EN 410
Energy Management

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Heat Loss “Quality and Quantity”

- Higher the temperature, higher the quality and most cost effective for recovery
  - Cascaded system is possible at high temperature , air preheating at high temperature and feed water heating at low temperature
- Conditions of stream – vapor condensation, impurities

Source	Quality
Heat in flue gases.	The higher the temperature, the greater the potential value for heat recovery
Heat in vapour streams.	As above but when condensed, latent heat also recoverable.
Convective and radiant heat lost from exterior of equipment	Low grade – if collected may be used for space heating or air preheats.
Heat losses in cooling water.	Low grade – useful gains if heat is exchanged with incoming fresh water.
Heat losses in providing chilled water or in the disposal of chilled water.	a) High grade if it can be utilized to reduce demand for refrigeration. b) Low grade if refrigeration unit used as a form of heat pump.
Heat stored in products leaving the process	Quality depends upon temperature.
Heat in gaseous and liquid effluents leaving process.	Poor if heavily contaminated and thus requiring alloy heat exchanger.

Types of Waste Heat Sources

- Sources of waste energy are sometimes divided according to temperature into three temperature ranges:
- - High temperature: > 650°C (1200°F)
- - Medium temperature: 230°C < T < 650°C (450°F < T < 1200°F)
- - Low temperature: < 230°C (450°F)
- High and medium temperature waste heat can be used for power generation and steam production.
- Low temperature waste heat can be used for steam and hot water production, process heating, space heating, and cooling applications.
- High and medium temperature waste heat is usually the result of burning fuel in a combustion chamber where the flame temperatures can be as high as 2000°C (3600°F) or more.

Types

Industrial application	Temperature range of waste heat	
High Temperature	°C	°F
Nickel refining furnace	1370 – 1650	2500 – 3000
Aluminum refining furnace	650 – 760	1200 – 1400
Zinc refining furnace	760 – 1100	1400 – 2000
Copper refining furnace	760 – 815	1400 – 1500
Steel heating furnace	925 – 1040	1700 – 1900
Copper reverberatory furnace	900 – 1100	1650 – 2000
Open hearth furnace	650 – 700	1200 – 1300
Cement kiln (dry process)	620 – 730	1150 – 1350
Glass melting furnace	980 – 1540	1800 – 2800
Hydrogen plants	650 – 980	1200 – 1800
Solid waste incinerators	650 – 980	1200 – 1800
Fume incinerators	650 – 1425	1200 – 2600
Medium Temperature		
Steam boiler exhausts	230 – 480	450 – 900
Gas turbine exhausts	370 – 540	700 – 1000
Reciprocating engine exhausts	315 – 595	600 – 1100
Reciprocating engine exhausts (turbocharged)	230 – 370	450 – 700
Heat treating furnaces	425 – 650	800 – 1200
Drying and baking ovens	230 – 595	450 – 1100
Catalytic crackers	425 – 650	800 – 1200
Annealing furnace cooling systems	425 – 650	800 – 1200
Low Temperature		
Process steam condensate	55 – 90	130 – 190
Cooling water from:		
Furnace doors	30 – 55	90 – 130
Bearings	30 – 90	90 – 190
Welding machines	30 – 90	90 – 190
Injection molding machines	30 – 90	90 – 190
Annealing furnaces	65 – 230	150 – 450
Forming dies	25 – 90	80 – 190
Air compressors	25 – 50	80 – 120
Pumps	25 – 90	80 – 190
Internal combustion engines	65 – 120	150 – 250
Air conditioning and refrigeration condensers	30 – 45	90 – 110
Liquid still condensers	30 – 90	90 – 190
Drying, baking and curing ovens	95 – 230	200 – 450
Hot processed liquids	30 – 230	90 – 450

