Centralised Utility System Planning for a Total Site Heat Integration Network

Peng Yen Liew (a), Sharifah Rafidah Wan Alwi (a),(∗), Petar Sabev Varbanov (b), Zainuddin Abdul Manan (a), Jirí Jaromír Klemes (b)

a Process Systems Engineering Centre (PROSPECT), Faculty of Chemical Engineering, Universiti Teknologi Malaysia, 81310 UTM Johor Bahru, Johor, Malaysia
b Centre for Process Integration and Intensification – CPI2, Research Institute of Chemical and Process Engineering – MUKKI, Faculty of IT, University of Pannonia, Egyetem u. 10, H-8200 Veszprém, Hungary

Summary

Total Site Heat Integration (TSHI) is a technique of exchanging heat among multiple processes via a centralised utility system. An analysis of the integrated multiple processes, also known as the Total Site (TS) system sensitivity, is needed to characterise the effects of a plant maintenance shutdown, to determine the operational changes needed for the utility production and to plan mitigation actions. This paper presents an improved Total Site Sensitivity Table (TSST) to be used as a systematic tool for this purpose. The TSST can be used to consider various 'what if' scenarios. This tool can be used to determine the optimum size of a utility generation system, to design the backup generators and piping needed in the system and to assess the external utilities that might need to be bought and stored. The methodology is demonstrated by using an Illustrated Case Study consisting of three processes. During the TS normal operation, the Total Site Problem Table Algorithm (TS-PTA) shows that the system requires 1065 kW of High Pressure Steam and 645.5 kW of Medium Pressure Steam as the heating utility, while for the cooling utility, 553.5 kW of Low Pressure Steam and 3085 kW of cooling water are required. The results of the modified TSST proposed that a boiler and a cooling tower with the system design requiring a maximum capacity of 2.172 MW of steam and 4.1865 MW of cooling water are needed to ensure an operational flexibility between the three integrated processes.

Main Findings

As a result of the work carried out, the Total Site Sensitivity Table (TSST) has been extended for planning the TSHI centralised utility system. This approach provides insights on the consequences of a plant shutdown or process upsets on the entire TS system integration and the centralised utility system. By identifying heating or cooling utility requirements during a plant shut down, a suitable size utility system can be planned to ensure a flexible and undisrupted operation for the integrated processes. These decisions must be balanced with the operational challenges as well as the capital and operating costs.

The proposed tool is able to determine the optimal design and operation of the centralised utility system by assuming 100% efficiency for the utility system. This is actually not representing the actual situation. For the future work, the effect of load changes on the TS utility system efficiencies can be further investigated. For example, the turbine and boiler efficiencies are affected by their loads (Möller et al., 2007 and Zhou et al., 2013). Hence, the off-design operation may require special considerations during the utility system sizing.