Abstract of Dissertation

題目 A Study on Opportunity-Based Age Replacement Models and Their Applications

(機会ベースの年齢取替モデルとその応用に関する研究)

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This thesis studies several opportunity-based age replacement models and their applications. In reliability theory, arrival of replacement opportunities often refers to delivery of spare parts with low cost, special service durations, or specific replacement time points. Overall, preventive maintenance can be performed flexibly and conveniently when the replacement opportunities arise.

Chapter 1 mainly summaries the optimal maintenance models developed in the past literature.

In Chapter 2, we consider two classical age-based replacement models in a discrete-time framework; a standard age replacement (AR) model and an opportunistic age replacement (DD) model. More specifically, we introduce the concept of replacement priority in situations where failure replacement and preventive replacement occur at a given age or opportunity. We explore two priority cases in each replacement model. First, we formulate the optimal preventive replacement policies minimizing the associated expected cost rates by the familiar renewal reward argument. Next, we extend the models by means of net present value (NPV) method. We develop the expected total discounted costs over an infinite time horizon and obtain the optimal preventive replacement policies by minimizing these total expected costs. Also, we introduce unified stochastic models incorporating the probabilistic priority of replacement options. Besides, we propose a general framework for optimizing replacement policies in discrete time. The discrete time AR and DD models with/without discounting are also reformulated under the framework. To provide practical insights, we present numerical illustrations using real failure data for pole air switches, by comparing the performance of these optimal preventive replacement policies.

In Chapter 3, we focus on discrete time opportunity-based age replacement models with replacement first (RF) and replacement last (RL) disciplines, where the expected cost model under each discipline can be further classified into six cases by taking account of the priority of multiple replacement options. We characterize several optimal opportunity-based age replacement policies minimizing the relevant expected costs. We also apply the NPV method to formulate the expected total costs under RF and RL disciplines. Similar to Chapter 2, we unify six discrete time opportunity-based age replacement models with deterministic priorities for each discipline. In numerical illustrations, we obtain and compare all the optimal scheduled preventive replacement times with RF and RL disciplines.

In Chapter 4, we concern about two opportunity-based age replacement problems in continuous/discrete time. Firstly, we formulate the opportunity-based age replacement models with RF and RL disciplines in continuous time. We also introduce a restricted duration for the opportunity arrivals which obey a homogeneous Poisson process. Next, we reconsider these opportunity-based age replacement models in discrete time, where the inter-arrival times of replacement opportunities obey an independent and identical geometric distribution. The optimal two-phase opportunity-based age replacement policies are characterized by minimizing the expected cost rates. The numerical examples

are presented to compare two replacement policies with RF and RL disciplines. The results indicates that RL policies could be better than RF policies in only a few limited cases where the impact of failure replacement is relatively small.

In Chapter 5, we generalize the opportunity-based age replacement policies in continous time by introducing the NPV of expected total costs, where two cases are considered. First, we reformulate two basic opportunity-based age replacement models with RF and RL disciplines, in which the failure time and the arrival time of a replacement opportunity are statistically independent. Next, we take place the NPV analysis for the failure-correlated opportunity-based age replacement models with RF and RL disciplines. Since the NPV approach is useful to estimate more accurate replacement costs over a long-time planning in an unstable economic environment, we obtain the expected total discounted costs over an infinite time horizon, and derive the optimal preventive replacement policies by minimizing them in both cases. Numerical examples with the Farlie-Gumbel-Morgenstern bivariate copula are presented to investigate the dependence of correlation between the failure time and the opportunistic replacement time on the opportunity-based age replacement policies.

Finally, Chapter 6 concludes the thesis and give some remarks on the future studies.