

Preface

Being composed of different components working with different programs, the liquid rocket engine (LRE) is a complex system that is widely used in the aerospace field. It can provide thrust for a vehicle outside of the atmosphere. However, the LRE is always working in execrable conditions with high temperatures and heavy corrosion. Therefore, it is necessary to monitor the condition of an LRE to enhance the reliability and safety of the thrust system and understand its working performance; it would also be useful to establish an advanced condition monitoring and fault diagnosis system for the LRE. Involving several disciplines and technologies, the core of LRE health monitoring is the technologies of fault detection and fault diagnosis. In recent decades, a special theory of fault detection and diagnosis was developed using digital computer technology, the theory of automatic control, signal processing, artificial intelligence, reliability theory, and engineering to provide a theoretical foundation for the development of fault detection and diagnosis in the LRE.

In this book, the mode, model, and characteristics of the LRE's fault are investigated. Then, the corresponding fault diagnosis methods, including methods based on the model, signal processing, and artificial intelligence are studied. Developed under the guidance of modern control theory and the modern optimization method, the model-based method carries out fault diagnosis by analyzing the residual obtained by the Luenberger observer, equivalent space equation, Kalman filter, parameter estimation, and identification based on the specialized criterion or threshold. It has attracted much attention because the model-based method can be closely combined with the control system and is a precondition of condition monitoring, fault tolerance control, system modification, and reconstruction.

By referring to the production of the residual, the model-based method can be divided into several methods, including the condition estimation method, parameter estimation method, and the equivalent space method. Comparatively, the method based on signal processing does not rely on an accurate model and has good suitability. Although most parts of signal processing-based methods are proposed

on the assumption that the system is linear, they are easily expanded to nonlinear systems. The methods involving Kullback information criterion, wavelet transform, time series analysis, and information fusion are included in the signal processing-based methods. With the development of the system, the system is becoming more and more complex and it is very difficult to establish an accurate model. In this instance, an artificial intelligence-based method, which does not rely on an accurate model, can be used for fault diagnosis. For example, the artificial neural net (ANN), expert system, pattern recognition, revolution algorithm, fuzzy logic method, and a combination of these methods are included in the intelligence-based method.

An LRE is a complex system involving high temperatures, high pressure, heavy corrosion, and strong power release. It is very difficult to establish an accurate model for the whole system, and the model-based method may be restricted in the engineering application. Comparatively, the signal processing-based method and the artificial intelligence-based method are advanced in the processing of the complex character of the object. In this instance, by combining the character and developing trends of the LRE fault diagnosis, wavelet transform, artificial intelligence, fuzzy logic, statistic learning theory, and gray theory are applied in the fault diagnosis of the LRE. This book concentrates on the subjects of monitoring technology of a healthy LRE, including its failure analysis, fault diagnosis, and fault prediction; several fault diagnosis methods have been investigated by combining the fault cases of LRE. We hope to have achieved the following characteristics in the writing of this book:

Advanced. The latest investigation achievements are summarized in this book and corresponding content is advanced and novel.

Applicable. As it is focused on the application of the fault character analysis and diagnosis technology in the LRE, this book can be used as the reference by researchers and engineers.

Readable. Although the theory is very complex, the content of this book, including the basic mechanisms, synthesis methods, and application cases, are logically arranged for the sake of understanding.

The content of this book is the culmination of research by our group. Many graduate students, including Tian Gan, Xu Zhi-gao, Yang Zheng-wei, Li Ming, Lin Xiang-jin, Gao Zheng-ming, Liu Chong-yang, Tian Lu, Xu Hai-bo, and Ming An-bo, worked on different parts of this book. All authors of references are appreciated because they provide rich material for the content in this book. We also thank the publishers for their help in the publishing process.

Because of restrictions in the knowledge of the authors, errors may appear in this book. All comments and corrections are cordially accepted!

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