ASME ORC 2013

EVALUATION OF PINCH POINT SMOOTHING AS A MEANS TO ENHANCE THE POWER PRODUCED IN ORC UNITS WITH VARIABLE TEMPERATURE HEAT SOURCE

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Rotterdam 7th & 8th 2013


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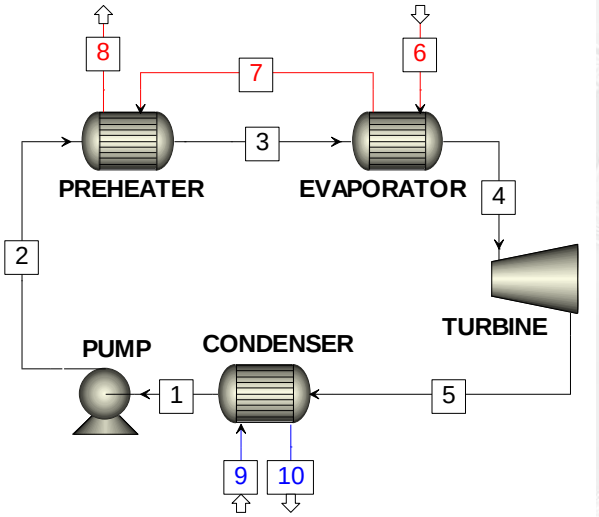
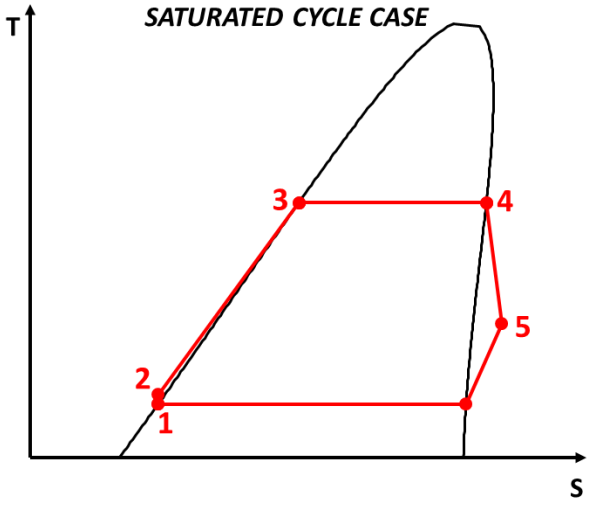
the challenge

