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Feasibility Study on Integration of Operator Modelling in DICE^{TM}

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EXTENDED ABSTRACT

Due to its unique characteristics, an NPP(nuclear power plant) requires a higher level of reliability than other engineering systems. In order to achieve a higher level of safety and systematic evaluation of NPPs, deterministic safety analysis and probabilistic safety assessment are performed respectively. As the scope of risk expands temporally (i.e., long-term) and spatially (e.g., multi-units), the need for an analysis that reflects more contextual behavior showing non-linear tendencies is steadily being raised. In addition, there is a potential weak point in that it is difficult to discover scenarios particularly for a new type of reactor.

To address this issue, Kyung Hee University has developed a modular platform for dynamic event analysis called DICE(Dynamic Integrated Consequence Evaluation) that makes probabilistic and deterministic methods into a calculation framework. DICE has been steadily developed with case studies:

In the past, research was conducted to evaluate the coverage of the simplified EOP(Emergence Operator Procedure) of NPPs, and recently, research are being carried out to calculate branch probability using MCET(Monte-Carlo Event Tree) method with MELCOR.

DICE also has two simulation methods with different branch generations previously, those called single-branch mode and multi-branch mode, and now called DDET(Discrete Dynamic Event Tree) method and MCET method, depending on the analysis purpose or the method of how to assign probability distributions. It is shown a schematic of the calculation process in Fig. 1. The explanation of DDET is referred to the literature. We describe briefly MCET methods below down:

• Possible to build boundary scenarios for MCET method analysis boundary

The MCET method has the following characteristics.

• Reflect on random failure/recovery of system and operator actions at random times

• In other words, scenario development reflects time-dependent changes in the power plant state according to the random system failure or operator actions and the creation of various scenarios through many simulations

• Scenario variability analysis according to random state/time change of equipment and operator action

→ It is possible to explore unknown or new scenarios. (Update the EOP and PSA)

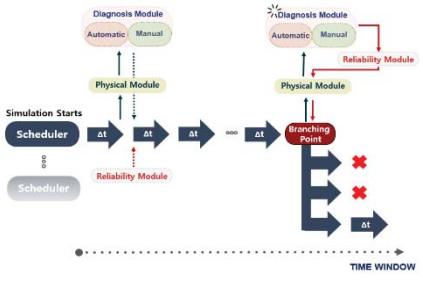

Fig. 1. DICE calculation process(MCET method)

In particular, the MCET method focuses on exploring unknown scenarios and can be applied to a new type of reactor as an initial part of PSA. To explore unknown scenarios using MCET, variability in time should be reflected, and this requires the operator model to provide the operator action time. In this paper, we present the results of applying a dynamic operator model based on HRA(Human Reliability Analysis) that provides various operator action times based on SPAR-H.

The operator model provides operator action time along with the HEP(Human Error Probability) resulting from SPAR-H. To do this, the operator action time for diagnosis is calculated, and then the operator action time for execution is also calculated. Additionally, if the diagnosis is performed quickly, it is also taking into account that the range of time for execution becomes wider. In Figure 2, the results of 7,000 calculations using the operator model based on specific operator tasks and data are shown. When the operator model conducts simulations with DICE, the temporal variability provided by the operator model can lead to different results even for the same accident sequence.

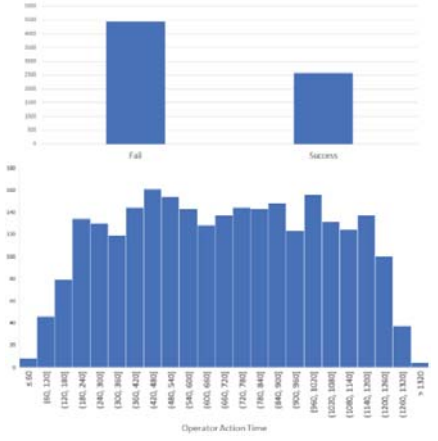

Fig. 2. Result of Operator Model(Upon: Success/Failure, Down: Operator Action Time Frequency)

In various HRA methods, the purpose is to calculate a HEP(Human Error Probability), but this approach is confronted with the difficulty of exploring unknown scenarios. However, by providing temporal variability similar to this operator model, there is a possibility of exploring unknown scenario possibilities. In order to effectively apply DICE using the MCET, the operator model that can provide temporal variability is necessary. Furthermore, this operator model can be applied to the SPAR-H and other HRA methods. we are planning to develop the operator model editor that enables the simulation of various operator models and methods with DICE.

Using this operator model concept and MCET together for accident simulations makes it possible to see various variabilities in accident scenarios. By applying this approach, it is possible to explore unknown scenarios and also see different results from the same accident sequence.

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