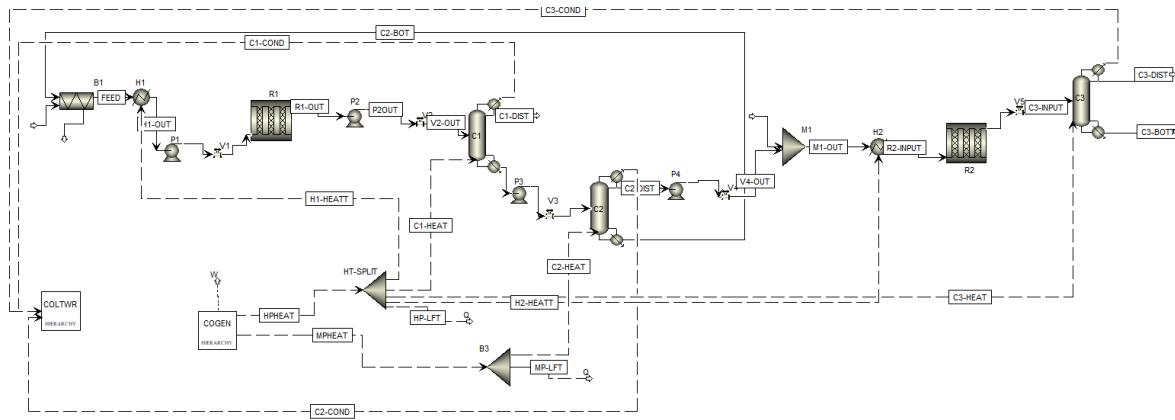
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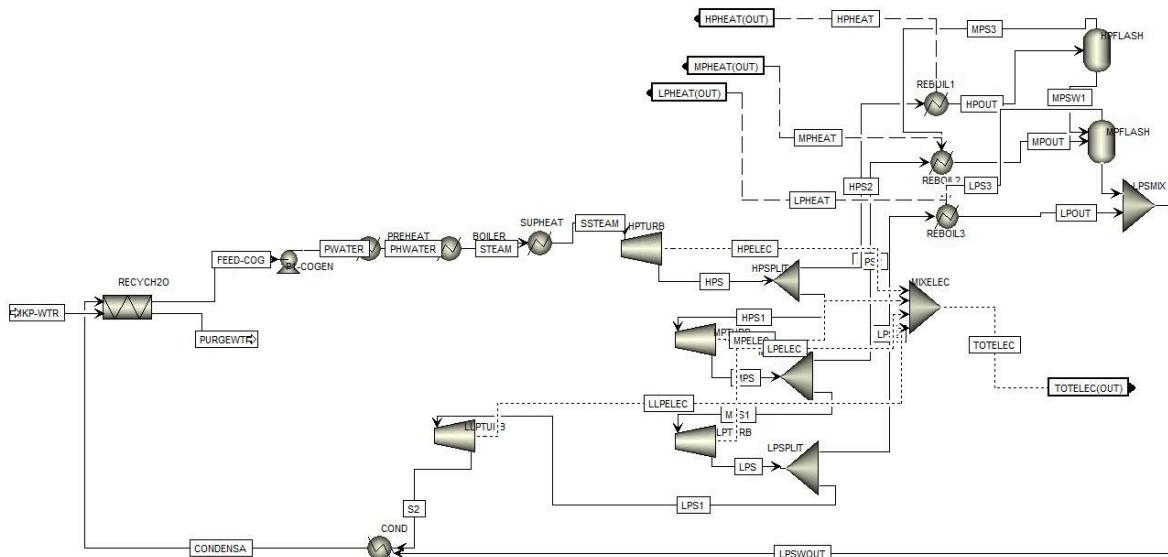
Objectives

This report focuses on three key deliverables: the design and sequencing of a distillation column to ensure efficient separation processes; the development of a sub-critical cogeneration power plant to optimize energy production and utilization; and the design of a cooling water loop to support effective thermal management within the system.



