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A Hybrid Approach for Power Plant Fault Diagnostics

Springer

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To my family, siblings and parents

Preface

Gas power plants, which are common in distributed power generation, are complex machines, both in terms of design and method of operation. These have led to the need for specialized preventive maintenance (PM) procedures. One of the core elements of PM is intelligent fault detection and diagnostics. In the past, several fault detection and diagnostics algorithms have been developed using analytical, multivariate and soft computing methods. These algorithms—with different levels of complexity—have been applied to various designs of gas turbine power plants (e.g., one-shaft, two-shaft, three-shaft, or combined cycle arrangements). The challenge, however, is that even though several cases have been addressed using different metrics for performance evaluation, it is still short of meeting the expectations in the field. This book provides a hybrid approach to fault detection and diagnostics. Effectiveness of the methods is tested based on data acquired from actual cogeneration and cooling plant (CCP).

Models are developed for Normal Operating Conditions (NOC) by applying Neuro-Fuzzy (NF) method. For the dynamic case, the same approach is employed in the framework of Orthogonal Basis Functions (OBF). The fault detection is evaluated in the presence of adaptive model uncertainty calculations. For the bounded error case, Minimum Volume Outer Bounding Ellipsoid (MOBE) algorithm is introduced for the estimation of rule consequent parameters and model confidence intervals. Applications of the methods are demonstrated by considering a CCP having a 5.2 MW Gas Turbine, 12 Tons/hr Heat Recovery Steam Generator (HRSG) and 1250 RTH Steam Absorption Chiller (SAC).

Chapter 2 presents literature review focusing on general classification of fault detection and diagnosis techniques, model-based approaches, NF-based methods, and fault detection and diagnosis techniques as applied to a CCP. Chapter 3 concentrates on the theoretical background on nonlinear model identification. It also includes important aspects of nonlinear models and the effect of model order on model performance.

Chapter 4 focuses on the theory behind the calculation of model confidence intervals and the fundamental concepts in the construction of a model-based fault detection and diagnosis system. Furthermore, it elaborates on model uncertainty equations derived on the bases of two different assumptions: (i) identically and independently distributed error assumption; and (ii) bounded error assumption. Last section of the chapter explains the structure of a fault diagnosis system that relies on fuzzy method.

Chapter 5, in a step-by-step manner, shows how the theory elaborated in Chaps. 3 and 4 is applied to a CCP. Additionally, a new method is revealed that can be used to systematically account for the effect of change in operating modes and the effect of external factors to the accuracy of the models for normal operating conditions.

Application of the methods from Chaps. 3 to 5 is discussed in Chaps. 6 and 7. Rather than demonstrating implementation of the proposed method only, detail analysis is carried out for different magnitudes and types of faults, respectively. The analysis is performed by comparing performance of the NF approach against fault detection and diagnostics systems designed on the basis of principal component analysis and auto-associative neural network, respectively. Chapter 8 summarizes the findings and analysis and highlights on possible future research directions.

The aim of the book is to share the findings on power plant nonlinear model identification and fault diagnostics. Efforts have been made to provide detail analysis that can relate to practical application of the fault detection and diagnostics framework. The presented material is useful for researchers and practicing engineers.

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