Intuitive perturbation-based optimization applied to a dividing-wall distillation column ⋆

Mark Haring * **Leontine Aarnoudse** ** **Ivar J. Halvorsen** *,***

* *Dept. of Mathematics and Cybernetics, SINTEF Digital, Trondheim, Norway (e-mail: mark.haring@sintef.no, ivar.j.halvorsen@sintef.no).*
** *Dept. of Geosciences, Norwegian University of Science and Technology, Trondheim, Norway (e-mail: leontine.i.m.aarnoudse@ntnu.no).*
*** *Dept. of Chemical Engineering, Norwegian University of Science and Technology, Trondheim, Norway.*

Optimization of industrial processes is vital to improve efficiency, decrease energy consumption, and reduce emissions. However, traditional, model-based optimization requires a thorough understanding of the process and its environment, which is frequently lacking in practice. Operators are often faced with large, time-varying uncertainties related to variations in feed, environmental changes, and planned and unplanned events that disrupt normal operation, among other things.

Although there is a push towards automatization, many optimization tasks of an operator are still performed manually. While process understanding and experience help the operator to find a stable operating regime, small changes to the process are required to achieve the best performance using a trial-and-error approach. The decision on which small changes are implemented is commonly left to the individual operator, sometimes supported by a small group of process experts. The success of manual optimization varies due to different reasons, for example: 1) small changes to process parameters are not implemented in order to prioritize steadiness; 2) a tight collaboration between operators is lacking (for slow process responses that span multiple work shifts); 3) a clear, common understanding of optimality is missing.

Our research aims to improve the consistency in execution of optimization tasks and to increase overall performance consequently. This is done by partially automating (e.g., in the form of operator support) or fully automating the optimization process. In Aarnoudse et al. (2026), a novel algorithm called uncertainty-based Perturb and Observe (uP&O) is presented that automatically makes small changes to process parameters in a similar manner as an operator does. Although the algorithm is designed for fully automated optimization, it is not required that each suggested step in parameter value is implemented, which makes the algorithm also suitable for operator support.

To demonstrate practical relevance and ease of implementation, uP&O has been applied to a dividing-wall distillation column to minimize the side-stream impurity of the column. The parameter that is tuned by uP&O is the setpoint of the Difference Temperature Symmetry (DTS) (see Halvorsen and Skogestad (1999)), which is indirectly controlled by the liquid split of the column. The cost to be minimized is given by a 10-second average of the temperature difference over the wall, which is strongly correlated to the side-stream impurity and can be easily measured in real time. Experimental results are shown in Fig. 1, where the feed rate is increased by 20% around 3.5 hours and a new (lower) optimum is found.

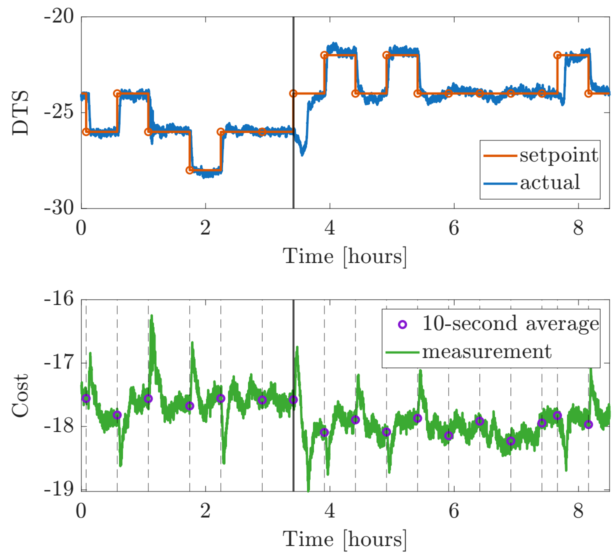

Fig. 1. Experimental results of a dividing-wall distillation column using uP&O.

REFERENCES

Aarnoudse, L., Haring, M., van de Wouw, N., and Pavlov, A. (2026). Uncertainty-based perturb and observe for data-driven optimization. URL `https://arxiv.org/abs/2604.15922`.

Halvorsen, I.J. and Skogestad, S. (1999). Optimal operation of Petlyuk distillation: steady-state behavior. *J. Process Control*, 9, 407–424. doi:10.1016/S0959-1524(99)00009-8.

⋆ This work was supported by the Research Council of Norway (RCN) through the project EXTREME EFFICIENCY: Data-driven optimization of industrial processes in time-varying environments (RCN project nr. 345272).