Optimal operation and advanced control using decomposition and simple elements

Organizers and Presenters:

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Summary

How can you control a complex plant effectively using simple elements with a minimal amount of modelling? How can you put optimization into the control layer? Industry has been using simple and effective as “advanced regulatory control” schemes for almost 100 years. The objective of the workshop is to provide a systematic approach for designing such control systems. The approach is illustrated on numerous real industrial applications. The target audience includes both practicing control engineers as well as PhD students and teachers from academia.

Control engineers rely on many tools, and although some people may think that in the future there will be one general universal tool that solves all problems, like economic model predictive control (EMPC), this is not likely to happen. The main reason is that the possible benefits of using more general tools may not be worth the increased implementation costs (including modelling efforts) compared to using simpler "conventional" advanced regulatory control (ARC) solutions. Economic optimization may be put into the control layer by using the magic of feedback to control the right self-optimizing variables, including economically active constraints.

Since its introduction in the 1940’s, about 80 years ago, advanced regulatory control (ARC) has largely been overlooked by the academic community, yet it is still thriving in industrial practice, even after 50 years with model-based multivariable control (MPC). Examples of “advanced” control elements are cascade control, ratio control, selectors, anti-windup, split range control, valve position control (VPC), multiple controllers (and MVs) for the same CV, and nonlinear calculation blocks.

This workshop takes a systematic view on how to design a conventional ARC system. The starting point is usually optimal steady-state economic operation. The process may have many manipulated variables (MVs) for control (typically valves), but usually most of these are used to control “active” constraints, which are the constraints which optimally should be kept at their limits at steady state. For the remaining unconstrained degrees of freedom, we should look for self-optimizing variables, which are measured variables for which the optimal values depend weakly on the disturbances.

We usually start by designing a good control system for the normal (nominal) operating point, preferably based on single-loop PID controllers where each manipulated variable (MV), which is not optimally at a constraint, is paired with a controlled variable (CV). To handle interactions, disturbances and nonlinearity, one may add cascade control, ratio control, feedforward control, decoupling and more general calculation blocks. However, during operation one may reach new (active) constraints, either on MVs or CVs, which may be easily observed from measurements of the potential constraints. Since the number of control degrees of freedom does not change, we will need to give up the control of another variable. The key is then to know which variable give up, and it is shown how this in most cases may observed by feedback and implemented using standard ARC elements, including selectors and split range control.

Other extremely simple and powerful methods include nonlinear feedforward using input transformations and bidirectional inventory control. Both these methods go back to Greg Shinskey, who is well known to all older process control engineers, but they are in this workshop presented for the first time in a systematic way.

The theory is illustrated on many industrial case studies, including buffer management, heat exchangers, continuous reactors and distillation columns.

About the presenters

Sigurd Skogestad received his Ph.D. degree from the California Institute of Technology, Pasadena, USA in 1987. He has been a full professor at Norwegian University of Science and Technology (NTNU), Trondheim, Norway since 1987. He is the principal author, together with Prof. Ian Postlethwaite, of the book "Multivariable feedback control" published by Wiley in 1996 (first edition) and 2005 (second edition). His research interests include the use of feedback as a tool to make the system well-behaved (including self-optimizing control and stabilization), limitations on performance in linear systems, control structure design and plantwide control, interactions between process design and control, and distillation column design, control and dynamics. His other main interests are mountain skiing (cross country), orienteering (running around with a map) and grouse hunting. He is a Fellow of both the American Institute of Chemical Engineers (2012) and IFAC (2014) and is a member of the Process Automation Hall of Fame (2011).

Krister Forsman got his Ph.D. degree from Linköping University, Sweden, in 1990. He has worked in the chemical and pulp and paper industries since 1994. Since 2005 he is Corporate Specialist in Process Control at Perstorp Specialty Chemicals. He has worked with around 50 plants in some 20 countries. In 2006 he published a text book in process control for practitioners. Since 2012 he is part time Adjoint professor at NTNU, dept of Chemical Engineering. Here, his research is focused around plant wide control concepts and applications of control structures.

References

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