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Multiple failure modes analysis and weighted risk priority number evaluation in FMEA

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ABSTRACT

Traditionally, failure mode and effects analysis (FMEA) only considers the impact of single failure on the system. For large and complex systems, since multiple failures of components exist, assessing multiple failure modes with all possible combinations is impractical. Pickard et al. [1] introduced a useful method to simultaneously analyze multiple failures for complex systems. However, they did not indicate which failures need to be considered and how to combine them appropriately. This paper extends Pickard's work by proposing a minimum cut set based method for assessing the impact of multiple failure modes. In addition, traditional FMEA is made by addressing problems in an order from the biggest risk priority number (*RPN*) to the smallest ones. However, one disadvantage of this approach is that it ignores the fact that three factors (Severity (S), Occurrence (O), Detection (D)) (S, O, D) have the different weights in system rather than equality. For examples, reasonable weights for factors S, O are higher than the weight of D for some non-repairable systems. In this paper, we extended the definition of *RPN* by multiplying it with a weight parameter, which characterize the importance of the failure causes within the system. Finally, the effectiveness of the method is demonstrated with numerical examples.

1. Introduction

Failure mode and effects analysis (FMEA) is a very powerful and effective analytical tool which is widely used in engineering projects to examine possible failure modes and eliminate potential failure during system designs. In particular, it provides design engineers with quantitative or qualitative measures necessary to guide the implementation of corrective actions by focusing on the main failure modes and its impact on the products [2]. FMEA has been widely adopted by reliability practitioners and has become standard practice in Japan, America, and European manufacturing companies [2,3]. Onodera [2,4] investigated about 100 FMEA applications in various industries in Japan and found that the FMEA is successfully in the many areas such as automobiles, electronics, consumer products, power plants, and telecommunications. Hsu et al. [5] proposed a method that utilizes the FMEA to analyze the risks of components in compliance with the EU RoHS directive in the incoming quality control (IQC) stage. Bluvband et al. [6] introduced an expanded FMEA or EFMEA for electronic designs. However, FMEA usually evaluates the failures impact on the system reliability based on a single failure. This significantly restricts the application of FMEA. Fortunately, Pickard et al. [1] proposed a method to combine multiple failure modes into a single one, which opens the possibility for us to analyze a system considering multiple failure modes at the same time. Unfortunately, although they proposed such method, the detailed procedure such as which multiple failures need to be com-

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