Waste heat recovery

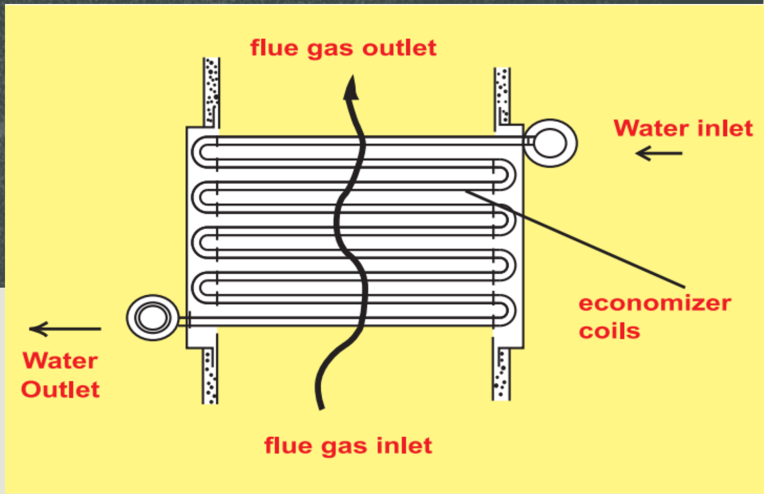
Benefits

- Improving the efficiency of process
- Reduction in pollution due to lesser use of fuel
- Reducing the size of equipment and thereby reducing the size of auxiliary energy consumption

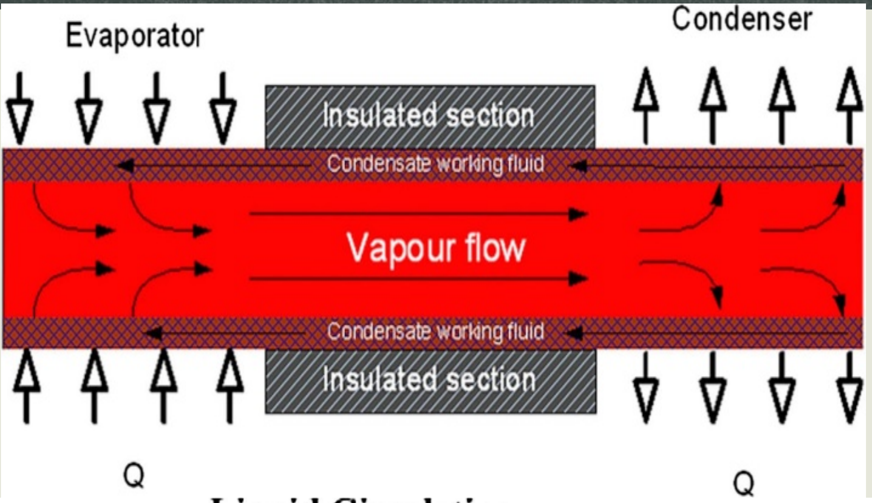
Process

- Identify the source of waste heat
- Availability of space
- Any constrain such as condensation which leads to corrosion
- Select the suitable HX
- Economic evaluation

