

Preface

The forging is widely applied for manufacturing parts from aviation, aerospace and transportation, etc. For example, most of the components in aircraft parts that bear alternating and concentrated loads are formed via forging including the fuselage, rotary parts in engines, the undercarriage, etc. Developments in forging technology have increased the range of shapes, sizes, material, and properties of formed products, enabling them to meet various design and performance requirements. Forged parts are required specifically to have high mechanical strength, high reliability, resistance to shock and fatigue, abrasion, as well as economy. Forging is a process that must accommodate all of these specifications.

In order to satisfy the requirements of forged parts, a strict process and minute control for hydraulic actuator for forging are necessary. Achieving this high-accuracy and high-performance control is a great challenge due to (1) complex forging process of irregular geometric shapes due to complex rheological behavior; (2) complex hydraulic drive process, such as multi-cylinder parallel drive, and huge inertia of the motion part of hydraulic actuator; (3) friction, leakage, and other uncertainties are inevitable; and (4) It often requires to using a huge driving force to control an extremely low or variable forging velocity within a large distance. As a result, accurate control of hydraulic actuator is one of the most important concerns in forging industry and other hydraulic manufacturing industries.

The studies of modeling, analysis, and control of hydraulic actuator for forging become more and more active and important. In the last few decades, much progress has been achieved in this field. However, there are still many unsolved problems in this field as the range of shapes, sizes, and properties of formed products have been increased and the forging machinery becomes huger and more complex, as well higher accuracy and higher performance control is further required. The purpose of the book is to provide a brief view of the previous work on modeling, analysis, and control of hydraulic actuator for forging, and develop new methods to tackle some of these unsolved problems.

In the book, a systematic overview and classification is first presented on modeling, analysis, and control of hydraulic actuator for forging. Limitations and advantages of various approaches are also discussed. Next, several novel modeling

approaches are proposed for modeling of the load and forging processes: a process/shape-decomposition modeling method to help estimate the deformation force, an online probabilistic extreme learning machine for the modeling of batch forging processes, and several data-driven identification and modeling approaches for unknown forging processes under different work conditions. Then, the model-based dynamic analysis methods are developed to derive the conditions of stability, vibration, and creep not only for open-loop forging processes but also for closed-loop forging processes. Finally, two novel intelligent control methods are proposed for complex forging processes. One method is for complex forging processes working in a large operation domain. Since the system complexity and control task are shared by a group of simple sub-controllers, this proposed method can be effective to control the complex system through the cooperation of a group of sub-controllers. Another method is for time-varying forging processes with big uncertainties and sudden changes. Through the intelligent integration control for the smooth operation region and the sudden change region, the continuity and smoothness between the multiple localized nonlinear dynamics can be guaranteed even if the forging processes have big uncertainties and sudden changes. All these methods presented in this book have been successfully applied to the practical forging processes and should be applicable to a wide range of systems in manufacturing industry.

The book will be of great benefit to undergraduate and postgraduate students in many disciplines including manufacturing engineering, mechanical engineering, electrical engineering, computer engineering, and control engineering. It is also intended for researchers, research students, and application engineers interested in modeling, dynamic process analysis, and control.

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