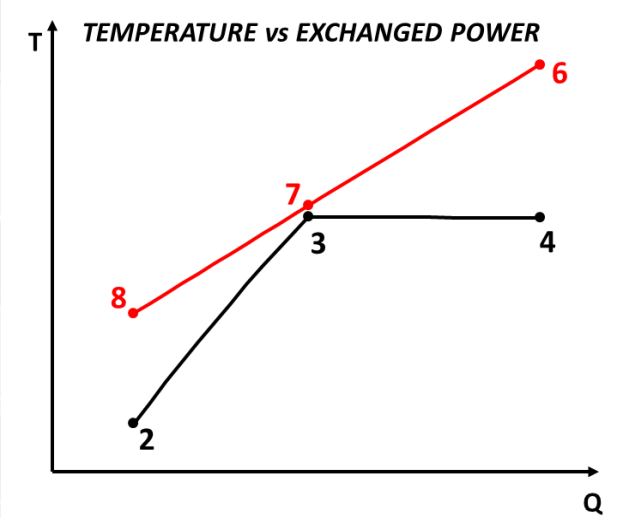
VARIABLE TEMPERATURE HEAT SOURCE

- HOT WATER
- EXHAUST GAS

SATURATED CYCLE ORC



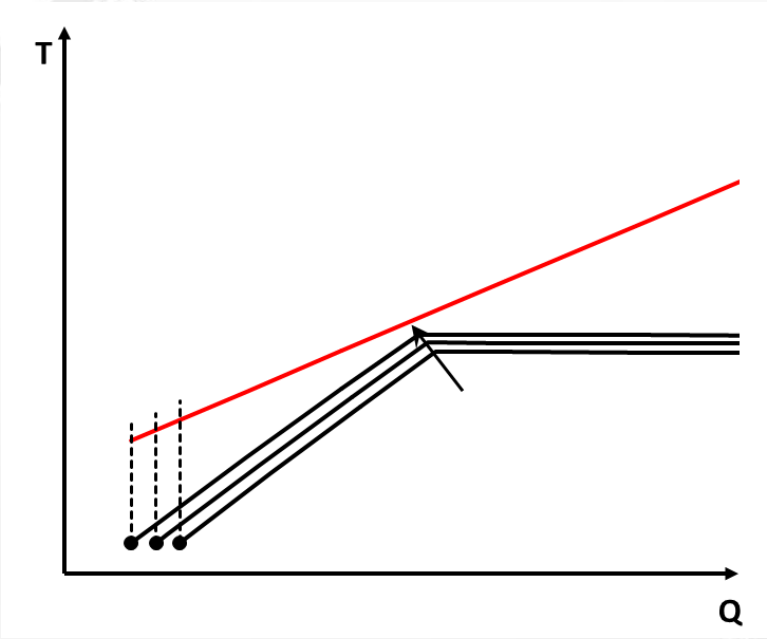




$\Delta T_{PP}=T_7-T_3$ PINCH POINT TEMPERATURE DIFFERENCE

CONSTANT HEAT CAPACITY STREAM

the challenge

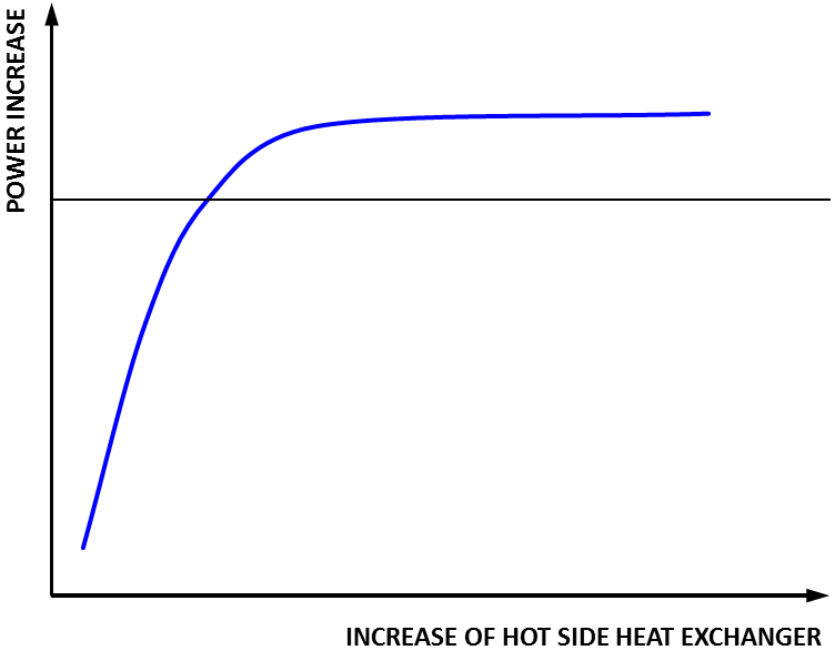


HIGH PERFOMANCE HOT SIDE HEAT EXCHANGERS

- LARGE SURFACE AREA
- EXTENDED SURFACES (various kinds of finned tubes)
- PLATE HEX (plate/ shell and plate/ etc)
- INNOVATIVE MATRICES

MINOR INCREASE OF EXCHANGED POWER

MINOR INCREASE OF EVAPORATION TEMPERATURE



the challenge

Quantify a case

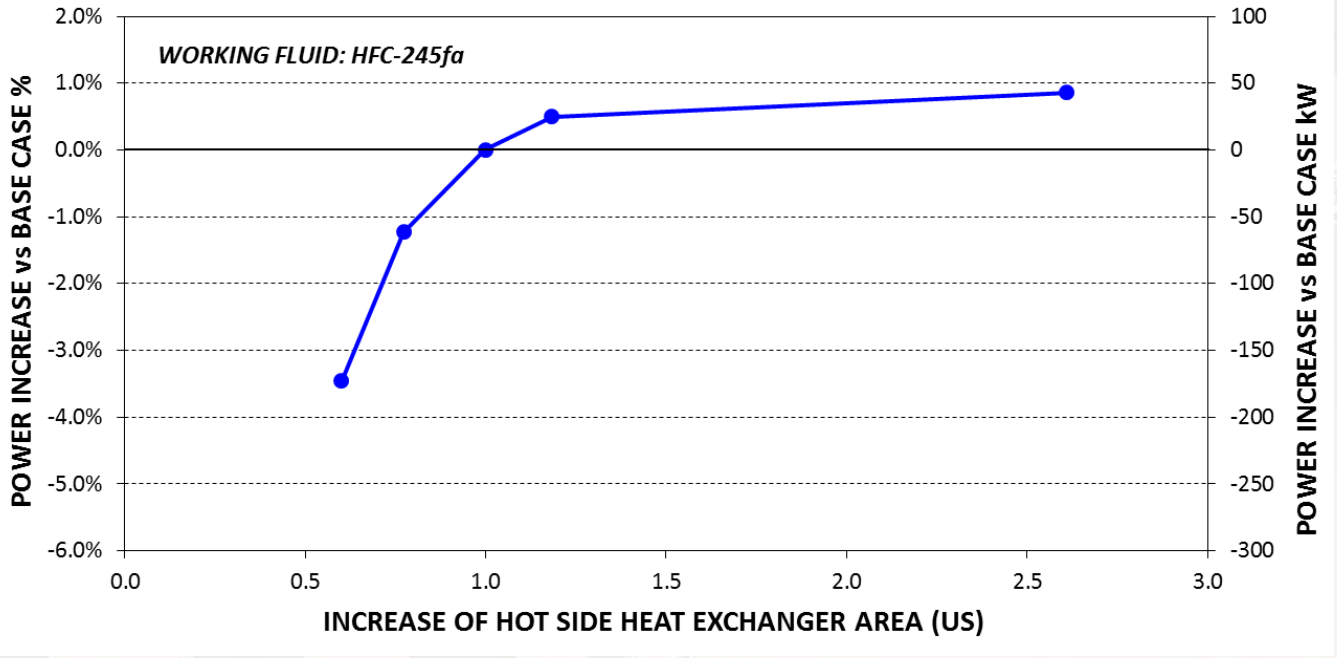
5 MW GEOTHERMAL

INPUT DATA

Working fluid	*R-245fa*	*R-134a*
$P_{evaporation}/P_{critical}$ (base case)	*0,28*	*0,62*
Base case Net Power kW	*5000*	*5000*
Hot source fluid	Hot Water	Hot Water
Hot source temperature °C	150	115
Hot source flow kg/s	100	170
Condensation temperature °C	20	22
Turbine efficiency	85%	
Generator efficiency	97%	
Pump efficiency	74%	
Compressor efficiency	71%	

