# Multi Objective Pinch Analysis (MOPA) for Integrated Process Design

J. Geldermann, H. Schollenberger, M. Treitz, O. Rentz

French-German Institute for Environmental Research (DFIU / IFARE)
University of Karlsruhe (TH), Hertzstr. 16, D-76187 Karlsruhe
Tel: +49-721-608-4583; Fax: +49-721-758909,
{jutta.geldermann; hannes.schollenberger; martin.treitz; otto.rentz}@wiwi.uni-karlsruhe.de

**Abstract**

The combination of process integration and Operations Research enables an integrated technique assessment and a subsequent process design. The application of Multi Objective Pinch Analysis (MOPA) permits the identification of overall saving potentials for energy, water and Volatile Organic Compounds (VOC). In this paper the general concept of MOPA is described and its application is shown in its first steps for a bicycle coating plant in Chile.

## Introduction

Most of the common VOC-reducing measures (e.g. for paint and adhesive applications) are installed as secondary measures (e.g. thermal incineration), process-integrated measures (e.g. reduced-overspray methods, powder coating) or as product-integrated measures (e.g. high-solid coatings). Further optimisation potentials can be identified by integrating additional unit operations (e.g. heat exchangers, condensers, etc.) into the plant layout and linking mass and energy flows between different production plants. Besides VOC emissions, energy and water consumption are also of significant interest. Therefore, a three dimensional problem must be solved in order to identify the overall set of feasible solutions.

In this paper, the coating of bicycle frames is investigated in order to demonstrate the underlying methodology. In the next section, the pinch analysis and its role in integrated process design as Multi Objective Pinch Analysis (MOPA) is described. In the third section, the example of bicycle frame coating is calculated, while in the last section conclusions are drawn.

## Multi Objective Pinch Analysis for Integrated Process Design

The pinch analysis is an approach for integrated process design. First applications were exclusively addressed to energy optimisation [7; 9] and as a consequence thereof, to the design of heat exchanger networks (HEN). In the last two decades applications targeting wastewater minimisation and VOC recovery from waste gas streams have been developed [1; 3; 12; 13]. Additionally, the algorithms for solving the design problems have been developed further, and in some cases have been adapted from the field of Operations Research (e.g. the transport algorithm [2; 5]).

Past investigations mainly focused on one target, whereas the approach presented in this paper aims at a Multi Objective Pinch Analysis (MOPA) which is characterised by simultaneous consideration of energy, VOC and water. The results of the different pinch analyses are combined using Multi Criteria Analysis approaches.

### Energy

The basic idea of energy pinch analysis is a systematic approach to the minimisation of lost energy in order to come as close as possible to a reversible system. In its first step the pinch analysis yields the best possible heat recovery. Further recovery can only be achieved by changing conditions or structures of the investigated system (e.g. flow rates, pressures etc.) [11].

The pinch analysis requires the combination of hot and cold process streams to composite curves and the description of the respective temperature - enthalpy relationships. Additionally, a minimum temperature gradient $\Delta T_{min}$ must be set representing the driving force of the heat transfer. The pinch point, where the distance between the hot and cold composite curves is equal to $\Delta T_{min}$, denotes the optimal internal heat transfer between the hot and cold flows [9].

The pinch point is always a corner or end point of at least one of the composite curves. Its temperature is less than $\Delta T_{min}$ above or below any of the temperatures spanned by the other composite curve. At the pinch point, either the slope of the cold composite curve becomes flatter or remains equal, or the slope of the hot composite curve becomes steeper or remains equal above the pinch point, or both [2].

The result of the pinch analysis is the energy saving potential for the considered set of processes representing the target for the subsequent design process. Furthermore, information is obtained on the amount of heat exchange required between the appropriate streams minimising the use of hot and cold utilities. Depending on the chosen design constraints, which reflect technical and chemical requirements, the actual savings are determined resulting in an economically feasible solution. Consequently, the layout planning is driven by a trade-off between