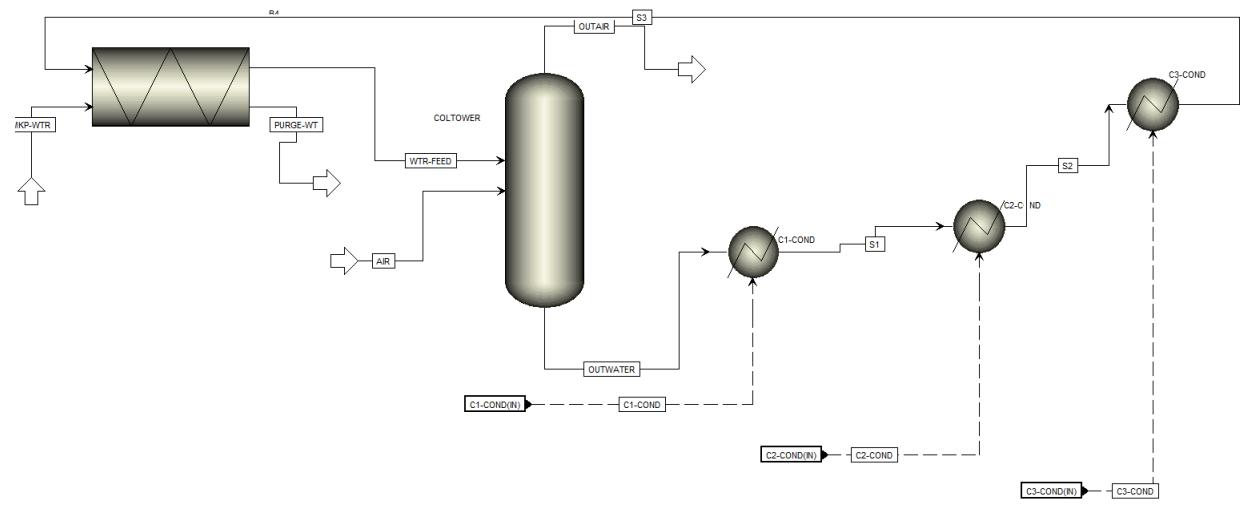
PROCESS FLOWSHEET

The process flowsheet outlines the cogeneration power plant, showing how steam is produced from fuel and then routed through turbines to generate electricity while also providing useful heat for downstream processes. The interconnected units such as the boiler, turbine, condenser, and generator highlight the dual purpose of energy generation and heat recovery, ensuring efficient use of resources.



COGENERATION POWER PLANT

The cogeneration power plant operates by heating water to produce steam, which is expanded in stages to simultaneously generate electricity and supply process heat. Feedwater is preheated, converted to steam in the boiler, and superheated before entering the high-pressure turbine, where power is produced and high-pressure steam is extracted for heating. The remaining steam expands through medium- and low-pressure turbines, generating additional electricity while providing medium- and low-pressure steam for plant heating duties. All electrical outputs are combined, and steam condensate is recycled, ensuring efficient utilization of fuel energy for both power and heating needs.



COOLING WATER TOWER

The cooling tower schematic highlights the circulation of water used to remove excess heat from the system. Hot water from the plant is passed through the tower where it is cooled by ambient air before being sent back for reuse, creating a closed loop that maintains safe operating temperatures and prevents overheating of critical units.

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Project 1 - Setup

Energy Analysis

Flowsheet Option Data Extraction Costing Constraints Information

Process type: Chemical

Customize

Flowsheet Selection

Flowsheet Name	Selected
Case (Main)	<input checked="" type="checkbox"/>
C1	<input checked="" type="checkbox"/>
C2	<input checked="" type="checkbox"/>
C3	<input checked="" type="checkbox"/>
COGEN	<input checked="" type="checkbox"/>