Base case

ΔT_{PP}=2 °C



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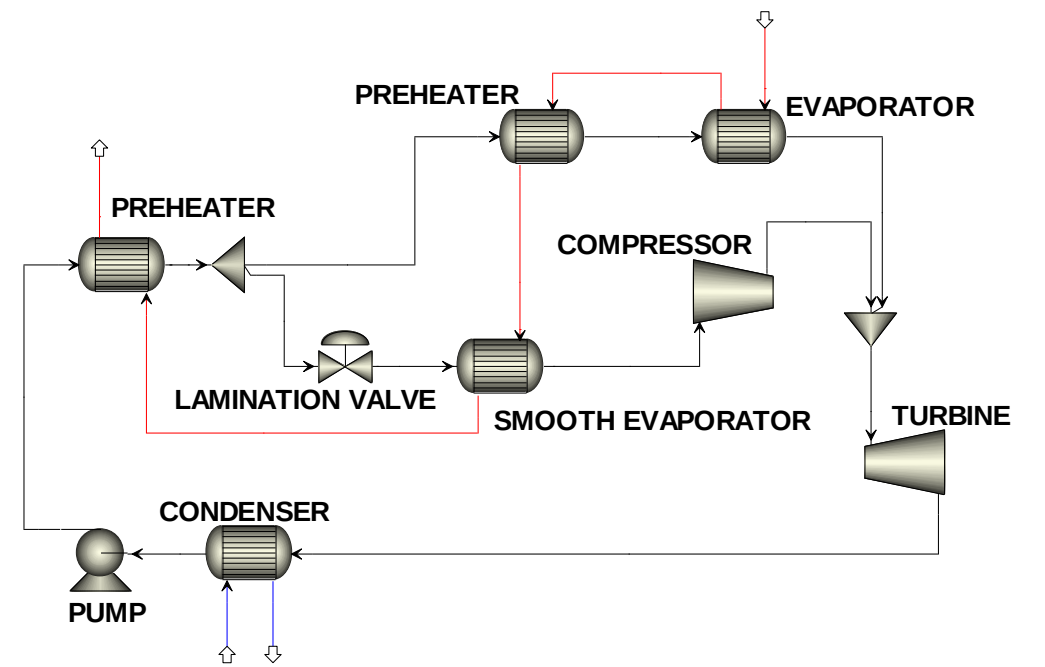
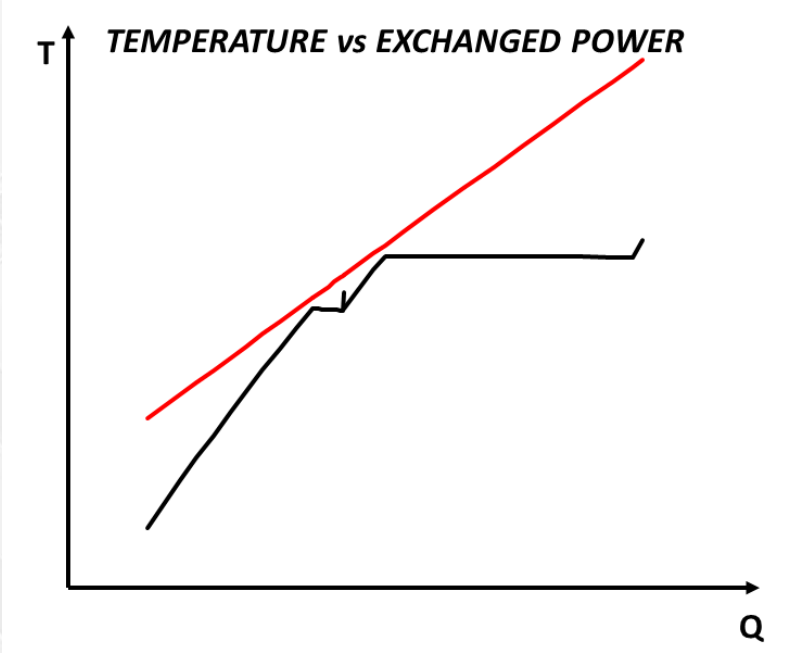
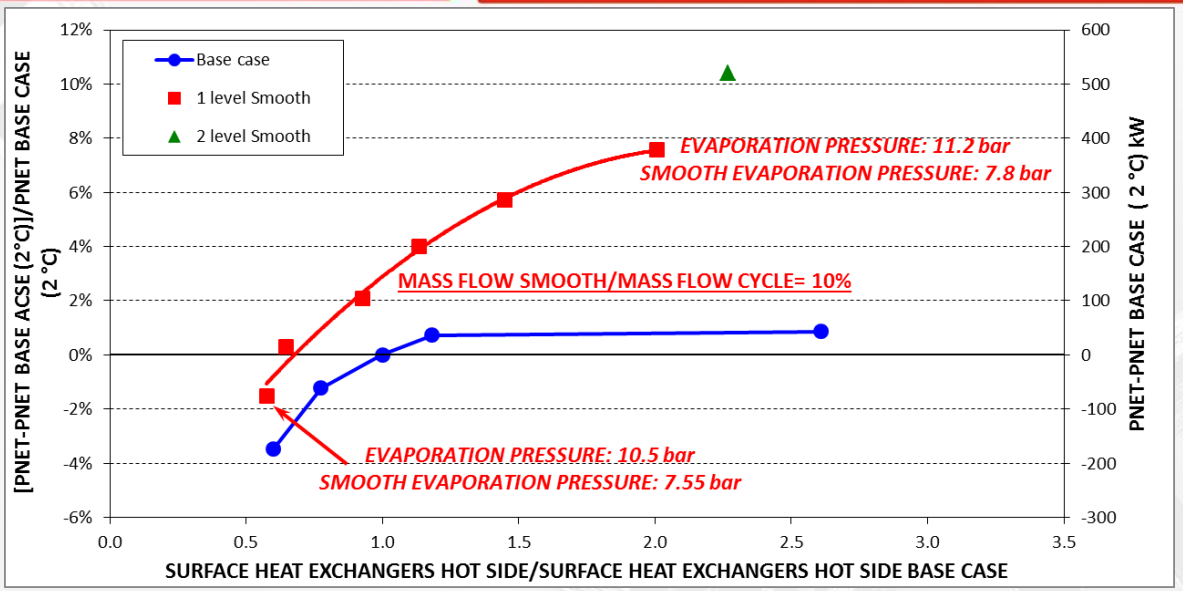
PINCH POINT SMOOTHING

- PINCH POINT SMOOTHING: a fraction of the working fluid flow evaporates at lower pressure and it is mechanically compressed to the turbine inlet pressure





