The process industry continuously searches for options to move towards a more energy and resource-efficient production.

Chemical production plants are complex systems, and the most resource-efficient operation is not easy to identify under varying conditions.

INEOS in Köln has been looking for a solution in between full automation operation at standard constant reference values to improve the resource efficiency of their production plants.

A data-based surrogate modelling framework was developed to derive baseline models that provide reference values for the most resource-efficient operation.

The models are stored in a model management platform and the results are visualised on dashboards of the plant operators.

Statistical methods are used to guide operators to the root causes of deviations from the most efficient operation.

The used toolchain is generic and easily transferable to other reference models.

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Operator support for improving energy and material efficiency

The problem

Efficient production under changing circumstances – The search for a solution

In the chemical process industry, the most resource efficient operation under the given circumstances is not easily identifiable due to the complex nature of the processing plants. Possible solutions differ in their complexity and affordability. They range from manually controlled plant operation which is at low cost but brings unstable performance to full model-based automation which promises good performance but at a high cost for development and maintenance. The decision on the appropriate solution depends on the savings potential compared to the effort that is required for its realisation.

There is no universal best solution for how to achieve improved resource efficiency, the best approach to realise the potential for savings has to be found for each individual case. In CoPro, INEOS in Köln pursued a middle–ground approach between total automation and traditional manually controlled plant operation.

Providing novel operator support through dashboards

The approach that has been selected by INEOS in Köln is the monitoring of Resource Efficiency Indicators (REI) of the process plants. These indicators were first proposed in the EU project MORE. Going beyond just showing numbers, the actual plant performance is compared to a value that provides a reference point for the most resource efficient operation. Due to the fact that the development of first principle models requires a large effort, a data-based modelling approach for identifying the baseline models from historical data was developed. The modelling approach employs an extension of state-of-the-art surrogate modeling techniques, data clustering and model simplification by backward elimination. These models return reference values which are not always straightforward to achieve improved resource efficient operation, a concept has been developed that uses historical data and statistical methods to gain insight into the process and to detect the reasons for deviations from the baseline. As demonstrated in Fig. 1, historic process data is classified into efficient (close to the BDP) and inefficient operation. A neighborhood close to the current operation is defined by limiting the allowed deviation of the input parameters from the current operation point. Statistical methods are used to compare the process variables that are under the control of the operators degree to efficient operation points that were observed under similar conditions. This results in a list of possible root causes for deviations from the most resource efficient operation that are sorted by likelihood and proposed reference values that led to an efficient operation in the past. While this solution was developed by using the BDP baseline models at INEOS in Köln, the approach is generic and can be transferred to any kind of reference model.

The summary

Information as the key to a more resource–efficient production

In CoPro, several technologies were developed and combined by INEOS in Köln into a toolchain that provides the operators of the plants with additional information about the most resource-efficient operation points. This facilitates the transition of the daily operation of existing plants to a consistent sustainable resource-efficient operation. The root cause analysis that provides hints for reasons for suboptimal process operation allows less experienced operators to make the right decisions to increase the energy and resource efficiency of the plants and thus also the plant economics.

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Fig. 1: Schematic representation of the baseline model, allowed deviations, and classification of operating points

Fig. 2: Operator dashboard for an unit operation

Intexc Suite, which is used to calculate the current model values using inputs from data sources on site. The BDP and the current values of the resource efficiency indicators are transferred to the visualisation tool Grafana to provide the plant operators with a dashboard that comprehensively visualises the possible improvement potentials. This solution increases the resource efficiency by raising the awareness of the operators about suboptimally performing unit operations.

However, the reasons for deviations of the current plant operation from these baseline values are not always straightforward and the performance improvement depends on the experience and the training of the operators. To facilitate the transition to a more resource-efficient process operation, a concept has been developed that uses statistical methods to gain insight into the process and to detect the reasons for deviations from the baseline. As demonstrated in Fig. 1, historic process data is classified into efficient (close to the BDP) and inefficient operation. A neighborhood close to the current operation is defined by limiting the allowed deviation of the input parameters from the current operation point. Statistical methods are used to compare the process variables that are under the control of the operators degree to efficient operation points that were observed under similar conditions. This results in a list of possible root causes for deviations from the most resource efficient operation that are sorted by likelihood and proposed reference values that led to an efficient operation in the past. While this solution was developed by using the BDP baseline models at INEOS in Köln, the approach is generic and can be transferred to any kind of reference model.