Associate energy stream with utility type

Unit Operation	Utilities Type	Process Stream Temperature [K]		Utility Temperatures [K]	
		Inlet	Outlet	Inlet	Outlet
Condenser@C1	COOLWTR	373.3	293.2	298.2	
Reboiler@C1	U-1	426.9	434.2	600.0	590.0
Condenser@C2	COOLWTR	424.7	418.4	293.2	298.2
Reboiler@C2	U-1	550.6	566.2	600.0	590.0
Condenser@C3	COOLWTR	446.5	433.7	293.2	298.2
Reboiler@C3	U-1	464.2	464.6	600.0	590.0
H1	U-1	360.7	473.2	600.0	590.0
H2	U-1	418.0	473.2	600.0	590.0
COGEN.BOILER	U-1	539.3	539.3	600.0	590.0
COGEN.COND	COOLWTR	406.8	372.7	293.2	298.2
COGEN.PREHEAT	U-1	376.8	539.3	600.0	590.0
COGEN.REBOIL1	COOLWTR	782.3	523.6	293.2	298.2
COGEN.REBOIL2	COOLWTR	596.1	453.2	293.2	298.2
COGEN.REBOIL3	COOLWTR	464.4	406.8	293.2	298.2
COGEN.SUPHEAT	HIGHTEMP	539.3	823.2	1273.2	673.2

Properties Simulation Safety Analysis Energy Analysis

Results Available

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Project 1 - Saving Potentials

Energy Analysis

Utilities

	Energy			Greenhouse Gases			Energy Cost Savings			ΔT_{min} [K]	Status
	Current [kWt]	Target [kWt]	Saving Potential [kWt]	Current [kg/sec]	Target [kg/sec]	Reduction Potential [kg/sec]	\$/yr	%			
U-1	1.00E+07	6.278E+06	4.334E+06	0.6279	0.3714	0.2564	341,961	40.84	10.0		
HIGHTEMP	6.405E+05	5.288E+05	1.12E+05	0.0379	0.03128	0.006625	15,018	17.48	25.0		
MPSTEAM	0	3.57E+06	-3.57E+06	0	0.2112	-0.2112	-247,820	N/A	10.0		
Total Heat Utilities	1.123E+07	1.038E+07	8.769E+05	0.6658	0.6139	0.05188	105,158	11.82			
COOLWTR	7.609E+06	6.792E+06	8.769E+05	0	0	0	5,867	11.43	5.0		
Total Cold Utilities	7.609E+06	6.792E+06	8.769E+05	0	0	0	5,867	11.43			

Heat exchanger details

Heat Exchanger	Status	Type	Ideas for Changes	Base Duty [Watt]	Hot Inlet Temperature [K]	Hot Outlet Temperature [K]	Cold Inlet Temperature [K]	Cold Outlet Temperature [K]	Recoverable Duty [Watt]	Base Area [sqm]	Overall Heat Trans. Coeff	Hot Side Fluid	Cold Side Fluid
Condenser@C3	On	Cooler		3.815E+05	446.5	433.7	293.2	298.2	3.815E+05	2.219	Default	To Condenser@C3_TO_C3-DIST	COOLWTR
H1	On	Heater		6.615E+05	600.1	590.1	360.7	473.2	2.808E+05	3.738	Default	FED_TO_H1-OUT	COOLWTR
COGEN.PREHEAT	On	Heater		1.022E+06	600.1	590.1	376.8	522.7	1.823E+05	2.446	Default	COGEN.PWATER_TO_COGEN.SSTEA	M
Condenser@C2	On	Cooler		7.948E+05	424.7	418.4	293.2	298.2	1.823E+04	5.622	Default	To Condenser@C2_TO_C2-DIST	COOLWTR
COGEN.REBOIL2	On	Cooler		7944	571.0	453.2	293.2	298.2	7944	0.07314	Default	COGEN.REBOIL2.Feed_TO_COGEN.	COOLWTR
COGEN.REBOIL1	On	Cooler		6234	783.3	523.6	293.2	298.2	6234	0.03774	Default	COGEN.REBOIL1.Feed_TO_COGEN.	COOLWTR
COGEN.REBOIL3	On	Cooler		7653	454.0	406.8	293.2	298.2	218.6	0.0944	Default	COGEN.REBOIL3.Feed_TO_COGEN.	COOLWTR
Condenser@C1	On	Cooler		4.037E+06	373.3	372.7	293.2	298.2	0.0	17.09	Default	To Condenser@C1_TO_C1-DIST	COOLWTR
COGEN.COND	On	Cooler		2.434E+06	372.8	372.7	293.2	298.2	0.0	9.022	Default	COGEN.COND_Feed_To_COGEN.CO	COOLWTR
Reboiler@C3	On	Heater		3.415E+05	600.1	590.1	464.2	464.6	0.0	0.7831	Default	3339.1	U-1
COGEN.BOILER	On	Heater		1.772E+06	600.1	590.1	522.7	593.4	0.0	7.192	Default	To Reboiler@C3_TO_C3-BOTT	COGEN.PWATER_TO_COGEN.SSTEA
H2	On	Heater		3.347E+05	600.1	590.1	418.0	473.2	0.0	1.44	Default	M1-OUT_TO_R2-INPUT	M
Reboiler@C1	On	Heater		3.56E+06	600.1	590.1	426.9	434.2	0.0	11.67	Default	To Reboiler@C1_TO_C1-BOTT	COGEN.PWATER_TO_COGEN.SSTEA
COGEN.SUPHEAT	On	Heater		6.406E+05	1273.2	673.2	539.4	823.2	0.0	51.75	Default	R1_heat	M
Reboiler@C2	On	Heater		9.293E+05	600.1	590.1	550.6	566.2	0.0	11	Default	To Reboiler@C2_TO_C2-BOTT	COGEN.PWATER_TO_COGEN.SSTEA
R2_heat_Exchanger	On	Heater		1.483E+06	600.1	590.1	473.2	473.7	0.0	63.06	Default	R1_heat	M
R1_heat_Exchanger	On	Heater		5.081E+05	600.1	590.1	473.2	473.7	0.0	21.6	Default	R1_heat	M

