Applied Thermal Engineering 43 (2012) 60–66

Contents lists available at SciVerse ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng

Cogeneration targeting for site utility systems

Ali Ghannadzadeh [1], Simon Perry, Robin Smith*

Centre for Process Integration, School of Chemical Engineering and Analytical Science, The University of Manchester, P.O. Box 88, Manchester M60 1QD, UK

A R T I C L E I N F O

Article history:
Received 26 July 2011
Accepted 3 October 2011
Available online 13 October 2011

Keywords:
Process integration
Total sites
Cogeneration
Steam turbine
Targeting

A B S T R A C T

Estimation of cogeneration potential prior to the design of the total site utility system is vital to set targets on site fuel demand and steam flowrate as well as heat and power production. This paper presents in detail the Iterative Bottom-to-Top Model (IBTM) as a new shaftwork targeting model which facilitates the targeting stage. The IBTM calculates the temperature of steam mains, steam flowrate and shaft power generated by the steam turbines in expansion zones of the site utility grand composite curve from bottom to top using a simple steam turbine expansion model with a constant isentropic efficiency. Unlike the existing models, IBTM provides the degree of superheat at process steam generators and steam boiler house. Through a case study of a refinery plant, the applicability of the IBTM in total site analysis is presented. It has been shown that the features of IBTM make it preferable for its implementation in flexible targeting tools to set realistic targets on the site fuel demand and the cogeneration at the early stages of design.

1. Introduction

Most processes in existing industrial plants operate within Total Sites [1,2] where they are integrated through a central site utility system. Recently, the Total Site methodology has been extended to integrate renewable energy sources and domestic, business, and social premises [3] where consideration of the variations in the energy supplies and demands is necessary [4]. Prior to the design of site utility system, estimation of cogeneration potential [5] is vital to set targets on boiler fuel demand and steam flowrate as well as heat and power production.

To estimate cogeneration potential of the site utility system, its overall picture has to be represented in form of the site utility grand composite curve (SUGCC) [2] starting with construction of the total site profiles (TSP) [1,5]. The TSP for a new design is constructed from the grand composite curves (GCC) of the individual process units. For a retrofit design the TSP is constructed from the individual process duties within each of the utility heat exchangers on the site (Fig. 1a). The targets are set for site cooling starting with the highest-temperature cooling utility. On the other hand, to set the targets for site heating, the lowest-temperature heating utility is first maximized (Fig. 1a). Site hot and cold composite curves with the steam profiles, all matched together in order to maximize the heat recovery across the site. Fig. 1b shows the site composite curve (SCC) [2] for this case as the site is pinched. The residual heating requirement is satisfied by very high pressure (VHP) steam generated in the boilers, while the residual heat must be rejected to the cooling water (CW) (Fig. 1b). Removing site composite curves and keeping only the steam profiles (Fig. 1c), all the temperature intervals of the steam profiles are shifted to the left side starting from VHP to CW which results in site grand composite curve (SGCC) (Fig. 1d) [6]. Finally, the SUGCC is constructed as heat recovery across the site is removed and only the part of steam profile interacting with site utility system is kept (Fig. 1e).

As Fig. 1e relates to the setting in a site that is pinched, thus this is only one possible setting with the maximum heat recovery, minimum heat rejection to the CW, and minimum heat demand from the boilers. However, it is not necessarily the optimum setting if the cogeneration potential (Fig. 1f) [5,7] is also taken into account. Consider the SUGCC shown in Fig. 1g that has been set such that the heat recovery is not maximized. This means an extra amount of fuel is fired in the boilers and an extra amount of heat is rejected to the CW. However, the larger area between the steam profiles means a more cogeneration potential. Generally speaking, the more heat that is recovered, the less power will be generated and the less fuel will be demanded. However, the amount of overlap between the steam profiles is a degree of freedom available to the designer [6].

* Corresponding author. Tel.: +44 161 200 4382; fax: +44 161 236 7439.
E-mail address: robin.smith@manchester.ac.uk (R. Smith).

[1] Present address: Department of Process System Engineering, Chemical Engineering Laboratory, University of Toulouse, 4, Allée Emile Monso, F-31030 Toulouse, France.

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doi:10.1016/j.applthermaleng.2011.10.006