CHE526: PINCH TECHNOLOGY

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PINCH ANALYSIS

- Pinch analysis is a methodology for minimizing energy consumption of chemical processes by calculating minimum energy required and achieving them by optimizing heat recovery systems, energy supply methods and process operating conditions.
- It is also known as process integration, heat integration, energy integration or pinch technology.
- Pinch analysis is a rigorous, structured approach that may be used to tackle a wide range of improvements related to process and site utility.
- This includes opportunities such as reducing operating cost, improving efficiency, and reducing and planning capital investment.
- Major reasons for the success of pinch analysis are the simplicity of the concepts behind the approach.
- It analyzes a commodity, principally energy, hydrogen or water , in terms of its quality and quality, recognizing the fact that the cost of using that commodity will be a function of both.

OTHER AREAS OF PINCH ANALYSIS

- **Water pinch analysis (WPA)** originates from the concept of heat pinch analysis.
  - WPA is a systematic technique for reducing water consumption and wastewater generation through integration of water-using activities or processes.
  - WPA was first introduced by Wang and Smith.
  - Since then, it has been widely used as a tool for water conservation in industrial process plants.
  - Water Pinch Analysis has recently been applied for urban/domestic buildings.
- **Hydrogen pinch analysis** (HPA) is a hydrogen management method that originates from the concept of heat pinch analysis.
  - HPA is a systematic technique for reducing hydrogen consumption and hydrogen generation through integration of hydrogen-using activities or processes in the petrochemical industry, petroleum refineries hydrogen distribution networks and hydrogen purification.

Benefits of Pinch Technology

- Pinch tells the best that can be achieved in a given system.
- Pinch gives the practical target to aim for that is less than the theoretical maximum.
- Both of the above are done before any detailed design. This target then set the basis for the design. Most importantly, it gives clear rules about how to construct a design to achieve the targets. It will also show where the inefficiency lie in the existing design.
- Pinch takes a system-wide view of the problem. This allows one to see interaction that would be difficult to spot on a process flow diagram or a flow sheet of site utility system.
- Pinch can work with incomplete data. One can refine the data in the areas where accuracy is most important. This is in the area around the pinch.
- Pinch Technology is in contrast to other design tools, which require detailed information about geometry, flow sheet structure, etc. Pinch technology is one of the few tools that really can be used in conceptual design.

Pinch Analysis techniques may be applied to address the following industrial issues:

a. Energy saving, and greenhouse gas emission reduction
b. Optimization of batch processes
c. Optimization of hydrogen use
d. Reactor design and operation improvements
e. Minimization of water use and wastewater production
f. Waste minimization
g. Investment cost reduction

Used in the following industries:

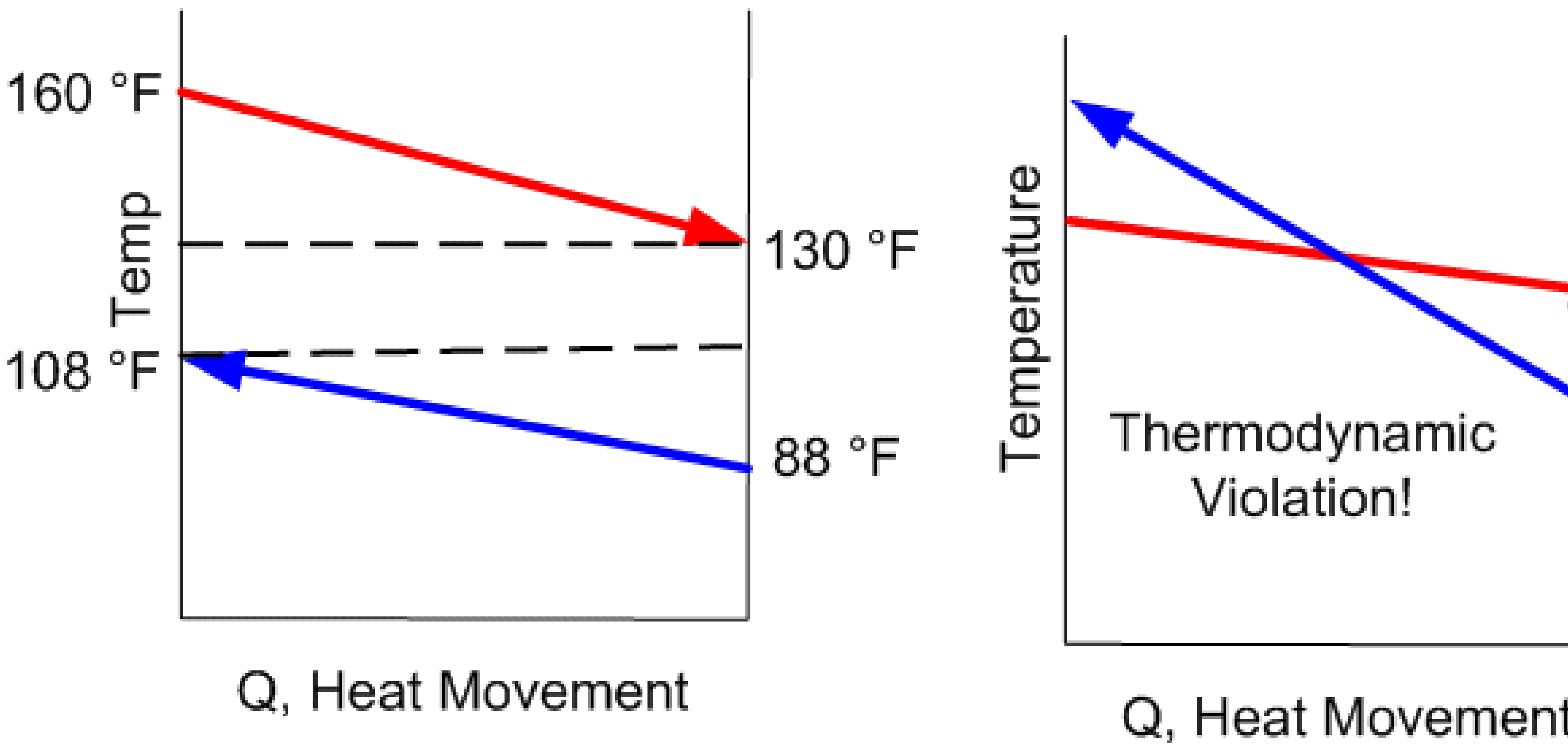
a. Chemicals
b. Petrochemicals
c. Oil refining
d. Pulp & Paper
e. Food & Drink
f. Steel & Metallurgy

Advantages of Pinch analysis over "conventional" design approaches:

- A systematic procedure. It guarantees an optimum solution without relying on luck or inspired guesses by the design engineer.
- A common denominator methodology. Based on fundamental thermodynamics, pinch analysis applies to all processes and technologies, continuous and batch, new and retrofit.
- Proven energy savings. Reductions of 15% or more in energy cost are typical, even where processes have already been optimized by "conventional" methods.
- Automatic pollution prevention. Reduced CO_2, SO_2 & NO_2 emissions are the natural consequence of better energy efficiency.
- Lower cost debottlenecking. Pinch analysis shows us how to make better use of existing equipment and systems, and thus minimizes new equipment requirements in capacity upgrades.

Basis of Pinch Analysis

- PT is a methodology for systematically analysing chemical processes and the surrounding utility systems with the 1st and 2nd Laws of Thermodynamics.
- The First Law of Thermodynamics provides the energy equation for calculating the enthalpy changes (ΔH) in the streams passing through a heat exchanger.
- The Second Law determines the direction of heat flow, i.e.
  - heat energy flow in the direction of hot to cold, and that
  - no **'temperature crossovers'** of the hot and cold stream profiles through the exchanger unit.
- In a heat exchanger unit:
  - a hot stream cannot be cooled below cold stream supply temperature (T_S)
  - a cold stream can be heated to a temperature more than the T_T of hot stream.
- In practice the hot stream can only be cooled to a temperature defined by the 'temperature approach' of the HE, which is the minimum allowable temperature difference (ΔT_{min}) in the stream temperature profiles, for the heat exchanger unit.


160 °F
Temp
130 °F
108 °F
88 °F
Q, Heat Movement
Temperature
Thermodynamic
Violation!
Q, Heat Movement

Objectives of Pinch Analysis

- The temperature level at which ΔT_{min} is observed in the process is referred to as "pinch point" or "pinch condition".
  - The pinch defines the minimum driving force allowed in the exchanger unit.
- Pinch Analysis is used to identify energy cost and heat exchanger network (HEN) capital cost targets for a process and recognizing the pinch point:
  - first, the minimum requirements of external energy, network area, and the number of units for a given process at the pinch point is predicted ahead of design.
  - Next a heat exchanger network design that satisfies these targets is synthesized.
  - Finally the network is optimized by comparing energy cost and the capital cost of the network so that the total annual cost is minimized.
- Thus, the prime objective of pinch analysis is to achieve financial savings by better process heat integration (**maximizing process-to-process heat recovery and reducing the external utility loads**).


Thank You!