Properties Simulation Safety Analysis Energy Analysis

Results Available

ENERGY ANALYSIS

		Units	V1-OUT	R1-OUT	R2-INPUT	R2-OUT
- MIXED Substream						
Phase		Liquid Phase	478.922	473.15	477.827	473.15
Temperature	K		110000	110000	2e+06	2e+06
Pressure	N/sqm		0	0	0.652871	0
Molar Vapor Fraction			1	1	0.347129	1
Molar Liquid Fraction			0	0	0	0
Molar Solid Fraction			0	0	0.329565	0
Mass Vapor Fraction			1	1	0.670435	1
Mass Liquid Fraction			0	0	0	0
Mass Solid Fraction			-5.67047e+08	-3.55483e+08	-1.86429e+08	-4.56192e+08
Molar Enthalpy	J/kmol		-7.085e+06	-7.33023e+06	-4.87063e+06	-5.99553e+06
Mass Enthalpy	J/kg		-434330	-231445	-152946	-508351
Molar Entropy	J/kmol-K		-5426.76	-4772.51	-3995.86	-6681.02
Mass Entropy	J/kg-K		13.9261	18.4137	0.752957	10.3654
Molar Density	kmol/cum		1114.57	892.983	28.8203	788.69
Mass Density	kg/cum		-1.57513e+07	-1.62965e+07	-6.61713e+06	-8.1454e+06
Enthalpy Flow	Watt		80.035	48.4955	38.2762	76.0887
- Mole Flows		kmol/sec	0.0277778	0.0458433	0.0354941	0.0178552
H2O	kmol/sec		0.00452082	0.0225863	4.74663e-08	4.74663e-08
H2	kmol/sec		0	0	0.0176389	0
GLYCEROL	kmol/sec		0.0232518	0.00518629	1.78077e-05	1.78077e-05
PROPODIOL	kmol/sec		0	0	0	0.0176391
ACETOI	kmol/sec		5.17326e-06	0.0180707	0.0178373	0.000198194

