1 Energetic and economic models

As a consequence of the first law of thermodynamics all energy that is put into a process will also, in a steady state situation, leave the process. The energy leaves the process in the shape of product, waste heat and other losses.

The temperature level of the waste heat is determined by process fundamentals and process equipment design, and is thus, for an existing plant, set. However the temperature level which the waste heat appears and can be used is determined by the design of the utility systems, i.e. cooling water and air. This essential difference is often overlooked when discussing waste heat utilization.

The amount and temperature level of the waste heat can be determined by process integration methods, e.g. pinch analyses. These methods are powerful tools and give a total picture of the situation at the plant including the possibilities for internal use of the heat.

There are several competing alternatives to utilize waste heat and it is normally not obvious which is the most favorable. The heat can internally be better used for heating purposes and in new or modified process parts. Heat pumping is also an alternative which today is common practice in some branches but has a large potential to grow in others. Another option is to use the heat for heating demands outside the plant in a district heating system.

To be able to increase the awareness of possibilities and to select between the alternatives, a high level of expertise for system design, process integration and planning is crucial. Design software on process integration and design plays an important role at this stage. However, this seemingly being a complex approach needing a lot of high level expertise, simple straight forward solutions on a small scale should not be overseen.

1.1 Pinch analysis

Pinch analysis is a methodology for minimising energy consumption of chemical processes by calculating thermodynamically feasible energy targets (or minimum energy consumption) and achieving them by optimising heat recovery systems, energy supply methods and process operating conditions. It is also known as process integration, heat integration, energy integration or pinch technology [Monard, 2006].

The process data is represented as a set of energy flows, or streams, as a function of heat load (kW) against temperature (deg C). These data are combined for all the streams in the plant to give *composite curves*, one for all *hot streams* (releasing heat) and one for all *cold streams* (requiring heat). The point of closest approach between the hot and cold composite curves is the pinch temperature (pinch point or just pinch), and is where design is most constrained. Hence, by finding this point and starting design there, the energy targets can be achieved using heat pumps to recover heat between hot and cold streams. In practice, during the pinch analysis, often cross-pinch exchanges of heat are found between a stream with its temperature above the pinch and one below the pinch. Removal of those exchanges by alternative matching makes the process reach its energy target.

1.2 EINSTEIN expert system

EINSTEIN is an **E**xpert system for an **In**telligent **S**upply of **T**hermal **E**nergy in **IN**dustry [Heigl, 2014].

For optimising thermal energy supply in industry, a holistic integral approach is required that includes possibilities of demand reduction by heat recovery and process integration, and by an intelligent combination of efficient heat and cold supply technologies.

EINSTEIN is a tool-kit for fast and high quality thermal energy audits in industry, composed by an audit guide describing the methodology and by a software tool that guides the auditor through all the audit steps.

The main features of EINSTEIN are:

1. the data processing is based on standardized models for industrial processes and industrial heat supply systems;
2. Special tools allow for fast consistency checking and estimation of missing data, so that already with very few data some first predictions can be made;
3. Semi-automation: the software tool gives support to decision making for the generation of alternative heat and & cold supply proposals, carries out automatically all the necessary calculations, including dynamic simulation of the heat supply system, and creates a standard audit report
4. A basic questionnaire helps for systematic collection of the necessary information with the possibility to acquire data by distance.

The software tool includes modules for benchmarking, automatic design of heat exchanger networks, and design assistants for the heat and cold supply system.

It is a methodology that works out energy efficient solution for your production process based on renewable energy sources, e.g. heat pumps. This will lead to a significant reduction of your operating cost. The benefits of Einstein are:

- Increase in know-how for local auditors
- Reduction of energy costs and CO_2 emissions
- Improved competitiveness and saving for your company by a reduction of operating costs
- Road map for realisation of energy concepts with an economic consideration.

The present status of EINSTEIN does not include heat pumps for heat recovery and process integration. However, a new project – EINSTEIN III is presently in the stage of approval as part of the European Commission research programme EE-16-2014 "Organisational innovation to increase energy efficiency in industry", which include industrial heat pumps.

Source: IEA HPT Annex 35