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Flow Modelling and Control in Pipeline Systems

A Formal Systematic Approach

Springer

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To my lovely wife and our newborn baby
Artin

Sina Razvarz

To my parents, parents in law,
my brothers and specially my husband

For their endless love, support and encouragement

Raheleh Jafari

To the visionaries for the United States of Europe

Alexander Gegov

Preface

A pipeline system as one of the effective tools for transporting fluids despite the cost of proper maintenance, has been taken to be a complex system accompanied by several kinds of components and consumers. Hence, pipeline systems have been taken as one of the most important tools for transmission around the world.

It will be important for industrial society that pipeline systems function appropriately by taking into consideration the growing requirement for effective interconnecting fluid networks. However, this task is difficult as someone should simultaneously certify a secure fluid supply and the fulfillment of the various requirements of consumers. Even this task could become more difficult with the appearance of leakage, blockage, and fault in sensors and actuators that could produce the degradation and glitch of the whole system.

Leakage and blockage in the system of pipes that transport process fluids such as oil, industrial gas, water could result in crucial environmental, social, economic, health and safety problems. Leakage in the pipeline can be caused from poor mechanism or from any devastating reason because of unexpected alterations of pressure, corrosion, fractures, faults in pipelines or absence of preservation. There exist various non-destructive testing (NDT) techniques to detect these faults in pipe networks like radiographic, ultrasonic, magnetic particle inspection, pressure transient and acoustic wave techniques.

The model structure of flow in pipe or pump could be designed by various techniques. One well-known technique is to present flow in pipe using two partial differential equations. In general, the closed-form solution of this method is not known, but it may be obtained based on numerical techniques. Another method of modeling is based on the use of the hydro-electrical analogy.

Over the past few years, various techniques involving uncertainties have been used for detecting flaws in pipelines. Various numerical tests have been carried out for improving the current approaches by taking into consideration parametric studies. The theoretical research focuses on evaluation the precision, robustness, calculational ability, applicability and limitations of the methodology. To achieve the safe operation of pipeline systems, special software tools have been produced in the past decades that are supplementary to the conventional supervisory control and

data acquisition systems (SCADA). Generally, those tools are made of fault detection, location and diagnosis algorithms, based on fluid mechanics for signal processing and also, they consider a finite number of existing variables from the pipe.

It should be noted that some defects to be identified need active recognition, for instance, the requirement of supervision systems upon the pipeline system in regular intervals or at acute time by applying test signals for generating, for example, transitory answers of the fluid to detect unusual occurrences. Hence, there exist a great number of research groups throughout the world with various backgrounds who are attempting to develop efficient automated monitoring and supervision systems for pipelines.

The background material needed for understanding this book is fluid dynamic and linear and nonlinear systems. This book will provide a good basis for those students who are interested in numerical analysis and partial differential equations. This book is mainly written for graduate and advanced undergraduate students of sciences, technology, engineering, and mathematics. It is organized as a textbook for a course on control and modeling. This book could be used for self-learning.

In this book we have rather attempted to unify the theory as far as possible with the practice by focusing attention on the most important methods to deal with the general problem. Our aim in this book is to introduce new methods using auxiliary systems called "observers" for solving the defect detection and identification problem in pipe networks and also develop the nonlinear equations for pipe networks. In reading this book, a reader who wants a general knowledge about fluid dynamic and pipeline should read Chaps. 1–5. These chapters provide an understanding of why pipelines are important (Chap. 1), a review on different pipeline fault detection techniques (Chap. 2), mechanisms of fluid flows in pipes (Chap. 3), flow control of fluid in pipelines using fuzzy logic controllers (Chap. 4), flow control of fluid in pipelines using neural networks and deep learning (Chap. 5), model structure of leakage in pipes (Chap. 6). The latter half of the book delves into some introduction to flow control techniques, model structure of blockage in pipes (Chap. 7) leakage detection in pipeline based on observation techniques (Chap. 8) flow control of fluid in pipelines using proportional-derivative (PD) and proportional–integral–derivative (PID) controllers (Chap. 9)

The authors contributed to shape the substance of this book are from computer science and engineering backgrounds. The first author, Sina Razvarz, would like to express his sincere gratitude to his advisor Prof. Cristobal Vargas for his continuous support of his Ph.D. study and research, and for his patience, motivation, enthusiasm, and immense knowledge. His guidance helped him throughout his research and writing of this book. Also, he would like to thank his wife for her time and dedication. Without her this book would not have been possible. The second author, Raheleh Jafari would like to thank her husband for his time and dedication. Without him this book would not have been possible. The third author, Alexander Gegov would like to thank his family members for their spiritual support during the work on this book.

The authors of this book would like to thank the editors for their effective cooperation and great care making possible the publication of this book.

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