REACTOR RESULTS

	Units	V2-OUT	C1-BOT	C1-DIST	V3-OUT	C2-DIST	C2-BOT	C3-BOTT	C3-DIST
Stream Class		CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN	CONVEN
Maximum Relative Error									
Cost Flow	\$/sec								
– MIXED Substream									
Phase		Liquid Phase	Liquid Phase		Liquid Phase	Liquid Phase	Liquid Phase	Liquid Phase	
Temperature	K	404.772	434.185	372.906	430.393	418.347	566.132	464.553	433.688
Pressure	N/sqm	120000	123000	100000	110000	100000	119000	114000	100000
Molar Vapor Fraction		0.243434	0	0	0.0157645	0	0	0	0
Molar Liquid Fraction		0.756566	1	1	0.984236	1	1	1	1
Molar Solid Fraction		0	0	0	0	0	0	0	0
Mass Vapor Fraction		0.178336	0	0	0.0149521	0	0	0	0
Mass Liquid Fraction		0.821664	1	1	0.985048	1	1	1	1
Mass Solid Fraction		0	0	0	0	0	0	0	0
Molar Enthalpy	J/kmol	-3.55478e+08	-4.49756e+08	-2.81235e+08	-4.49711e+08	-3.97434e+08	-6.04135e+08	-4.58895e+08	-4.30232e+08
Mass Enthalpy	J/kg	-7.33012e+06	-5.75603e+06	-1.51398e+07	-5.75546e+06	-5.36369e+06	-6.56121e+06	-6.02971e+06	-5.73139e+06
Molar Entropy	J/kmol-K	-228822	-375699	-147689	-375568	-341409	-463789	-514740	-427129
Mass Entropy	J/kg-K	-4718.4	-4808.24	-7950.56	-4806.56	-4607.58	-5036.99	-6763.51	-5690.05
Molar Density	kmol/cum	0.145626	12.4479	49.5082	1.69064	12.3833	11.2229	10.4742	11.5164
Mass Density	kg/cum	7.06223	972.638	919.66	132.101	917.57	1033.36	797.146	864.488
Enthalpy Flow	Watt	-1.62963e+07	-1.03574e+07	-6.41621e+06	-1.03563e+07	-7.09627e+06	-3.12559e+06	-8.06146e+06	-123933
Average MW		48.4955	78.1365	18.5759	78.1365	74.0973	92.0767	76.1055	75.0659
– Mole Flows	kmol/sec	0.0458433	0.0230289	0.0228144	0.0230289	0.0178552	0.00517366	0.0175671	0.000288062
H2O	kmol/sec	0.0225863	4.74703e-08	0.0225863	4.74703e-08	4.74663e-08	2.72166e-12	3.32535e-12	4.7463e-08
+									

COL 1 RESULTS

		Liquid Phase	Liquid Phase		Liquid Phase	Liquid Phase	Liquid Phase	Liquid Phase	
Phase									
Temperature	K	404.772	434.185	372.906	430.393	418.347	566.132	464.553	433.688
Pressure	N/sqm	120000	123000	100000	110000	100000	119000	114000	100000
Molar Vapor Fraction		0.243434	0	0	0.0157645	0	0	0	0
Molar Liquid Fraction		0.756566	1	1	0.984236	1	1	1	1
Molar Solid Fraction		0	0	0	0	0	0	0	0
Mass Vapor Fraction		0.178336	0	0	0.0149521	0	0	0	0
Mass Liquid Fraction		0.821664	1	1	0.985048	1	1	1	1
Mass Solid Fraction		0	0	0	0	0	0	0	0
Molar Enthalpy	J/kmol	-3.55478e+08	-4.49756e+08	-2.81235e+08	-4.49711e+08	-3.97434e+08	-6.04135e+08	-4.58895e+08	-4.30232e+08
Mass Enthalpy	J/kg	-7.33012e+06	-5.75603e+06	-1.51398e+07	-5.75546e+06	-5.36369e+06	-6.56121e+06	-6.02971e+06	-5.73139e+06
Molar Entropy	J/kmol-K	-228822	-375699	-147689	-375568	-341409	-463789	-514740	-427129
Mass Entropy	J/kg-K	-4718.4	-4808.24	-7950.56	-4806.56	-4607.58	-5036.99	-6763.51	-5690.05
Molar Density	kmol/cum	0.145626	12.4479	49.5082	1.69064	12.3833	11.2229	10.4742	11.5164
Mass Density	kg/cum	7.06223	972.638	919.66	132.101	917.57	1033.36	797.146	864.488
Enthalpy Flow	Watt	-1.62963e+07	-1.03574e+07	-6.41621e+06	-1.03563e+07	-7.09627e+06	-3.12559e+06	-8.06146e+06	-123933
Average MW		48.4955	78.1365	18.5759	78.1365	74.0973	92.0767	76.1055	75.0659
– Mole Flows	kmol/sec	0.0458433	0.0230289	0.0228144	0.0230289	0.0178552	0.00517366	0.0175671	0.000288062
– Mole Fractions									
– Mass Flows	kg/sec	2.22319	1.79939	0.423799	1.79939	1.32302	0.476374	1.33696	0.0216236
– Mass Fractions									
Volume Flow	cum/sec	0.3148	0.00185001	0.000460821	0.0136214	0.00144188	0.000460993	0.00167718	2.50132e-05
– Vapor Phase									

