Weighting Factors of the Performance Shaping Factors for the Segmentation of Reactor Pressure Vessel Internals Using Fuzzy AHP

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1. Introduction

In recent years, the development of technology for multiplicity and protection has reduced the incidence of accidents due to technical problems. However, it is impossible to say that the system is reliable without mentioning the failure rate of all system components, especially the impact of one of the components, Human Errors, on the system. For this reason, in order to reduce the human error, job analysis and related performance factors of reactor pressure vessel internal structure cutting work were derived. In this paper, we use Fuzzy-AHP to derive the weighting factors of performance shaping factors to understand the importance of performance impact factor items.

2. Fuzzy-AHP

Fuzzy theory, initiated by Zadeh in 1965, has been used in many fields as a mathematical model for analyzing uncertainty involving ambiguity based on the fuzzy set theory. Especially, it is useful for risk analysis in situations where ambiguity due to the subjective perception of the human being can't be handled stochastically.

2.1 Fuzzy-AHP decision step

The decision steps of Fuzzy-AHP are as follows.

- ○ Step 1 : Form a hierarchy
- ○ Step 2 : Pairwise Comparison of evaluation items by expert questionnaire
- ○ Step 3 : Construct a pairwise comparison matrix using a fuzzy membership function
- ○ Step 4 : Calculation of final weighting by normalization after calculating fuzzy weighting
- ○ Step 6: Evaluate the preferences of the alternatives for the sub-items
- ○ Step 7: Convert to consider the preference of each alternative by weighting and Final selection

2.2 Advantages of Fuzzy-AHP

Fuzzy-AHP is effective in describing uncertain phenomena in actual field by introducing fuzzy theory which reflects many similarities and characteristics of natural language which represents human thought. Although the data used for risk assessment are mostly ambiguous language expressions, the pairwise comparison values of Fuzzy-AHP can be more accurate using three values rather than having one value per interval on nine interval scales.

2.3 Deriving Weighting factors, Using Fuzzy-AHP

The order of weight derivation using Fuzzy-AHP is as follows.

1) Derive the comparison fuzzy membership function by AHP weighting
- Compute pair of fuzzy matrices using the 9 - factor significance table applied Ishizaka 's relative important fuzzy membership function.

2) Derivation of the mean value of the pairwise fuzzy matrix
- Find the trigonometric fuzzy function from multiple experts and derive the average value using the fuzzy averaging method (arithmetic mean).

3) Derivation of Fuzzy Synthetic Extent Value
- Compute the fuzzy synthesis extension value to obtain the degree of possibility (V, Degree of Possibility) for given information.

4) Calculate the degree of possibility (V) and weighting
- Calculate the degree of possibility and use it to derive a weighting.

5) Weighting vector conversion
- Normalize the derived weighting.

3. Performance Shaping Factors

Human error probability (HEP) is calculated based on the worker's activity. Much human reliability analysis (HRA) methodologies use performance shaping factors (PSFs) to obtain quantitative estimates from calculated HEPs. Because it can

characterize important aspects of human error and provide numerical criteria that can be adjusted to nominal HEP levels.

The performance shaping factors derived from the reactor pressure vessel cutting process are as follows.

Table 1. Performance shaping factors (Level 1, Level 2) affecting reactor pressure vessel internal structure cutting

Level 1	Level 2
Human	Psychological State
	Physical State
	Performance Capability
Operation	Organizational Factors
	Task Management
	Procedure and Information
Ergonomic System	HMI
	Workplace Design
	Workplace Physical Environment

Table 2. Performance shaping factors(Level 2, Level 3) affecting reactor pressure vessel internal structure cutting

Level 2	Level 3
Psychological State	Stress
	Emotional State
	Safety Awareness
Physical State	Fatigue
	Physical Capability
	Discomfort
Performance Capability	Task Knowledge and Memory
	Experience
	Personal capability
Organizational Factors	Overall Planning
	Supervision of Management
	Team Factors
Task Management	Work Process Design
	Workload Management
	Problem Identification and Solution
	Communication Availability and Quality
Procedure and Information	Availability
	Complexity
	Accuracy and Completeness
	Feedback and Recency
HMI	Interaction Element
	Familiarity of Controller and Display
	Complexity of Controller and Display
	Maintenance
Workplace Design	Physical Access to Work Items
	Warning Sign
	Arrangement of Functional Areas
	Safety Device
Workplace Physical Environment	Noise
	Lighting
	Temperature
	Radiation Level

4. The results of derived Performance effect factor weighting

The weighting factors for the performance shaping factors derived from the reactor pressure vessel internal structure were derived using Fuzzy-AHP. A total of 32 Level 3 performance shaping factors' weighting were derived. Typically derived weightings are Task Knowledge and Memory 0.16, Stress 0.10, Personal Capability 0.09, Emotional State 0.05, Fatigue 0.06, Safety Device 0.04, Radiation Level 0.03. As a result, it is possible to reduce the possibility of human errors by improving the knowledge and ability of the individual through continuous education and training programs. In addition, if the environment is well maintained and managed, it will be effective to prevent human errors in cutting the internal structure of the reactor pressure vessel.

5. Conclusion

It is difficult to predict the probability and type of human errors that can occur between jobs, if the overall characteristics of the worker's job performance can’t be accurately grasped, or if the decision process and job characteristics of the worker are not completely known. In order to mitigate such human error, the importance of performance factors related from the cutting work of the reactor pressure vessel internal structure was grasped, and it was considered necessary to manage the items with high importance among the items.

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