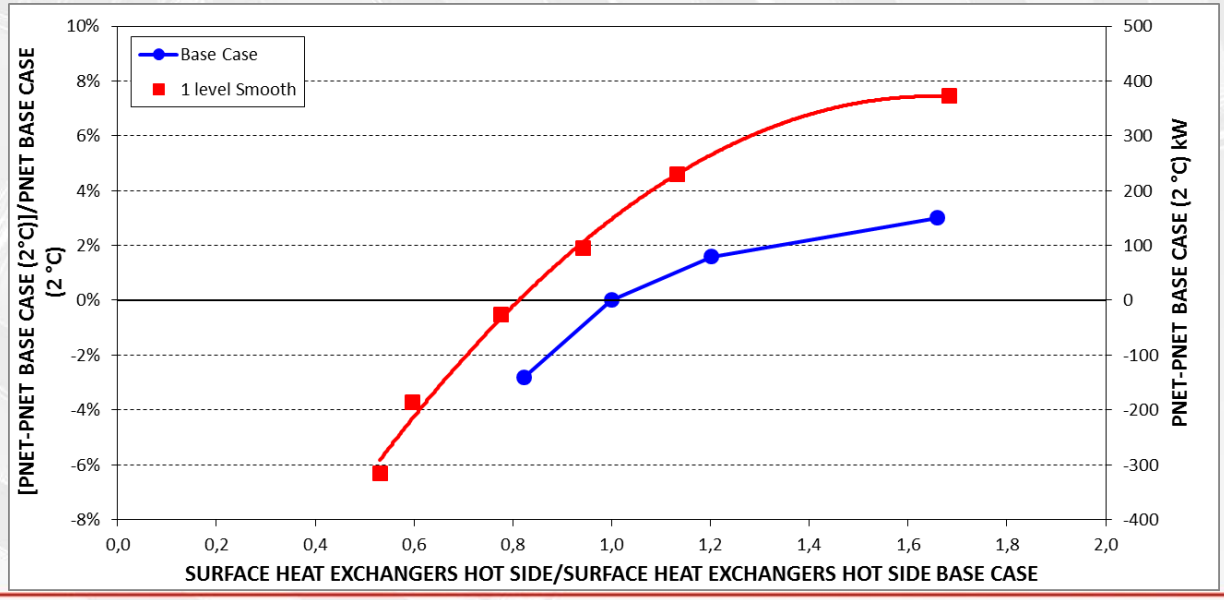
PINCH POINT SMOOTHING



WORKING FLUID HFC-245fa

5 MW Geothermal
base case
Delta T Pinch Point: 2°C

WORKING FLUID HFC-134a



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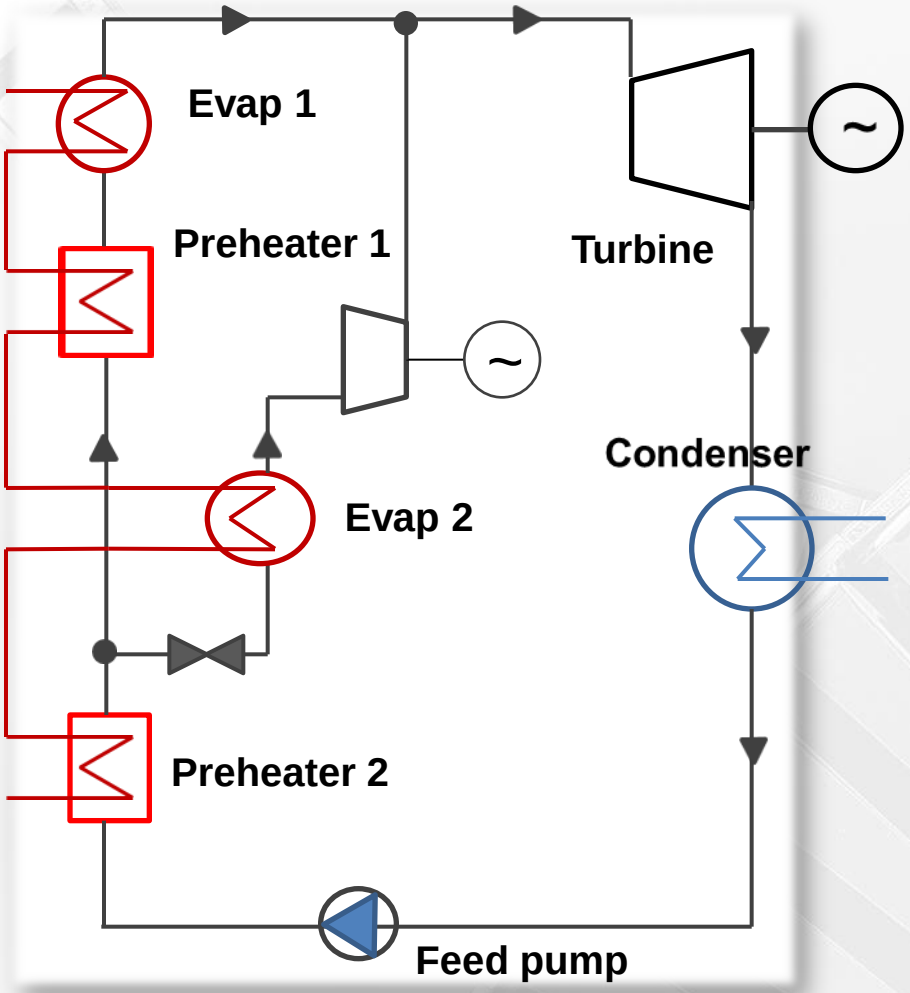
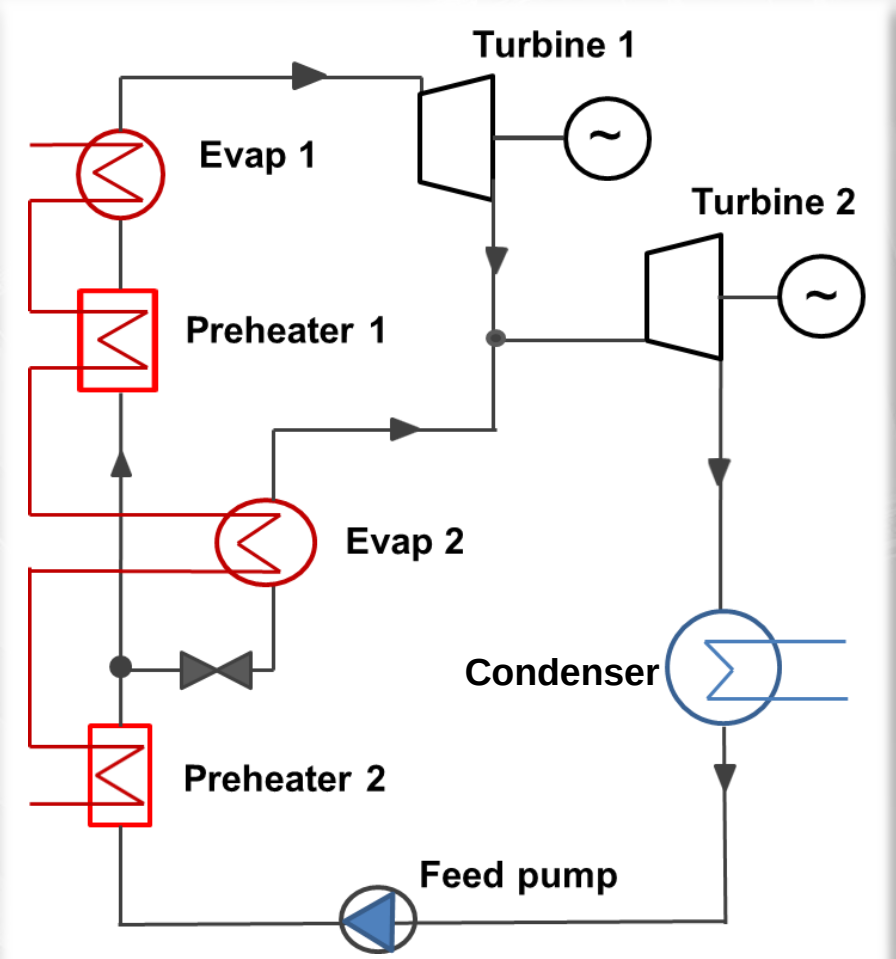
Pinch point smoothing