COL 2 RESULTS

	Units	V2-OUT	C1-BOT	C1-DIST	V3-OUT	C2-DIST	C2-BOT	C3-BOTT	C3-DIST
N2	kg/sec	0	0	0	0	0	0	0	0
O2	kg/sec	0	0	0	0	0	0	0	0
- Mass Fractions									
H2O		0.183024	4.75266e-07	0.960121	4.75266e-07	6.46338e-07	1.02926e-10	4.48085e-11	3.95429e-05
H2		0	0	0	0	0	0	0	0
GLYCEROL		0.21484	0.265439	6.71811e-60	0.265439	0.00123959	0.999195	0.00122667	3.20756e-17
PROPDIOL		0	0	0	0	0	0	0.995867	0.500699
ACETOL		0.602136	0.73456	0.0398793	0.73456	0.99876	0.000804558	0.00290681	0.499261
N2		0	0	0	0	0	0	0	0
O2		0	0	0	0	0	0	0	0
Volume Flow	cum/sec	0.3148	0.00185001	0.000460821	0.0136214	0.00144188	0.000460993	0.00167718	2.50132e-05
- Vapor Phase									
Molar Enthalpy	J/kmol	-2.74898e+08			-3.53191e+08				
Mass Enthalpy	J/kg	-7.73766e+06			-4.76576e+06				
Molar Entropy	J/kmol-K	-95296			-236240				
Mass Entropy	J/kg-K	-2682.34			-3187.69				
Molar Density	kmol/cum	0.0356569			0.0307397				
Mass Density	kg/cum	1.26679			2.27813				
Enthalpy Flow	Watt	-3.0678e+06			-128222				
Average MW		35.5272			74.1101				

COL3 RESULTS

	Units	V1-OUT	R1-OUT	R2-INPUT	R2-OUT
ACETOL	kmol/sec	5.17326e-06	0.0180707	0.0178373	0.000198194
N2	kmol/sec	0	0	0	0
O2	kmol/sec	0	0	0	0
- Mole Fractions					
H2O		0.16275	0.492685	1.3373e-06	2.6584e-06
H2		0	0	0.496953	0
GLYCEROL		0.837064	0.113131	0.00050171	0.000997342
PROPDIOL		0	0	0	0.9879
ACETOL		0.000186237	0.394184	0.502544	0.0111001
N2		0	0	0	0
O2		0	0	0	0
- Mass Flows		2.22319	2.22319	1.35858	1.35858
H2O	kg/sec	0.0814439	0.406899	8.55119e-07	8.55119e-07
H2	kg/sec	0	0	0.0355579	0
GLYCEROL	kg/sec	2.14137	0.47763	0.00164	0.00164
PROPDIOL	kg/sec	0	0	0	1.34226
ACETOL	kg/sec	0.000383232	1.33866	1.32138	0.0146821
N2	kg/sec	0	0	0	0
O2	kg/sec	0	0	0	0
- Mass Fractions					
H2O		0.0366337	0.183024	6.29422e-07	6.29421e-07
H2		0	0	0.0261728	0
GLYCEROL		0.963194	0.21484	0.00120714	0.00120714
PROPDIOL		0	0	0	0.987985

- Mass Fractions					
H2O		0.0366337	0.183024	6.29422e-07	6.29421e-07
H2		0	0	0.0261728	0
GLYCEROL		0.963194	0.21484	0.00120714	0.00120714
PROPDIOL		0	0	0	0.987985
ACETOL		0.000172379	0.602136	0.972619	0.010807