Types

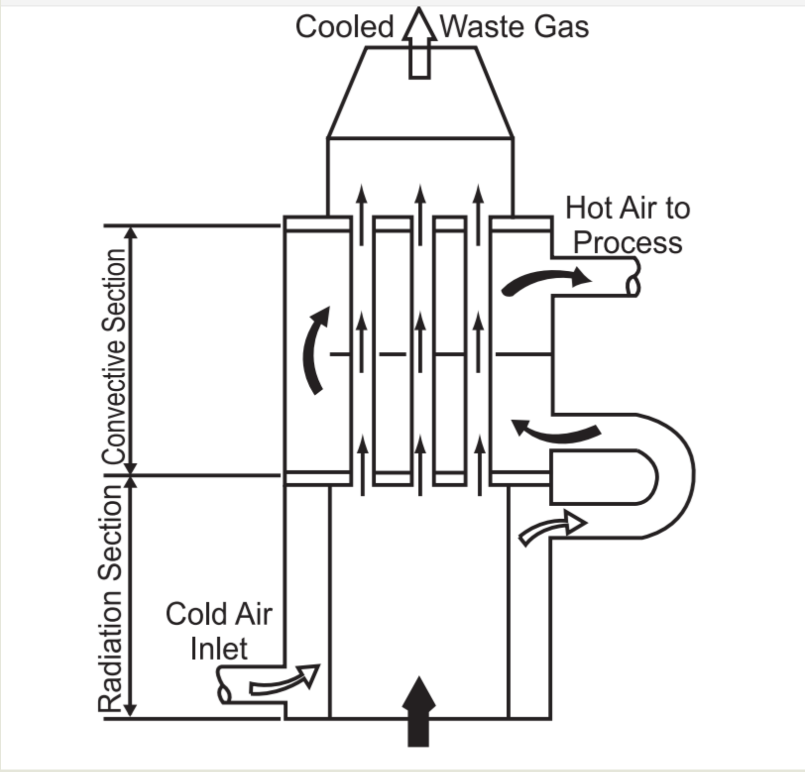


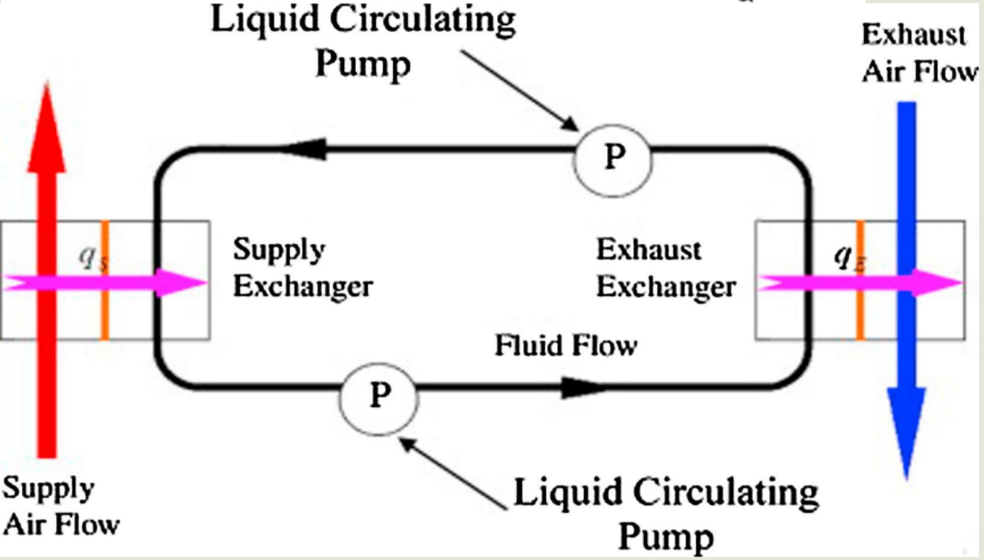
Economizer



Heat pipe

Recuperator



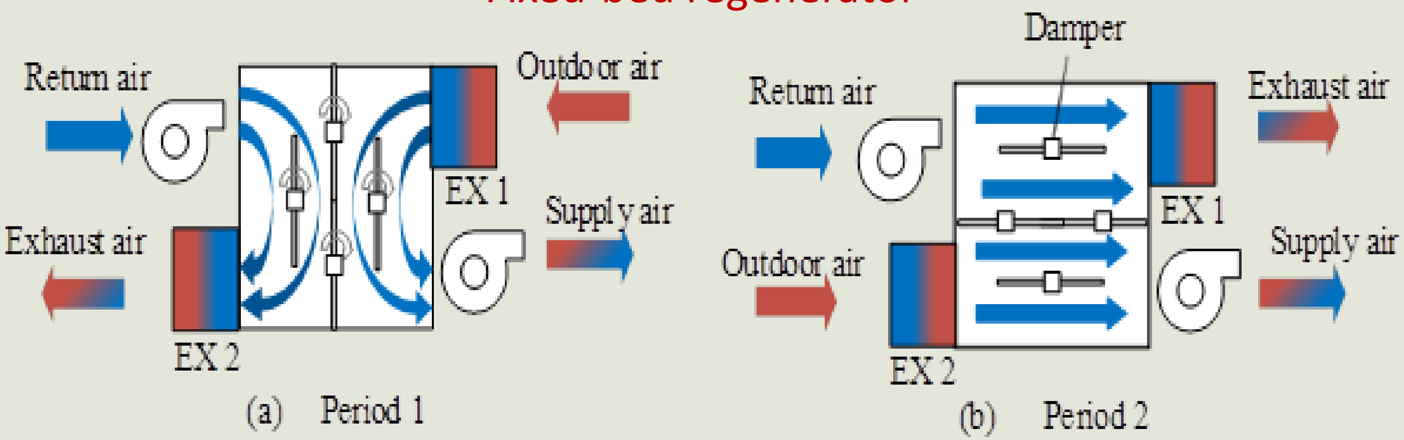


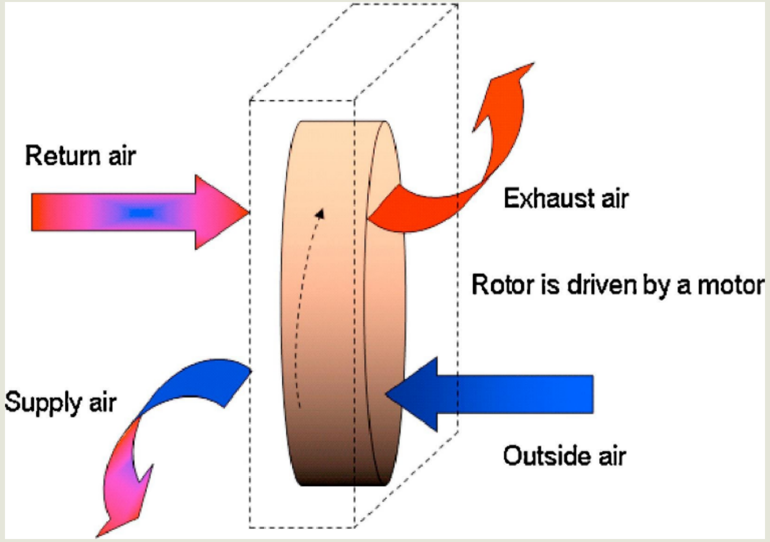
Runaround coil loop

Types

- Useful for larger application and at glass and steel melting furnaces

Fixed-bed regenerator





Rotary / Heat wheel

Pinch Technology

- Methodology for minimizing the energy consumption by optimizing the heat recovery systems