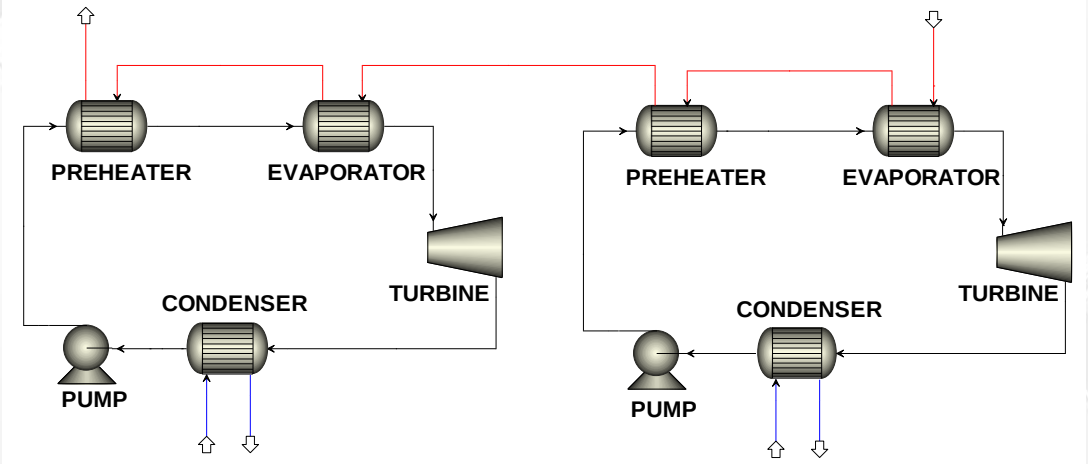


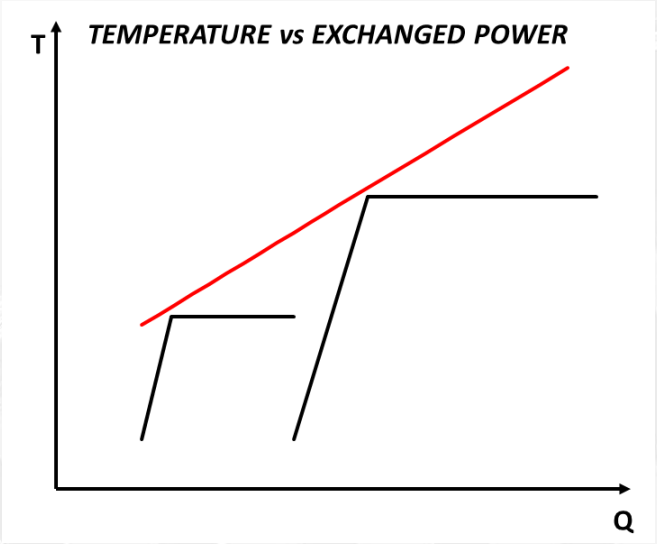
vs TWO LEVEL EVAPORATION ORC



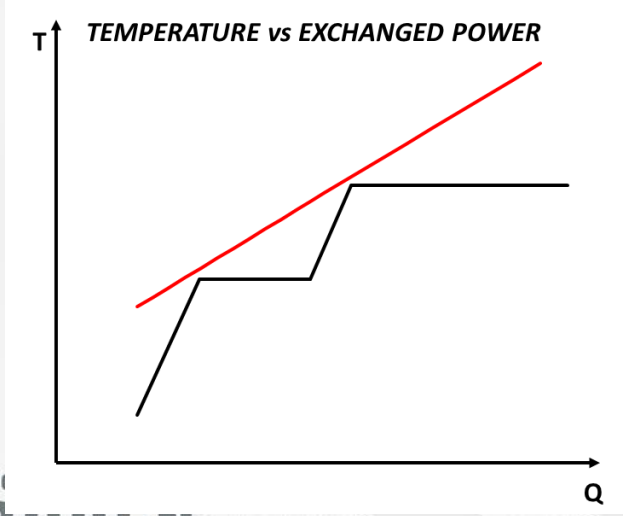
alternatives to simple cycle

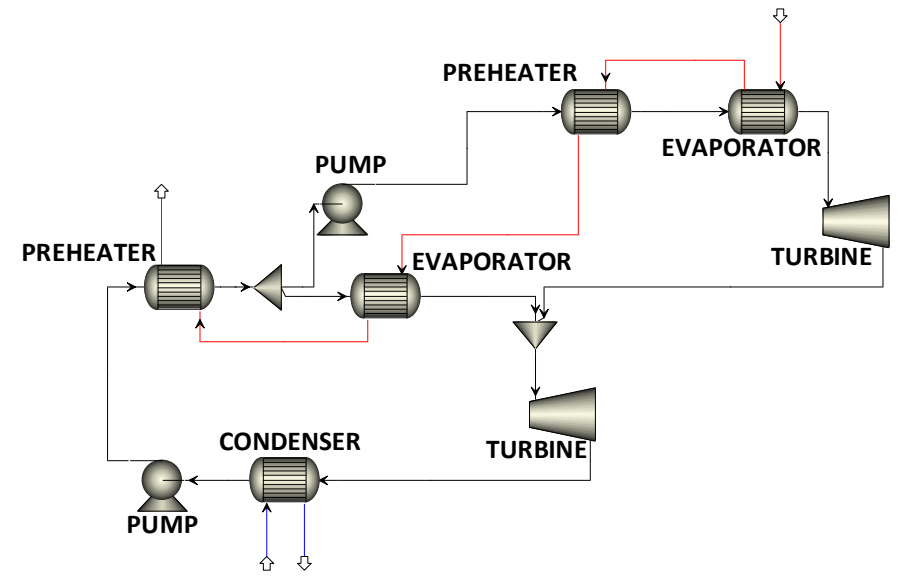
- TWIN CYCLES IN SERIES





- TWO LEVEL EVAPORATION CYCLE

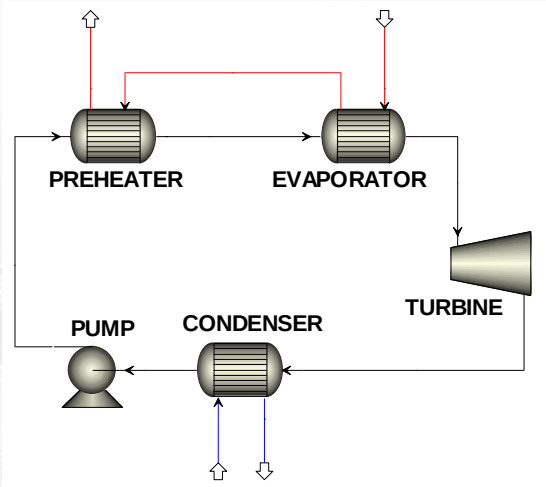


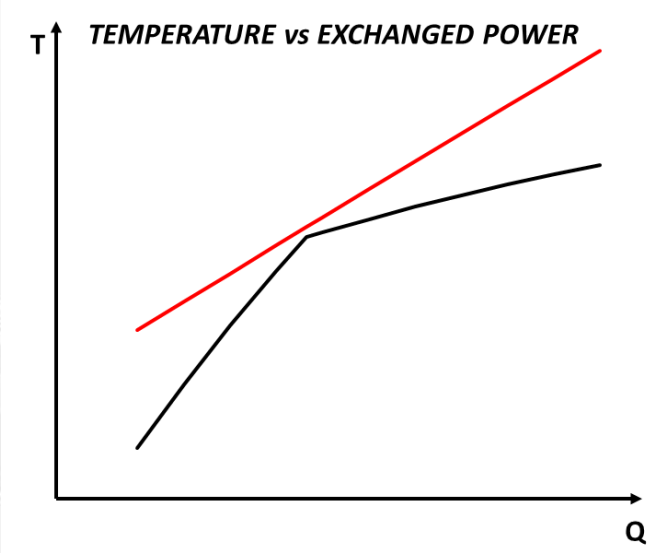


alternatives to simple cycle

ZEOTROPIC MIXTURE AS WORKING FLUID

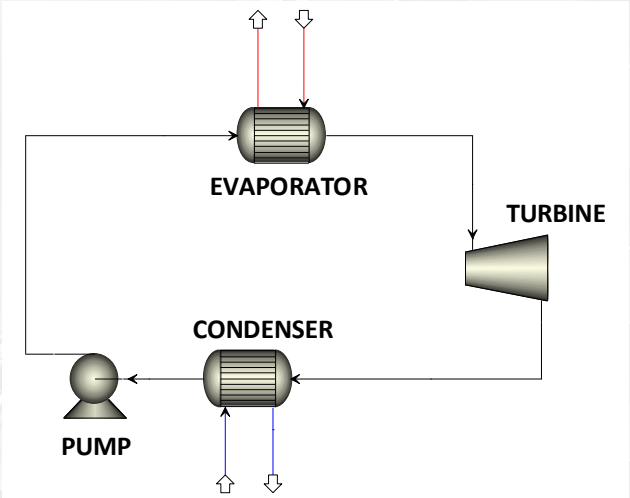
- lower heat exchange coefficient
- control of composition
- consequences of local deviation