COOLING WATER RESULTS

HEATER RESULTS

COLTWR.C1-COND (Heater) - Results		COLTWR Results Summary (All)		Flowsh
Summary	Balance	Phase Equilibrium	Utility Usage	<input checked="" type="checkbox"/> Status
Outlet temperature	372.798136	K		
Outlet pressure	100000	N/sqm		
Vapor fraction	0.422759			
Heat duty	4.03692e+06	Watt		
Net duty	0	Watt		
1st liquid / Total liquid	1			
Pressure-drop correlation parameter				
Pressure drop	0	N/sqm		

Heater1

COLTWR.C2-COND (Heater) - Results		COLTWR.C1-COND (Heater) - Results		
Summary	Balance	Phase Equilibrium	Utility Usage	<input checked="" type="checkbox"/> Status
Outlet temperature	372.798342	K		
Outlet pressure	100000	N/sqm		
Vapor fraction	0.535799			
Heat duty	793860	Watt		
Net duty	0	Watt		
1st liquid / Total liquid	1			
Pressure-drop correlation parameter				
Pressure drop	0	N/sqm		

Heater2

COLTWR.C3-COND (Heater) - Results x COLTWR.C2-COND (Heater) - Results

Summary	Balance	Phase Equilibrium	Utility Usage	<input checked="" type="checkbox"/> Status
Outlet temperature	372.798414	K		
Outlet pressure	100000	N/sqm		
Vapor fraction	0.590089			
Heat duty	381270	Watt		
Net duty	0	Watt		
1st liquid / Total liquid	1			
Pressure-drop correlation parameter				
Pressure drop	0	N/sqm		

Heater3

HPHEAT (HEAT) - Results x COLTWR.C2-COND (Heater) - Results x COL

Heat	<input checked="" type="checkbox"/> Status
Display	Streams
HPHEAT	
QCALC Watt	4906269.36
TBEGIN K	783.297465
TEND K	523.567242

High Pressure Steam

MPHEAT (HEAT) - Results × Main Flowsheet × COLTWR.C2-COND (Heat)

Heat Status

Display Streams ▾

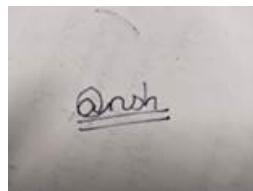
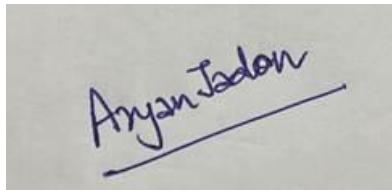
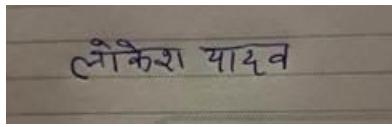
	MPHEAT	
QCALC Watt	959905.452	
TBEGIN K	453.134981	
TEND K	453.126508	

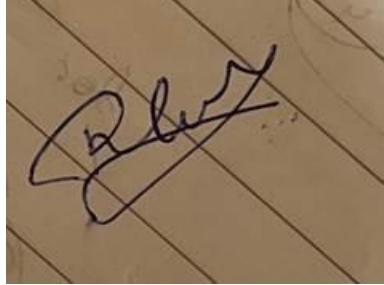
Medium Pressure Steam

Objectives that could not be accomplished with reasons: - None

Any other challenges: - None

Number of hours spent on Capstone project during this period: 15 hours

Name (Roll No.)	Contribution	Signature
Anas Ali (220137)	Cooling Water Loop and Report preparation	<i>Anas</i>
Ansh Sethi (220167)	Report making and Cooling Tower calculations	
Aryan Jadon (220223)	Flowsheet design and Report Preparation	
Jatin Madan (220475)	Cooling Water Loop and Report preparation	<i>Jmadan</i>
Lokesh Yadav (220594)	Flowsheet design Cogeneration and Cooling Water Loop	
Madhav Lata (220597)	Prepared Flowsheet(Cogeneration and Cooling Water) , Aspen Simulation	

Pratyush (220813)	Gupta	Prepared Flowsheet(Cogeneration and Cooling Water) , Aspen Simulation	
Punam (220835)	Singh	Prepared Flowsheet(Cogeneration and Cooling Water) , Aspen Simulation	