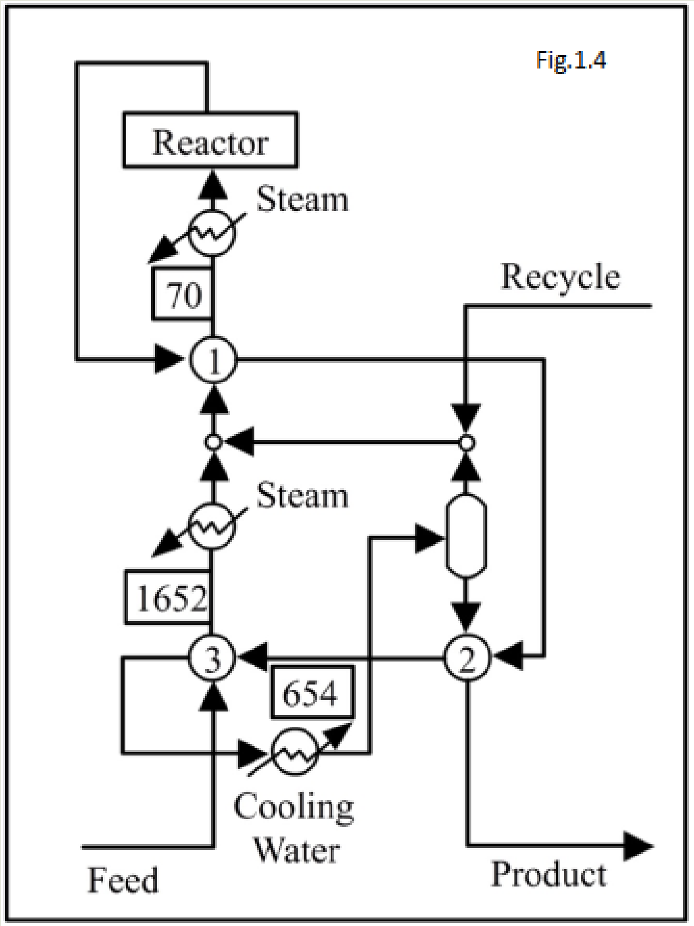


Fig.1.4

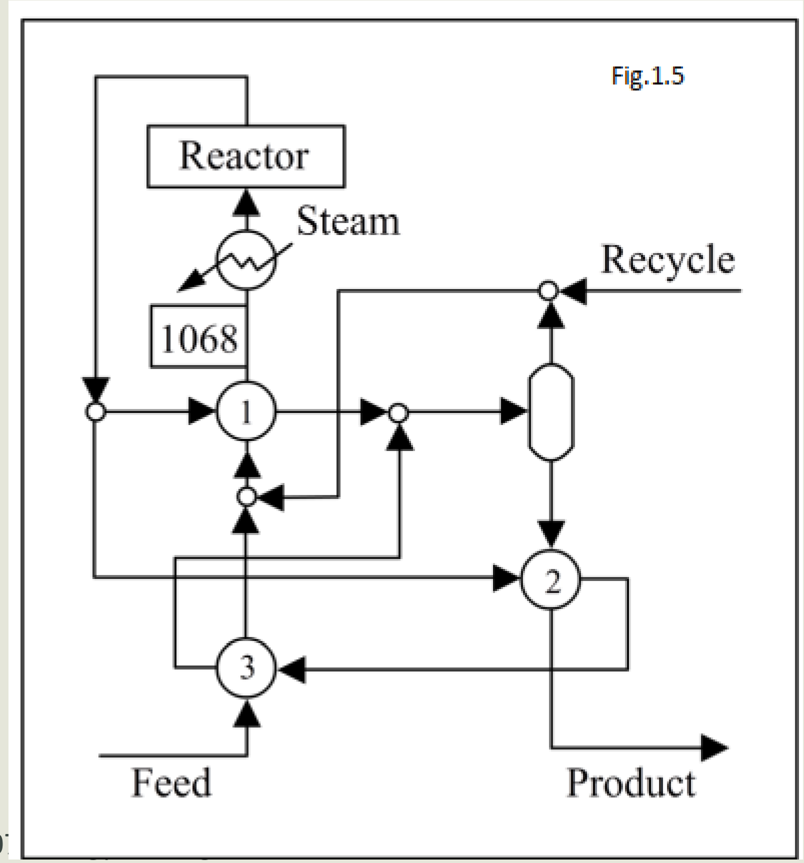


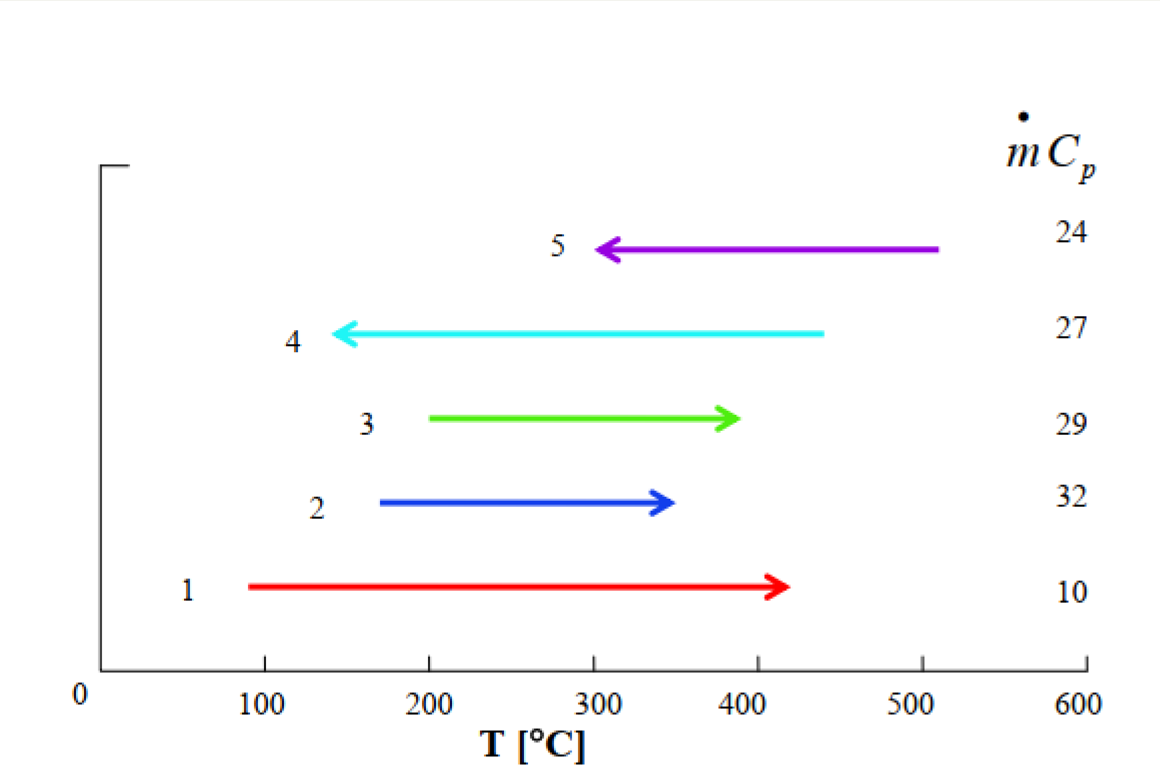
Fig.1.5

Pinch Technology

	Process stream type	Inlet temp	Outlet temp	Heat capacity rate	Q
	-	℃	℃	kW/K	kW
1	Cold	90	420	10	3300
2	Cold	170	350	32	5760
3	Cold	200	390	29	5510
4	Hot	440	140	27	8100
5	Hot	510	300	24	5040

Find out the heating and cooling requirements?