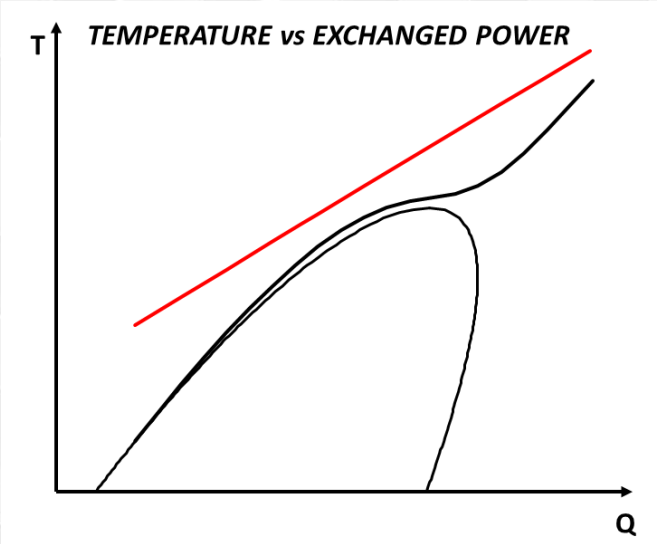




SUPERCRITICAL CYCLE

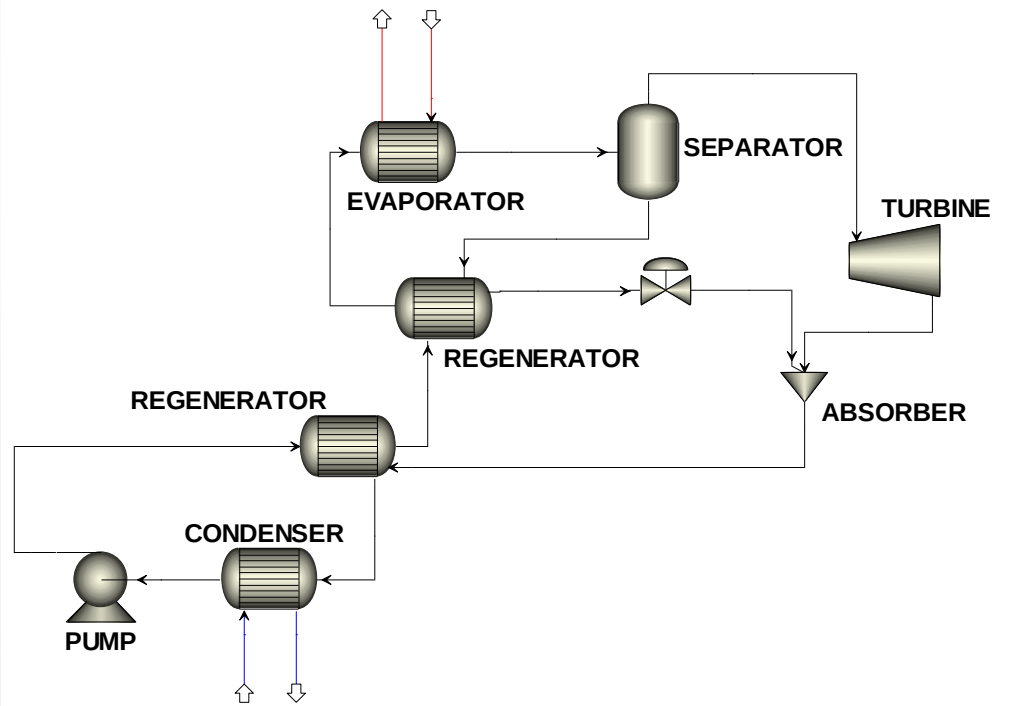
- high pressure
- high feed pump power

