AHMEDABAD UNIVERSITY

School of Engineering and Applied Science

2025-2026 Winter

ENR514 Process Integration: Heat Recovery, Pinch Technology, and Network Optimization

Mid-Term Examination

Tuesday 24 February 2026. 8:00 – 9:30

Name:	Roll no.	A	U	2						Marks /30

Instructions:

This is a No Book –No Notes Examination. Answer all questions. All parts of a question must be answered together. Please do not raise any queries with the invigilators. In case of insufficient information, if any, make and mention suitable assumptions and proceed further.

Q.1 The petrochemical industries are one of the crucial energy sections that have a high impact on energy consumption as well as environmental quality. Here, a real industrial chemical process unit which produces naphtha is considered in this study. Fig. 1 shows the Process Flow Diagram (PFD) of this process unit. For convenience, the streamlines, heat exchangers, reactors, and vessels are numbered in the flow diagram. The temperature and enthalpy of each streamline are demonstrated in Table 1. The heat load for each equipment is given in Table 2. In this chemical unit heaters, air-cooler and water-cooler condensers are employed as an external utility to provide the heating and cooling demands in the process of naphtha production. According to the data demonstrated in Fig. 1 and Table 2, the heating and cooling loads provided by the external utilities are 22.264MW (H-101 & H-102) and 12.33MW (E-102, E-104 & E-105), respectively. It is claimed that this design does not meet maximum energy recovery targets for $\Delta T_{min} = 9.5°C$. Verify or disprove this claim. If verified, then design a HEN to meet MER targets for $\Delta T_{min} = 9.5°C$.

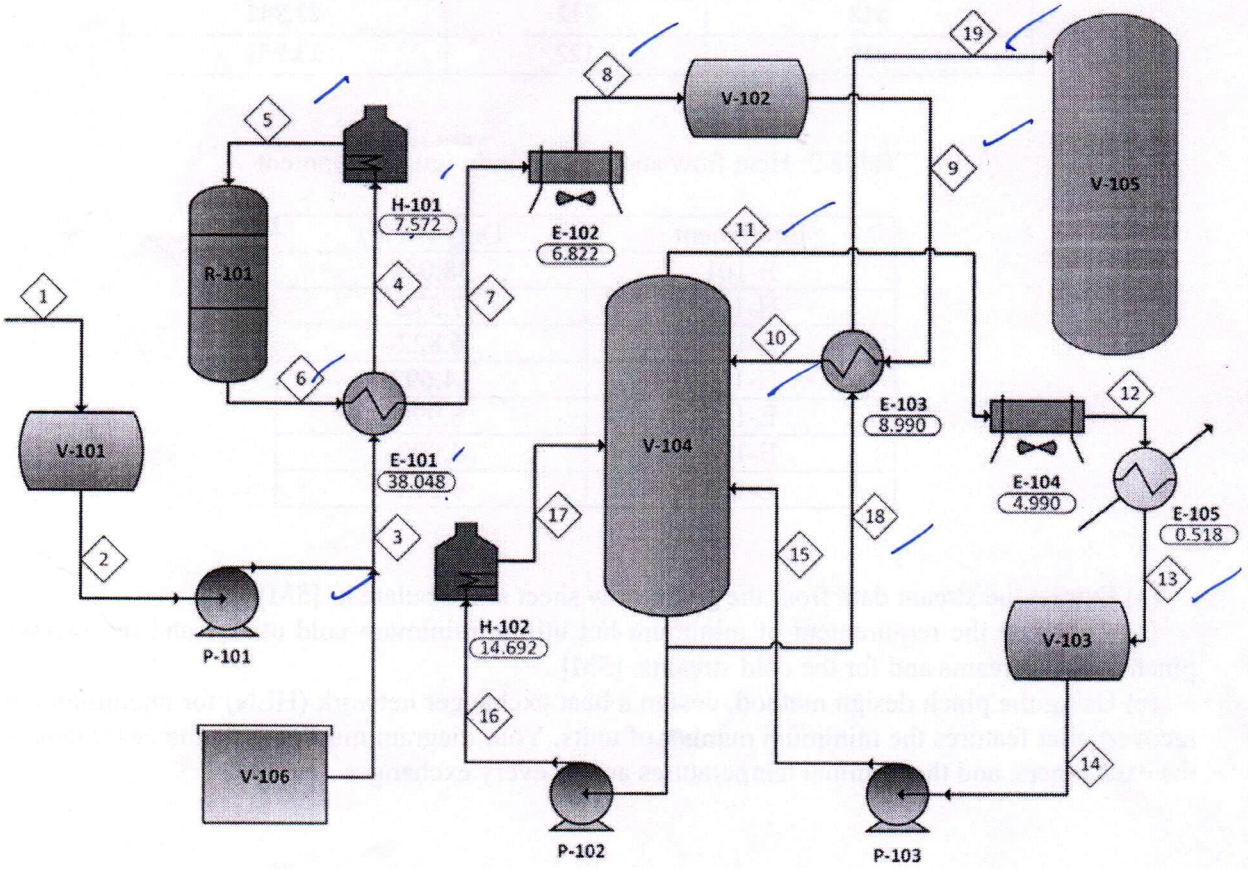


Fig. 1. Process flow diagram of the industrial unit produced Naphtha.

Table 1: Flows properties pointed in the flow diagram.

Stream number (point)	Temperature (°C)	Total enthalpy (MW)
p1	40	3.685
p2	36	0.066
p3	42	4.999
p4	282	43.047
p5	340	50.619
p6	340	50.595
p7	108	12.547
p8	50	5.725
p9	50	4.876
p10	135	13.866
p11	111	6.791
p12	55	1.801
p13	40	1.283
p14	40	1.283
p15	40	1.174
p16	212	55.369
p17	226	70.061
p18	212	22.941
p19	122	13.951

Table 2: Heat flow and duty of individual equipment

Equipment	Duty (MW)
E-101	38.048
H-101	7.572
E-102	6.822
H-102	14.692
E-103	8.990
E-104	4.990
E-105	0.518

(a) Extract the stream data from the given flow sheet and tabulate it. **[5M]**

(b) Calculate the requirement of minimum hot utility, minimum cold utility, and the location of pinch for hot streams and for the cold streams. **[5M]**

(c) Using the pinch design method, design a heat exchanger network (HEN) for maximum energy recovery that features the minimum number of units. Your diagram must include the heat loads on all the exchangers, and the terminal temperatures across every exchanger. **[10M]**

Q-2: The stream data for case study is given below:

Stream	Flow rate capacity, kW/^{0}C	Supply temperature, ^{0}C	Target Temperature, ^{0}C
H1	3.2	350	160
H2	3	400	100
H3	8	110	60
C1	4.5	50	250
C2	2	70	320
C3	3	100	300

For ΔT_{min}=10^{0}C, the minimum hot utility and cold utilities are 237 and 145 kW with pinch temperature 105 ° C. Using the pinch design method, design a heat exchanger network (HEN) for maximum energy recovery that features the minimum number of units. Your diagram must include the heat loads on all the exchangers, and the terminal temperatures across every exchanger. **[10M]**

	Cp			Q
6 → 8	0.1547340	⟶	350	44.87
3 → 5	0.153142	⟶	340	45.62
16 → 17	1.0494	212 ⟶	226	14.692
18 → 19	0.0999	212 ⟶	122	8.990
9 → 10	0.10576	50 ⟶	135	8.990
11 → 13	0.07758	111 ⟶	40	5.508