THE SUMMARY OF Ph.D. DISSERTATION

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Title

A study on the evaluation of safety in production systems

Abstract

The layout of a production system is more complex compared to simple groupings of individual pieces of equipment. This leads to unavoidable accidents when safety is not systematically practiced. For example, when equipment is run while installation work is taking place, worker/machine related accidents become more common. But, research studies that reflect a fundamental way of thinking about system safety only appear from time to time. There are few studies that can be applied directly in the factory. And, because safety measures are applied as symptomatic therapy, under present conditions it will take time for most safety measures to be enforced in the factory and to eliminate accidents. This paper aims to systematically evaluate safety measures of the various systems in continuous type production and in separation type production. Therefore, I propose safety evaluation procedures for the total system and for both system reliability assessment methods for safety and diagnosis methods.

Chapter 1 is an introduction, and I have outlined the objectives and concepts in this paper. In chapter 2, I talk about the standardization of the safety index set up for safety design and evaluation for the workforce. We had to overcome the problem of making a TAS (Tree Analysis for Safety) for every targeted system made in the safety index. The path to accidents resulting in injury or death in each hazard potential factor existing in the production system was examined to solve this problem. Then, the path is expressed in combinations of both the logic product and the logic sum of the events that occur. Then, I propose the method along this path to make standard TAS that is not dependent upon the equipment composition of the system.

In chapter 3, I talked about the reliability assessment for safety and the design method of the production system. Because the safety index can't express the magnitude of an accident, it shows that standard TAS can logically resolve the sub-system of each hazard potential factor to solve this problem. Then, I propose taking into account the lowest evaluation sub-system, the representative of the system, after the safety index of all subsystems are established. Next, I propose that the production system is designed so that reliability for safety is satisfied and cost becomes minimal.

In chapter 4, I described the failure diagnosis method targeting a nuclear power plant that is a continuous type production system. When the first cause can be identified, the CCT (Cause Consequence Tree) analysis of building up an accident scenario in a tree shape can be utilized. But, there are subsequent problems that occur in CCT analysis. One is spending too much time on the diagnosis. Another is to signal the wrong alarms when the accuracy of cause identification decreases. So, it becomes necessary to speed-up the diagnosis treatment of the CCT analysis and then the accuracy of diagnosis results will improve. I propose separating the qualitative logical CCT-model, and the relation-file. Then, I also propose periodically calculating the CCT-model with another diagnosis treatment.

And, even when the first cause cannot be identified, it is desirable for the information to be included in the cause investigation for the operator. Then, I propose a symptom based diagnosis method that can search for an abnormal cause by combining knowledge of the physical causal relationship between each event with the rule based inference.

In chapter 5, I described the safety evaluation method of the total system against various accidents caused by human error that can't be prevented by improving dependability and cause identification. First, for the exhaustive safety evaluation, I propose an accident occurrence model that is associated with an accident object and a hazard potential factor because an interception mechanism between the accident object and the hazard potential factor is destroyed by the occurrence of the hazard. Next, a safety measure that prevents an accident occurrence is synthetically evaluated based on this model. Therefore, I propose a safety evaluation matrix with "the person's relations" in the vertical axis and "the applicable conditions of the safety measure" in the horizontal axis. I propose a safety ranking in each element of that matrix. This safety ranking is composed of six steps from "-2" to "+3". The method is called the Safety Evaluation Matrix & Safety Rank method (SEM&SR).

In chapter 6, the Safety Evaluation Matrix & Safety Rank method proposed in the chapter 5 was applied to accidents in the production system and it was verified that safety can be synthetically evaluated with this method although safety can not be totally evaluated with just single evaluation measures. Furthermore, a checklist was made so anyone could efficiently evaluate safety with this method. The result shows that this was tentatively used in the factory. In chapter 7, I describe the conclusion of this paper and also talk about the possibilities for safety evaluation with the exception of the production system.