氏　　　　名	周（シュウ）　蕾（ライ）
所　　　　属	システムデザイン研究科 システムデザイン専攻
学 位 の 種 類	博士（工学）
学 位 記 番 号	シス博　第 131 号
学位授与の日付	令和 2 年 9 月 30 日
課程・論文の別	学位規則第 4 条第 1 項該当
学位論文題名	Study on Design and Maintenance Policies for Linear Consecutive-*k*-out-of-*n*:G Systems （線形連続 *k*-out-of-*n*:G システムの設計と保全方策に関する研究）
論文審査委員	主査　教授　山本　久志 委員　教授　梶原　康博 委員　教授　松田　崇弘 委員　教授　福本　聡 委員　教授　秋葉　知昭（千葉工業大学大学院）

【論文の内容の要旨】

System failure is an unavoidable event, and the consequences of such failures could significantly impact our lives. Therefore, in reliability engineering, optimization plays an important role in ensuring high reliability and availability of a system. In general, optimization problems include design problems in design phase and maintenance problems in operation phase.

In practice, a system exists such that a series of working components causes system to work, which can be modeled as a consecutive-*k*-out-of-*n*:G system. Given the theoretical development and practical applications in the reliability field, much effort has been devoted to studying the properties of this system. Many of these studies have been solved the component arrangement problem for improving the system reliability. But though this system is important in terms of its application to the general system, there are no studies on the above optimization problems for this system which has significance in reliability engineering. Therefore, the main objective of this thesis is to consider two types of optimization problems and obtain the optimal results for consecutive-*k*-out-of-*n*:G systems. First, in system design phase, the size of the system is considered, and the optimal number of components is obtained. Second, in operation phase, the age replacement is considered, and the optimal replacement time is obtained.

This thesis consists of six chapters. Chapter 1 briefly gives the background of this study and introduces the concept of consecutive-k-out-of-n systems and optimization problems. In addition, literature reviews related to this thesis are detailed and systematically classified.

Chapter 2 focuses on system reliability evaluation, which includes system reliability and mean time to failure (MTTF). System reliability evaluation is a fundamental step in system performance evaluation. Furthermore, to build mathematical models of optimization problems, system reliability and MTTF are needed. In detail, we consider two cases: $k=2$ and $k\geq3$. When $k=2$, system reliability and MTTF can be easily derived by using a simple expression, which could reduce the complexity of the calculation. Furthermore, when $k\geq3$, we propose the general expressions of the system reliability and MTTF.

Chapter 3 deals with the general formulas for calculating the expected number of failed components of a coherent system. A coherent system is the one in which every component is relevant, and the improvement of components cannot lead to a deterioration in system performance. The consecutive-k-out-of-n:G system is an example of coherent systems. The number of failed or working components in a working system is considered to be useful for understanding the behavior of the system, and it gives an idea that how many spare components should be available to replace failed components. The purpose of this chapter is to propose the general formulas for calculating the expected number of failed components of any coherent system. Furthermore, some examples are given, which include a bridge-structure system and a consecutive-k-out-of-n:F system, and the results of the expected number of failed components are given.

In Chapter 4, we consider two optimization problems for the consecutive-k-out-of-n:G system. In system design phase, although the system reliability increases with n, the large number of components will cause the wastage of resources. Therefore, we focus on the system configuration, e.g., number of components, and the optimal number of components is discussed. In operation phase, we consider the age replacement, and the optimal replacement time is discussed. Under the assumption that all components are replaced, we build the models of the expected cost rates of these two problems and obtain the corresponding optimal policies by minimizing the expected cost rates. To investigate the proposed optimal policies, we perform the numerical experiments and analyze the results.

In Chapter 5, under the assumption that all components follow the exponential lifetime distribution, we consider that only failed components are replaced and working components are maintained from an economical view. First, we focus on the number of components in system design phase. We give the expected number of failed components at the time of system failure for the consecutive-k-out-of-n:G system. Then, we build the model of the expected cost rate and obtain the optimal number of components by minimizing the expected cost rate. Second, we focus on the replacement time in system operation phase. By considering replacing failed components at the time of replacement, we first obtain the expected number of failed components at a particular time t. Then, we build the model of the expected cost rate and judge the existence of the optimal replacement time by numerical experiments. Finally, we perform the numerical experiments to evaluate the efficiency of the proposed improved policies.

Chapter 6 summarizes the contributions of this thesis and discusses various future perspectives. The optimal policies proposed in this thesis will be useful for the improvement of reliability and availability of the consecutive-k-out-of-n:G system.