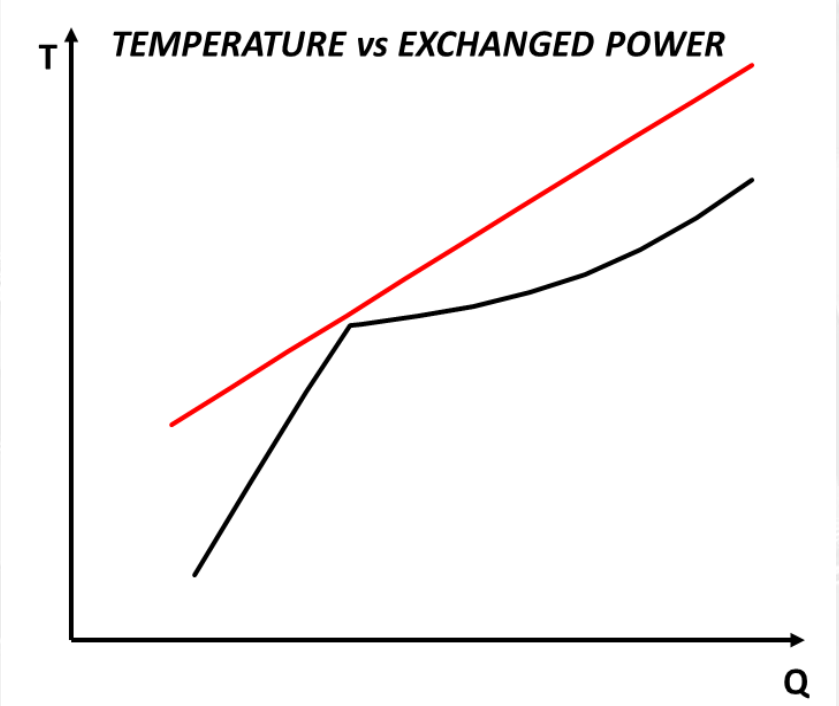




alternatives to simple cycle

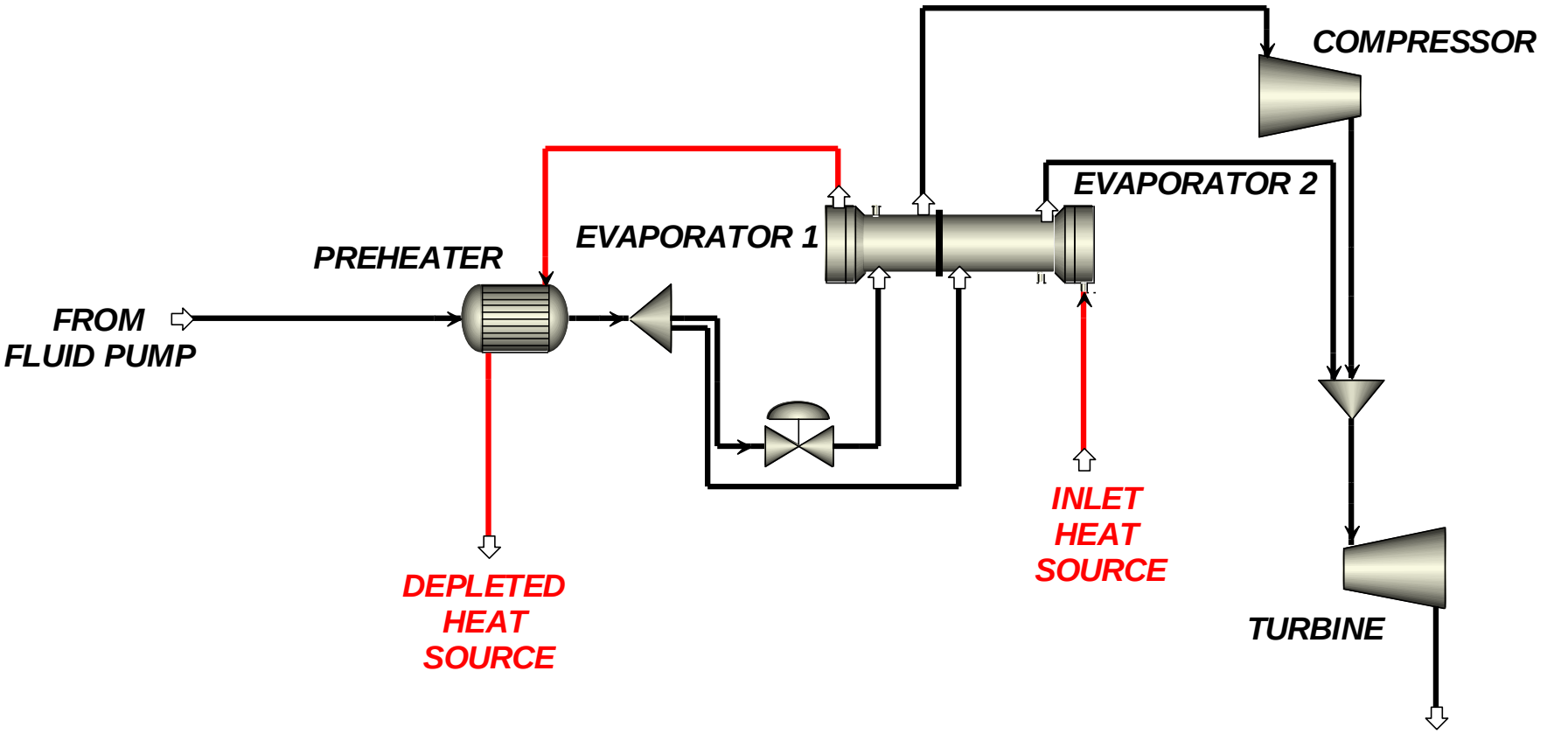
- VARIABLE CONCENTRATION WORKING FLUID eg Kalina Cycle



