Advanced approaches of nonconventional process control

Abstract

This thesis presents the scientific activity and achievements of the candidate after defending her PhD thesis at the Technical University of Cluj-Napoca on September 2006 and receiving the PhD title confirmation by the Ministry of Education and Research's Order No. 5764, dated 28.11.2006. The research topics of the candidate continue the tradition of the team she joined: study of conventional and advanced control methods, control system development and industrial applications. The main research results are included, noting the most important scientific papers, research grants, patents and awards published or awarded after defending the doctoral thesis. Specific aspects refer to the results obtained in the modeling and simulation of complex chemical processes, results in the design and implementation of control systems and contributions to the development of new advanced control strategies.

With this respect, in this first part of the main chapter entitled "Scientific and professional achievements" the operation of a 13C isotopic separation column is briefly described, followed by a list of mathematical models developed for this nonconventional, complex process. The sensors and actuators of such unique process exhibit special features, therefore common, industrial versions can not be accepted. This is the reason why have developed original sensors: a sensor for carbon monoxide level in the boiler of column, a level sensor for the liquid nitrogen from the condenser of the column, a device that determines the phase shifting between two signals in an intuitive manner, a sensor used in the control of the power dissipated by the boiler and a nonconventional algorithm for frequency analysis. The principles of operation and the original ideas of these sensors are summarized in section 2.3. In chapter 2.4 are presented the control strategies designed for the isotope separation column, starting from classical control methods to advanced control

strategies, both for the primary process from the column and the auxiliary processes. Chapter 2.5 presents one of the current research topics, focusing on the control system design of a cascade of three isotope separation columns, a novel technology in the field of isotope separations. Chapter 2.6 presents the results of research related to distributed control systems, presenting specific problems, challenges posed by the distributed nature, by the communication infrastructure, by the vulnerability to possible faults. At the same time, the distributed nature of these systems and the possibility to interconnect the control system components in different ways, could be exploited to ensure robustness and fault tolerance. The research addresses the issue of fault-tolerant control and monitoring of distributed systems with application in multivariable systems with dead time. The contributions to the development of new algorithms using fractional order calculus are described in Chapter 2.7. In the attempt to eliminate the major drawback of the existing fractional order controller design methods, namely the complexity of the calculus, the candidate proposed simple algorithms, useful even for engineers with less experience in fractional order derivatives. With this respect the candidate developed a fractional order controller design method, inspired by the symmetry method of Kessler and a method based on vector calculus. In Chapter 2.8 the contributions in the field of modeling and control of other complex processes are listed, and in section 2.9 the directions for future research are presented. These require development of new methods, based on fractional calculus, for robust controller design, for a wide range of distributed systems, design of multi-agent control systems to ensure fault tolerance, robustness, reactivity and flexibility, allowing the control system to be reliable and to react to faults that may occur. It also facilitates engagement into a new research field: modeling and control of ultra-precision single point diamond turning process, in collaboration with a research team from South Africa.

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