**Pinch Analysis and Heat Exchanger Network Integration**

**1. Introduction**

Pinch analysis is a systematic methodology used for optimizing heat recovery in industrial processes. By analyzing temperature and enthalpy relationships, the pinch point is identified, allowing for the design of an efficient heat exchanger network (HEN). This report presents the composite temperature-enthalpy curve, determines the minimal heating and cooling loads, and proposes an optimized heat exchanger network (HEN) integration.

**2. Composite Temperature-Enthalpy Curve (ΔTmin = 10°C)**

**2.1 Data Collection**

The first step in pinch analysis involves gathering information about all process streams, including their supply and target temperatures, heat capacity flow rates, and heat loads.

**2.2 Constructing the Composite Curves**

1. **Cold Composite Curve:** Represents the cumulative heat demand of cold streams that require heating.
2. **Hot Composite Curve:** Represents the cumulative heat rejection of hot streams that need cooling.
3. **Graphical Representation:** By plotting these curves on a temperature-enthalpy diagram, the pinch temperature given by cold stream is 90°C.

**2.3 Identifying the Pinch Point**

* The pinch point is the temperature at which there is **no heat transfer across the pinch**. In this case, it is 90°C in cold stream.
* It divides the heat exchanger network into two sections: the **heat recovery region** and the **utility requirement region**.

**2.4 Minimum Heating and Cooling Loads**

* **Qh,min (Minimum Hot Utility Load):** The additional heat required from external sources. The hot utility required for cold stream is 0.1MW.
* **Qc,min (Minimum Cold Utility Load):** The excess heat that must be removed by cooling utilities. The cold utility required for hot stream is 0.05MW.

**3. Pinch Temperature Estimation via Temperature Cascade**

**3.1 Temperature Interval Method**

1. Divide the temperature range into **small intervals** based on stream supply and target temperatures using Ts\* and Tt\*.In hot stream, ΔTmin/2 = 5°C will be subtracted from hot stream inlet and outlet temperature and in cold stream, it will get added.
2. Determine the **heat surplus or deficit** for each interval.
3. Identify the **pinch temperature** by locating the interval where the heat balance equals zero.

**3.2 Verification Using the T-H Diagram**

The pinch temperature obtained from the temperature cascade should match the point of closest approach between the **hot and cold composite curves** on the T-H diagram along with hot utility and cold utility.

**4. Optimized Heat Exchanger Network (HEN) Design**

**4.1 Pinch Design Rules**

1. **No heat transfer across the pinch.**
2. **Maximum heat recovery before using external utilities.**
3. **Above the pinch:** No external cooling should be used.
4. **Below the pinch:** No external heating should be applied.

**4.2 Network Synthesis**

* Develop an efficient network where **heat is exchanged between process streams** instead of using external utilities.
* Design **minimum number of heat exchangers** to achieve energy savings.
* Avoid temperature mismatches that increase utility consumption.

**5. Process Flowsheet Integration**

**5.1 Heat Exchanger Placement**

* Incorporate **heat exchangers at optimal locations** within the process.
* Ensure efficient **heat transfer between streams** that satisfy the pinch design constraints.

**5.2 Optimized Flow Diagram**

* Develop a **process flow diagram (PFD)** illustrating the integration of heat exchangers.
* Clearly indicate **hot and cold utility requirements**.
* Label all heat exchangers (e.g., HX1, HX2) and their respective **heat duties**.The heat exchanger is denoted by no. with blue digital marker.

**6. Conclusion**

This report highlights the methodology for pinch analysis and heat exchanger network optimization. By identifying the pinch temperature and designing an efficient HEN, significant energy savings can be achieved through reduced heating and cooling utility consumption. The integration of an optimized heat exchanger network into the process flow ensures **maximum heat recovery and process efficiency**.