A Numerical Analysis for Total Site Sensitivity

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Summary

Total Site Heat Integration (TSHI) is an established method for analysis and mapping of heat sources and sinks of multiple processes linked via a centralised utility system. The TSHI method is very beneficial for analysing a total site's sensitivity to plant maintenance shutdown and production changes that affect integrated heat sources and sinks. This paper presents the Total Site Sensitivity Table (TSST) as a systematic approach for exploring the effects of plant shutdown or production changes. TSST can be used hand in hand with TSHI graphical approaches (Grand Composite Curve, Total Site Profile and Site Composite Curve) or numerical approach (Total Site Problem Table Algorithm). The graphical approach provides better insights while the numerical approach provides faster, easier and accurate calculations. Both approaches have its advantages and disadvantages and it is up to the engineers which approach they prefer or complement. The use of TSST allows a design engineer to clearly see the sensitivity of Total Site (TS) towards operational changes. The best setting for different operation condition in total site context can be selected by exploiting this tool. The worst case scenario can also be explored for the integrated TS system through the use of TSST. This information is useful for exploring the individual plant operational flexibility. Decision for having a backup heat exchanger network according to TSST would increase the energy saving for various TS operating conditions. TSST can be used to consider various 'what if' scenarios. They allow the determination of the optimum size of utility generation system and backup piping needed to be designed, external utilities that need to be bought and stored. Application of this technique on a case study demonstrates with the assistance of TS-PTA, TSST clearly pinpoint the effects of plant shutdown or production changes on heat distribution and utility generation systems of a Total Site.

Main Findings

In the following, we present a summary of the contributions of this work:

1) A new method was developed for calculating multiple utility levels in the PTA that is simpler than that presented by Costa and Queiroz. This work introduced the use of multiple utility cascades to determine multiple utility levels for individual PTAs and TS-PTAs. This tool enables the multiple utility targeting for individual processes to be done effectively using the numerical approach which produces more accurate results.

2) The TS-PTA was introduced for TSHI. We further demonstrated that the TS-PTA yields more accurate results for TSHI analysis when compared with a graphical approach, which is prone to inaccuracies. The tool saves time and effort in determining amounts of heat interchange among plants compared with graphically constructed CCs, GCCs, TSPs and SCCs. This tool could be explored further for the variable supply and demand Total Site problem as proposed by Varbanov and Klemes.

Also, TS-PTA could be used for continuous and batch processesthat may not be conveniently solved using graphical tools.

3) The Total Site Utility Distribution (TSUD) table can be beneficial for the design of a Total Site utility distribution network. This tool can be used to visualise and design the heat transfer network in the system, between utility streams and process streams.

4) The Total Site Sensitivity Table (TSST) is introduced to analyse Total Site sensitivity. A typical example is, TSST can be use for analysing the variation in a plant’s utility requirements when one of the integrated site plants is shutdown for reasons such as scheduled maintenance (e.g., for repairing faulty parts or clearing unwanted material in the reactor), periodic shutdowns (e.g., summer district heating shutdowns in the northern hemisphere), operability problems or unpredicted accidents. TSST results can also be used for utility design and production planning.

The present research can be extended for the optimisation of cogeneration potential. A prior study on assisted heat transfer can also be integrated into the TS-PTA. These developments should be especially useful in increasing the applicability of the TS-PTA. Heat storage in Total Site system also could be explored through the mathematical tool proposed.