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Estimating utility saving by using the technique of energy situation image

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HIGHLIGHTS

- A simple energy situation image technique was presented the heat integration between processes.
- This method can be easily and quickly selected the real integration between processes.
- This method can be saved utilities.
- This method is provided the optimal allocation between processes.

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ABSTRACT

The main future goal is energy-saving and emission–reduction and, thereby, the most effective way of ensuring a reduction in carbon emissions. Energy waste should be reduced from the very beginning of process production.

This paper presents an estimation of utility savings by using 'an energy situation image technique'. This technique is an extension of a simple graphical utilities targeting method for heat integration between processes (Kovac Kralj, 2012) [1] that evaluates the maximum possible heat integration between processes. The energy situation image technique chooses the best transfer allocation between hot and cold streams regarding waste heat. Therefore, the original process cannot be changed but the utilities themselves could attract savings. The grand composite curves of different processes represent optimal heat transfers between processes, and optimal transfer allocations. This method is based on pinch analysis and is very general, it can be used within new designs and within existing processes' integrations for utility savings.

1. Introduction

Pinch analysis, along with other principles of process integration, has established itself as one of the more important tools for analyzing and optimizing the energy systems of process plants. Techniques of pinch analysis have been applied for analyzing heat exchanger networks [2–6], utility system optimization [7], mass exchanger networks [8], water networks [9,10], waste reduction in process plants [11], fired heater integrated networks [12], and different energy systems [13–17], etc.

Total site integration of the overall plant offers energy conservation opportunities across different individual processes. The concept of 'total-site' was introduced by Dhole and Linnhoff [18] to describe a set of processes serviced by and linked through a central utility system. Total-site integration of independent processes or plants can provide more energy saving opportunities.

Morton and Linnhoff [19] considered the overlap of grand composite curves for identifying the maximum possible heat recovery between processes. This graphical method was limited to two processes, but later this concept was extended for direct and indirect integrations by Ahmad and Hui [20]. Using the site source and site sink profiles, the targets for steam generation and utilization between processes were set by Dhole and Linnhoff [18]. Since a pocket in the grand composite curve indicates the intra-process heat recovery potential, Dhole and Linnhoff [18] proposed removing these pockets of the individual grand composite curves first. The above and below pinch portions of the modified grand composite curves are shifted appropriately in order to construct site source and the site sink profiles.

Typically, the maximum indirect heat integration is realized through transferring heat between the pinch locations of two

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Nomenclature

Abbreviations

GCC	grand composite curve

Variables

f_{MPI}	fraction of the maximum possible integration, 1
T	temperature, K
T_s	supply temperature, K
T_t	target temperature, K
Q	heat flow rate, W
Q_{HU}	hot utility flow rate, W
Q_{MPI}	maximum possible integrated heat flow rate, kW

processes. However, in certain cases as reported by Rodera and Bagajewicz [21], to achieve the maximum possible indirect integration between processes, heat should also be transferred outside the regions between pinches. Heat transfer outside the pinch regions is called assisted heat transfer. Heat transfer between pinches is assisted by the heat transfer outside the pinch region for improved indirect integration [21]. Mathematical optimization techniques have been used for optimizing indirect integration between several processes [22–24]. This papers proposes a new methodology for the total site integration of processes by generating a site level grand composite curve (SGCC). The proposed SGCC targets the maximum possible energy saving potential through indirect integration, incorporating assisted heat transfer. The SGCC is also used for targeting the cogeneration potential of the overall site.

Dhole and Linnhoff [18] introduced a simple exergetic model for estimating cogenerational potential for the total site based on the site source and the site sink profiles. Based on the total site source and sink profiles, proposed by Dhole and Linnhoff [18], Raissi [25] proposed site utility composite curves for given steam levels. Raissi [25] proposed a temperature–enthalpy (T–H) model based on Salisbury [26] approximation and on the observation that the specific power produced by the turbine is approximately proportional to the differences in saturation temperatures. Klemes et al. [27] proposed a site utility grand composite curve to provide designers with a tool for determining potential for cogeneration.

Bandyopadhyay et al. [28] presented a new concept for total site integration by generating a site level grand composite curve (SGCC). The proposed SGCC targeted the maximum possible indirect integration as it incorporated assisted heat transfer. A methodology was proposed for estimating the cogenerational potential at the total site level, utilizing the concept of multiple utility targeting on the SGCC. The proposed methodology for estimating the cogenerational potential was simple and linear, as well as utilizing rigorous energy balance at each steam header.

This paper presents a simple energy situation image technique which estimates transfer allocations between processes.

2. A simple energy situation image technique

The usage of waste energy could be improved by energy efficiency. Processes operating within one location can be mutually integrated. If more heat flow can be recovered, their energy consumption could be lowered. Heat transfer between the processes could reduce energy usage, CO_2 and SO_2 emissions, as well as pollution.

An analysis of possible integration and allocation would only include those streams that are heated or cooled by using utilities, therefore, this would not change the basic operations. All the characterized hot and cold streams would be inserted within the GCC (grand composite curve). The method first evaluates the maximal possible heat integration and then its allocation between processes.

2.1. Estimation of the maximal possible heat integration

Estimation of the maximal possible heat integration between processes could be determined quickly by using GCC. The maximum possible integration between the processes would be estimated by using the fraction of maximum possible heat integration between the processes from a grand composite curve (GCC) at defined $\Delta_{min}T$ (Fig. 1 [29]):

$$f_{MPI} = (\min \Sigma Q - Q_{HU})/\min \Sigma Q \quad (1)$$

f_{MPI} being the fraction of the maximum possible heat integration between processes, $\min \Sigma Q$ the minimum sum of the heat flow rates for hot (ΣQ_H) or cold (ΣQ_C) streams, whichever is smaller,

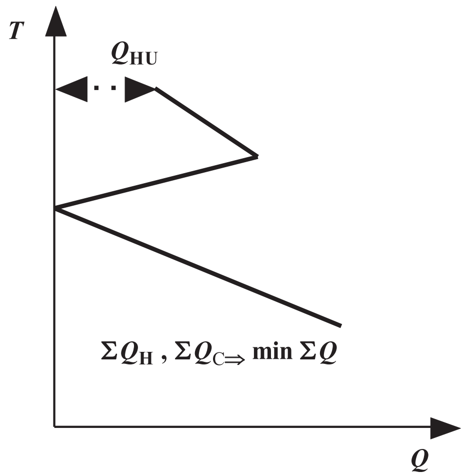

Fig. 1. Flow diagram for maximal possible heat integration between processes.

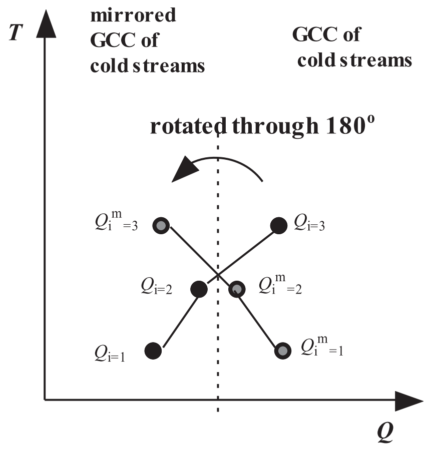

Fig. 2. Mirrored GCC.