

Forty Years of Heat Integration: Pinch Analysis (PA) and Mathematical Programming (MP)

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Summary

Reducing and economising of resource consumption can be achieved by increasing the internal recycling and re-usage of energy and material streams. Projects for improving process resource efficiencies have proven to be beneficial and also potentially improve the public's perceptions of companies. Motivating, launching, and carrying out such projects, however, involves proper optimisation, based on adequate process models. Several methodologies began to emerge during the 1970s as a response to those industrial and societal challenges connected with the oil crises and a need to use these resources more economically. One of them was 'Process System Engineering (PSE)' and later extended again by Sargent. Contributing methodology that received world prominence was 'Process Integration (PI)' — at that time more precisely 'Heat Integration (HI)' based on PA (Pinch Analysis). HI was formulated within the book presented by Linnhoff et al. that has been reprinted several times — last updated edition, Linnhoff et al. Its development was further contributed to by a number of works from UMIST, Manchester, UK and other research groups in the US, Europe, and more recently by a strong contribution from Asia.

Main Findings

HI has been a leap forward in the development of resource conservation and emission reduction. Its crucial advantage has been the conceptual clarity and insight delivered to the practising engineers, which helped its widespread, fast, and robust adoption. Combining the conceptual insight with the power of MP has made HI even more robust and powerful in solving large-scale problems. The methodology is thriving even forty years after its conception.

Different directions in MP have been undertaken in order to overcome a number of drawbacks related to the use of MP, for example global optimisation in order to provide global solutions, the development of graphical interfaces to help users to comprehend their resulting numerical solutions, or the development of open source and generic data-independent models for providing users mathematical formulations for different current and future applications. Finally, different techniques and tools have been developed for solving complex industrial applications by using the advantages of the combined concept. As the PA and MP concepts exhibit different advantages and drawbacks, the important question is which of the drawbacks of the PA can be overcome by MP, and vice versa. However beside MP has been also other tools, which can be applied in HI as P-Graphs developed by Friedler et al.