

A BIVARIATE RENEWAL PROCESS AND ITS APPLICATIONS IN MAINTENANCE POLICIES

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(ABSTRACT)

Systems of the same type and with the same age often have different amounts of accumulated usage. When in operation these systems usually have different performance and effectiveness. In this case the existing models of the univariate measures of system effectiveness are inadequate and incomplete. For example, the univariate availability measures for these same-aged systems are all the same even though the systems have different amounts of usage. This is the motivation for this research to pursue a bivariate approach in reliability and maintenance modeling.

This research presents a framework for bivariate modeling of a single-unit system. Five key efforts are identified and organized as: (i) bivariate failure modeling, (ii) bivariate renewal modeling, (iii) bivariate corrective maintenance (CM) modeling, (iv) bivariate preventive maintenance (PM) modeling, and (v) bivariate availability modeling. The results provide a foundation for further study of bivariate and multivariate models.

For bivariate failure modeling, several bivariate failure models are constructed to represent the possible correlation structures of the two system aging variables, time and usage. The behavior of these models is examined under various correlation structures. The developed models are used to analyze example maintenance problems.

Models for bivariate renewal, bivariate CM, and bivariate PM are derived based on the constructed bivariate failure models and the developed bivariate renewal theory. For bivariate CM modeling, corrective maintenance is modeled as an alternating bivariate renewal process or simply an ordinary bivariate renewal process. For bivariate PM modeling, PM models are examined under a bivariate age replacement preventive maintenance policy. The Laplace transforms of the renewal functions (and densities) for these models are obtained.

Definitions for bivariate availability functions are developed. Based on the derived CM and PM models, the Laplace transforms for their corresponding bivariate availability models are constructed. The idea of the quality of availability measure is also defined in terms of bivariate availability models.

The most significant observation is that this framework provides a new way to study the reliability and maintenance of equipment for which univariate measures are incomplete. Therefore, a new area of reliability research is identified. The definitions offered may be modified and the approach to model formulation presented may be used to define other models.