An implementation of compensation of interactions in a DeltaV automation system

Kimmo Leppäkoski and Harri Aaltonen

Systems Engineering Laboratory, Department of Process and Environmental Engineering, University of Oulu, P.0. Box 4300, FIN-90401 Oulu, Finland
e-mail: kimmo.leppakoski@oulu.fi harri.aaltonen@oulu.fi
Subject line: A-FIN-Leppäkoski-K-1

Our laboratory teaches several basic and advanced systems and control engineering courses. The basic courses discuss SISO systems whereas the advanced courses cover more complex systems including the interactions among control signals. We have pieces of pilot-scale process equipment and process automation systems as DeltaV and Simatic S7. These means are utilized in basic laboratory exercises. On the other hand, the effect of compensation of interactions can be illustrated to students by applying these instrument.

This paper describes a three tank system that was built to allow students and researchers to study control strategies on a system that is as close as possible to an actual industrial plant. The laboratory exercise is called "The measurement and control of conductivity". Conductivity is an index of how easy it is for electricity to flow. The control of conductivity is made in the second tank, and the salt (NaCl) is dissolved in tap water to form salt water.

The aim of the study is to control the level and the temperature of the first tank at the same time. Control of the level and temperature is first conducted by separate PID controllers. It is possible to define existing interactions between the level and temperature control using separate controllers. Multivariable-based decoupling is conducted to remove the interactions (Åström & Hägglund 1995, 2005). Control strategies are realized in the DeltaV automation system, which is used to control the process.

The DeltaV automation system contains software and hardware for process control. The system contains a work station, a control unit, I/O units, a power supply and different system busses. A safety instrumented system is also possible to link to the automation system. The professionalPLUS workstation is a human/machine interface between the operator and the automation system. The control unit manages communication between I/O units. Analog I/O units, digital I/O units and the Fieldbus Foundation fieldbus enable effective data transfer. The system contains many tools for the design and maintance of automation system. DeltaV software enables to design graphical user interfaces, to construct control modules and to configurate them, and to collect data. The most important design tools are DeltaV Explorer, Control Studio ja DeltaV Operate Configure. The control program can be made by applying the DeltaV Explorer and Control Studio programs. By using DeltaV Explorer, the structure of the system can be investigated. The components of system can defined (areas, modules, equipment and alarms) by using the DeltaV Explorer. Control modules are designed and modified by using the Control Studio. The modules are graphically composed by using ready-made component, which are available in the programming libraries. Graphical user interfaces are designed by using the DeltaV Operate Configure program, which is used also during operation. The state of process can be observed by using the Process History View program. (Emerson Process Management 2008, DeltaV Books Online 2002)

The theory of the multivariable control, the function and the tuning of PID controllers are investigated (Åström & Hägglund 1995, 2005, Ikonen & Najim 2002), and the way in which the controllers are tuned and the response of the process to different parameter values is introduced. Step response experiments are conducted to define the behaviour of the process in the entire area of operation as it was performed in other processes, see for example (Leppäkoski 2006). With the help of the step response experiments, it is also possible to define the strength of the interactions in the process. The control strategy implemented with decoupling is compared to the control strategy conducted with separate controllers in order to observe the level of compensation for interactions.

The results of the research show that even partial decoupling enables better control than the separate PID controllers. With decoupling, it is possible to reduce interactions between the level and the temperature control so that they do not interact with each other so much. Because of this, the behaviour of the process is faster and the accuracy of the control is better. The results give an possibility to illustrate to students the effect of decoupling.

References

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