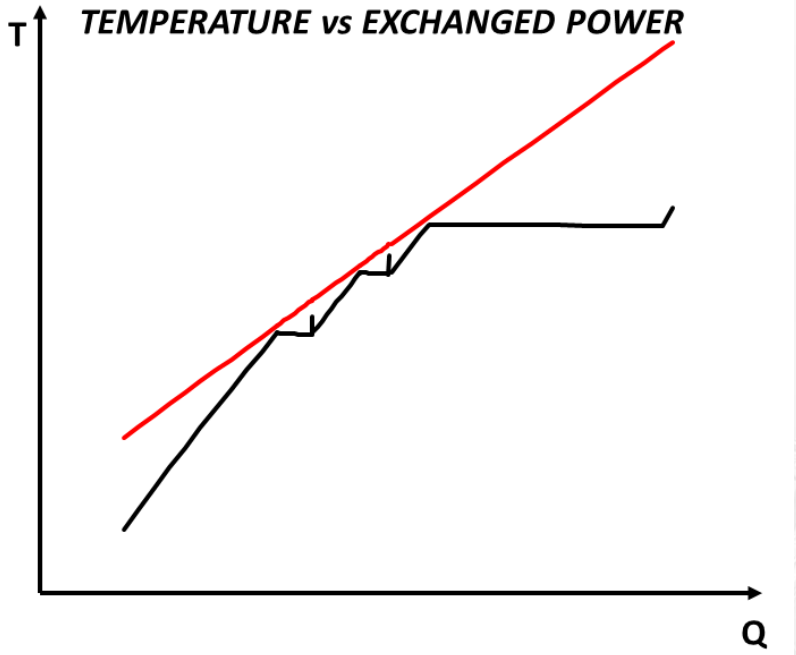


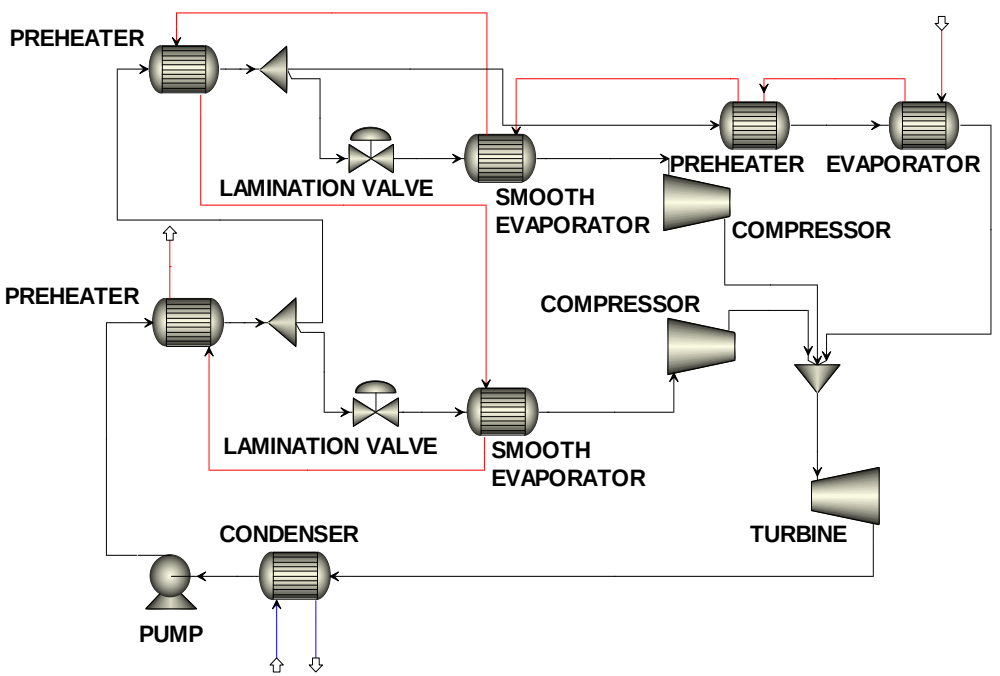
PINCH POINT SMOOTHING a possible heat exchanger solution

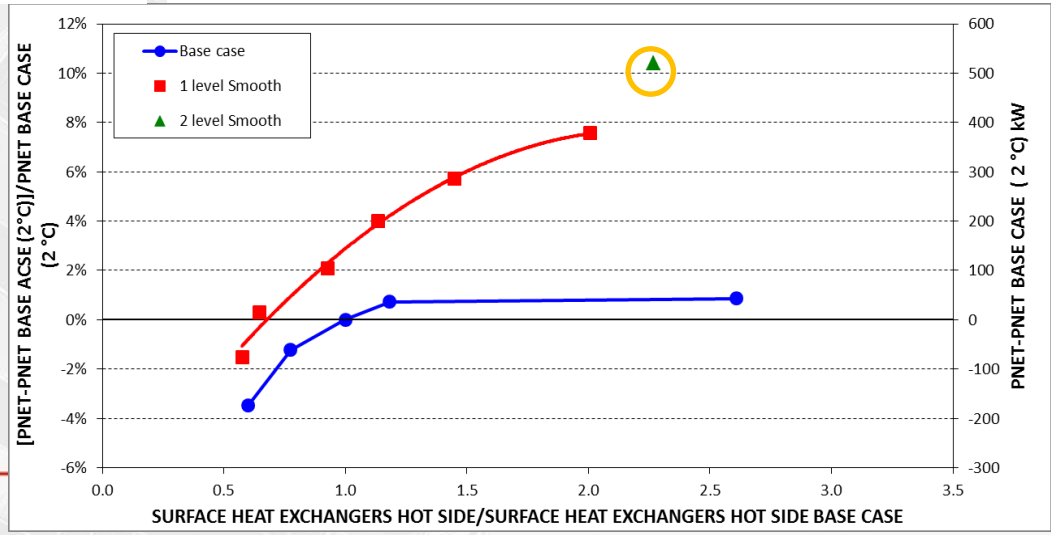
SINGLE SHELL&TUBE EVAPORATOR WITH AN INTERMEDIATE TIGHT BAFFLE



TWO LEVEL SMOOTHING







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Final remarks

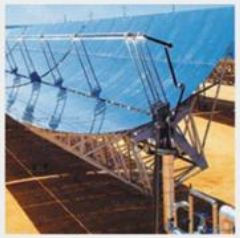
PINCH POINT SMOOTHING ALLOWS EITHER TO **INCREASE POWER OUTPUT FOR A GIVEN HEAT EXCHANGER SURFACE**
OR TO **REDUCE HEAT EXCHANGER SURFACE FOR A GIVEN POWER**

WHILE ADOPTING **SINGLE INLET TURBINE**, SUBSTANTIALLY UNMODIFIED COMPARED TO A BASE CYCLE TURBINE
(COST OF TURBINE IS LOWER THAN IN A TWO LEVEL EVAPORATION SYSTEM)

PINCH POINT SMOOTHING MOREOVER CAN BE CONSIDERED AS A **RETROFITTING ITEM** AND DOES **NOT REDUCE THE BASE RELIABILITY**
(A COMPRESSOR FAULT DOES NOT INVOLVE NECESSARILY A SHUTDOWN OF THE PLANT).

THANK YOU FOR YOUR ATTENTION



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