Temperature interval of streams



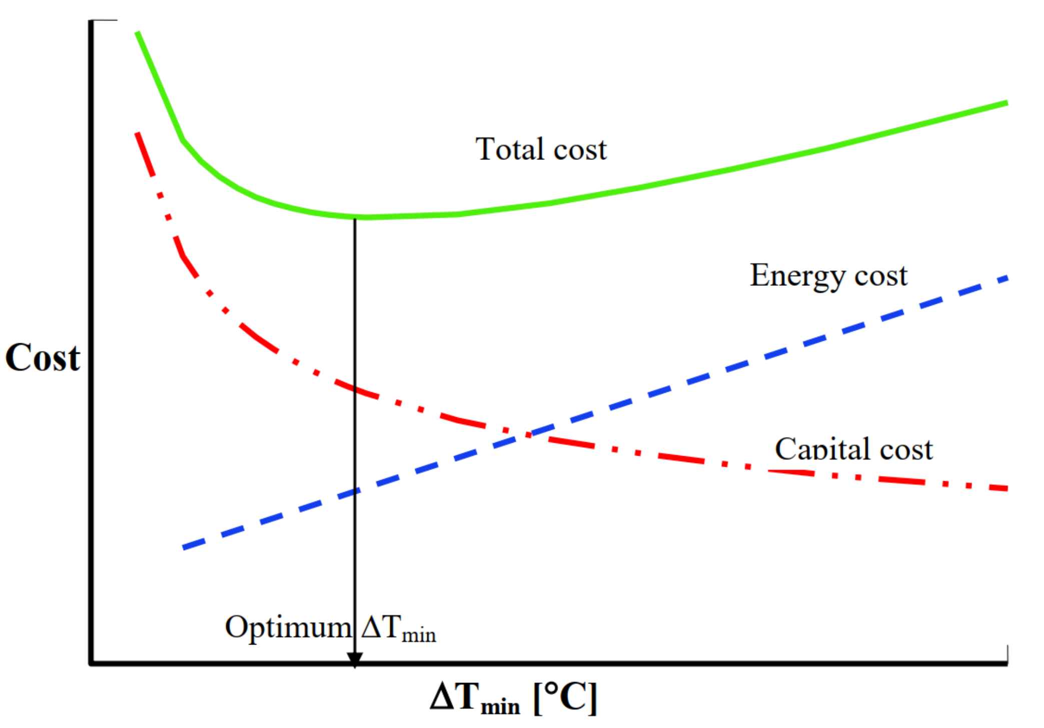
External heating and cooling requirements

Interval Number	Temperature interval [°C]	Stream Numbers	$\dot{Q}_{cool}$ [kW]	$\dot{Q}_{heat}$ [kW]	$\Delta\dot{Q}$ [kW]
1	510 – 440	5	1680	0	1680
2	440 – 420	4 + 5	1020	0	1020
3	420 – 390	1 + 4 + 5	1530	300	1230
4	390 – 350	1 + 3 + 4 + 5	2040	1560	480
5	350 – 300	1 + 2 + 3 + 4 +5	2550	3550	- 1000
6	300 – 200	1 + 2 + 3 + 4	2700	7100	- 4400
7	200 – 170	1 + 2 + 4	810	1260	- 450
8	170 – 140	1 + 4	810	300	510
9	140 – 90	1	0	500	- 500

Minimum temperature difference

$$Q = AU\,\Delta T_{lm}$$

- Higher the ΔT lesser the area, lesser the heat recovery, larger the external utilities
- Vice versa



Industrial Sector	Typical values for ΔT_{min}
Low Temperature Process	3 – 5 °C
Chemical	10 – 20 °C
Petrochemical	10 – 20 °C
Oil Refinery	20 – 40 °C