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Application of generalized failure mechanism knowledge to reprocessing plant for proactive risk management

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Abstract

In this study, the generalized failure mechanism knowledge (GFMK) derived from a mechanical subsystem in the Rokkasho reprocessing plant is applied to an instrumentation subsystem in the same plant in order to examine its general applicability. This study confirms that the GFMK can be applied to the instrumentation system of a backup diesel generator and that a potential failure mechanism can be successfully derived. The efficacy of the derived knowledge regarding this failure mechanism was evaluated by referring to past failure events that have occurred in the same subsystem. This study has demonstrated exactly that some of the failure modes derived by applying GFMK had actually occurred in the real plant subsystem. The importance of this observation is that these failure modes were not included in the collection of failure events utilized to derive GFMK, which implies that the GMFK can possibly be utilized to proactively identify possible failure events in a realistic scale system.

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Keywords: Generalized Failure Mechanism Knowledge (GFMK); Rokkasho reprocessing plant; failure mode analysis; knowledgebase; plant diagnosis

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1. Introduction

The Rokkasho reprocessing plant is a facility comprised of equipment and systems that uses a unique outcome of a variety of fields. Although the plant has been carefully designed to avoid severe troubles, the possibility for equipment failure remains due to a variety of factors. In order to prevent such failures from occurring, potential failure mechanisms have been thoroughly examined in the design phase. However, since it is impossible to predict all sources of failure in the design stage, unforeseen failure mechanisms may still pose a threat to the operations of this facility. In order to achieve a higher level of safety in the Rokkasho reprocessing plant, it is important to be able to predict failure mechanisms extensively and proactively. Although efforts aimed at developing proactive approaches to explore potential failure mechanisms have already been adopted, the potential for overlooking important failure mechanisms must be reduced as much as possible.

Humans are prompted to the specific mind sets due to factors, such as the finite nature of time and knowledge source, or the situational dependency of human thought, and may overlook failure mechanisms. In order to determine the failure mechanism extensively and exhaustively, it is important to consider the failure mechanism of dissimilar equipment in order to exclude specific mind sets.

In order to reduce the possibility of overlooked failure mechanisms, GFMK has been proposed in the field of knowledge engineering [1, 2]. GFMK is a knowledge scheme that describes failure mechanisms independent of a particular subject. GFMK is represented based on the cause–consequence relationship of failure development and the combination of influential factors that describe the enabling conditions, such as failure development. In this scheme, specific conditions are generalized, which allow us to apply GFMK to completely different equipment. Once GFMK has been constructed, it is possible to estimate the likelihood of failure without relying on the empirical and specific knowledge of failures. In our previous study, the GFMK knowledge base according to the events experienced in the Rokkasho reprocessing plant has been developed and it has been confirmed that GFMK can be applied to the realistic scale mechanical subsystems of the Rokkasho reprocessing plant [3].

In this study, the GFMK derived from a mechanical system has been applied to an instrumentation system in the Rokkasho reprocessing plant to examine the generality of the proposed method and to evaluate the efficacy of the derived knowledge on failure mechanism.

2. Method

The derivation process of failure mechanism for a specific system using GFMK is shown in Fig. 1. The target system has been selected and has been represented on a multi-attribute model. By applying the GFMK to the model, a set of possible failure mechanisms is derived. The failure mechanisms already considered in the design phase have been omitted and the remaining failure mechanisms have been taken for further evaluation. The effectiveness of the derived failure mechanism knowledge has been evaluated from two viewpoints shown below:

- Past failure events which actually occurred in a target system
- Knowledge sources, which have been used for deriving failure mechanism knowledge

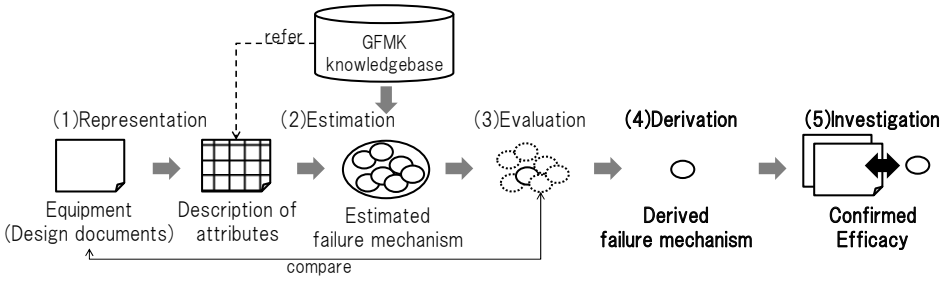

Fig. 1. Procedure for deriving failure mechanisms and efficacy evaluation.