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A systematic reliability-centred maintenance framework with fuzzy computational integration – a case study of manufacturing process machinery

Abstract

This study presents a systematic framework for maintenance strategy development of manufacturing process machinery. The framework is developed based on the reliability-centred maintenance (RCM) approach to minimise the high downtime of a production line, thus increasing its reliability and availability. A case study of a production line from the ghee and soap manufacturing industry in Taiz, Yemen, is presented for framework validation purposes. The framework provides a systematic process to identify the critical system(s) and guide further investigation for functional significant items (FSIs) based on quantitative and qualitative analyses before recommending appropriate maintenance strategies and specific tasks. Design/methodology/approach: The proposed framework integrates conventional RCM procedure with the fuzzy computational process to improve FSIs criticality estimation, which is the main part of failure mode effect criticality analysis (FMECA) applications. The framework consists of four main implementation stages: identification of the critical system(s), technical analysis, Fuzzy-FMECA application for FSIs criticality estimation and maintenance strategy selection. Each stage has its objective(s) and related scientific techniques that are applied to systematically guide the framework implementation. Findings: The proposed framework validation is summarised as follows. The first stage results demonstrate that the seaming system (top and bottom systems) caused 50% of the total production line downtime, indicating it is a critical system that requires further analysis. The outcomes of the second stage provide significant technical information on the subject (seaming system), helping team members to identify and understand the structure and functional complexities of the seaming system. This stage also provides a better understanding of how the seaming system functions and how it can fail. In stage 3, the application of FMECA with the fuzzy computation integration process presents a systematic way to analyse the failure mode, effect and cause of items (components of the seaming system). This stage also includes items' criticality estimation and ranking assessment. Finally, stage four guides team members in recommending the appropriate countermeasures (maintenance strategies and task selection) based on their priority level. Adopting the fuzzy computational process improves the risk priority number (RPN) estimation, resulting in better criticality ranking determination. Another significant contribution is introducing an extended item criticality ranking assessment process to provide maximum levels of criticality item ranking. Finally, the proposed RCM framework also provides detailed guidance on maintenance strategy selection based on criticality levels, unique functionality and failure characteristics of each FSI.

Keywords

Criticality ranking; Fuzzy FMECA; RCM; Seaming system