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Development of RCM analysis software for Korean nuclear power plants

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ABSTRACT

A software called KEPCO RCM workstation (KRCM) has been developed to optimize the maintenance strategies of Korean nuclear power plants. The program modules of the KRCM were designed in a manner that combines EPRI methodologies and KEPRI analysis technique. The KRCM is being applied to the three pilot systems, chemical and volume control system, main steam system, and compressed air system of Yonggwang Units 1&2. In addition, the KRCM can be utilized as a tool to meet a part of the requirements of maintenance rule (MR) imposed by U.S. NRC.

1. Introduction

RCM is a systematic consideration of system functions and the ways in which functions can fail, leading to the identification of applicable and effective preventive maintenance tasks (PMs) with consideration of safety and economy[1]. The RCM process involves the completion of a series of discrete analyses on each system selected by an analyst. As such, there are several advantages to develop a computer software for the RCM analysis. Therefore, we have developed the KEPCO RCM workstation (KRCM) based on EPRI methodologies and analysis technique established newly by Korea Electric Power Research Institute (KEPRI). The KRCM makes it a lot easier to do the RCM analysis than solely by manual process.

Through RCM project of the pilot systems of Yonggwang Units 1&2, the KRCM is being used to find out more effective tasks and intervals, furthermore it will be used for feedback of the results of RCM implementation to monitor effectiveness of maintenance tasks, which satisfies a part of the requirements of maintenance rule.

2. Description of the KRCM

The KRCM was developed under Windows 95 environment using MS Visual Basic and MS Access RDBMS. The KRCM is a improved computer software comparing to EPRI RCM Workstation, also it includes both EPRI's generic data and Yonggwang Units 1&2 plant specific reliability data. Main differences between the KRCM and EPRI RCM Workstation are; 1) The grading method in failure mode effects analysis (FMEA) to screen critical components, 2) selection method of applicable PMs in logic tree analysis (LTA), and 3) non-critical components evaluation process (NCE).

The procedures of RCM analysis with KRCM consist of as follows: 1) creation of systems and plants, 2) system analysis, 3) maintenance tasks analysis, 4) implementation, and finally living program. In this section, the analysis process will be described with KRCM workstation program.

2.1. Creation of systems and plants

The initial main screen of the KRCM is shown in Fig. 1 in which main menus are displayed, and it contains visual command buttons according to RCM analysis flowchart as an alternative of menus. The main menus are consist of Administration, RCM analysis, Living Program, Reporting, and Help.

First of all, a plant and system module must be established before any work is performed with the KRCM. The Administration menu provides assembled administration of plants, systems, users, and data related to RCM analysis. In this menu, we can create a plant and system to be analyzed. Creating a new plant will be completed by editing information on plant ID, name, type (e.g. PWR, PHWR, and BWR), and description. In the created plant module, a new system can be created by editing information on system ID, name, analysis method (e.g. Function Based, Experience Based, Preventive Maintenance Optimizer, Criticality Check List, and Criticality Matrix), system operating conditions, and selection method of PMs (e.g. Simplified LTA, Modified LTA). Through the above two steps, a plant and system is designated for the analysis, the next steps are described in terms of function based analysis (FMEA) and modified LTA (MLTA).

2.2. System analysis

The functional failure analysis (FFA) must be completed before the FMEA process is started. The FFA sub-menu defines the system function, functional failure, and assign the components related to functional failure.

In the FMEA sub-menu, the critical failure modes of a component are screened by an analyst's decision with the KRCM support. The FMEA process is described as follows: 1) selecting a

failure mode to be analysed, 2) assigning failure effects to the failure mode, these failure effects are local, system, and plant effects, 3) grading of the failure mode in the summary box showing all information on functional failure, component name, failure mode, failure effects, and failure rate like as shown in Fig. 2. In this summary box, the failure mode is evaluated by analyst's engineering judgment. The failure modes are graded as A, B, C, and NC. The "A" means safety related component, the "B" means availability related component, the "C" means high maintenance cost required component, and the "NC" means non-critical component. Especially the "C" can be determined quantitatively using COSMA, which is a module to calculate the cost of maintenance tasks. The "NC" is evaluated again in the NCE process, as a result, the "NC" is graded as again D and N. The "D" means non-critical components but it needs PMs, and the "N" means original non-critical component resulting in run-to-failure operation mode. The "A", the "B", and the "C" are all critical components to be evaluated at the next steps such as assigning failure cause (AFC) and MLTA.

2.3. Maintenance tasks analysis

The RCM analysis menu of the KRCM also provides AFC and MLTA sub-menu related to maintenance tasks analysis. In the AFC step, failure causes associated with critical failure mode can be assigned. Next step is MLTA process selecting applicable preventive maintenance tasks (PMs). From this MLTA process, a failure cause is selected, then, several questions about PMs and conditions of failure cause are provided to an analyst. Then PMs preventing failure cause are selected through these questioning and answering process as shown in Fig. 3. These selected PMs are finally determined at the last step in MLTA process, it can be composed of more than one PM such as failure finding tasks, condition monitoring tasks, and so on.

2.4. Implementation

When the PMs are selected in the MLTA process with the KRCM, all PMs related to component must be compared to the other PMs such as existing PMs and vendor recommended PMs to determine finally what PMs will be implemented. Then implementation planning must be established as shown in Fig. 4.

2.5. Living Program

All PMs finally determined will be implemented according to the KRCM recommendations. But, these recommendations are not always exactly optimized strategies. Therefore it is always necessary to monitor the RCM program and correct it periodically with KRCM. It will be accomplished by Living Program menu in the KRCM.

3. Relationship to Maintenance Rule

The maintenance rule (MR) requires plant safety to be preserved through effective maintenance[2]. As we have seen, RCM strives to maintain plant safety and increase efficiency through the improved component reliability resulting from cost-effective maintenance. The rule implies cost-effectiveness maintenance and NUMARC 90-01 guide suggests a structured process for determining appropriate SCCs and associated maintenance tasks[2,3]. RCM provides systematic structure for system and component selection, failure analysis of the system, and maintenance task analysis. As a result of precise review the relationship between RCM program and the MR, most MR requirements are met and supported by RCM as a part of its evaluation and monitoring processes.

Through RCM project of the pilot systems of Yonggwang Units 1&2, the KRCM is being used to find out more effective tasks and intervals, furthermore it will be used for feedback of the results of RCM implementation to monitor effectiveness of maintenance tasks, which satisfies a part of the requirements of maintenance rule.

4. Conclusions

A software called KRCM has been developed to help RCM analysis for the Korean nuclear power plants. It provides the systematic RCM analysis tool to optimize maintenance strategies of a plant, resulting in improvement of reliability, safety, availability, and cost effectiveness. The KRCM is being well used in RCM analysis process of the pilot systems of Yonggwang Units 1&2. In addition, the KRCM can be utilized as a tool to meet a part of the requirements of maintenance rule (MR) imposed by U.S. NRC.

References

[1] S.Y. Hong, K.H. Choi, H.J. Jeong, Y.H. Kim, "RCM Analysis Methodology Development and Pilot System Study for Yonggwang Unit 1&2", KEPRI Technical Memo TM.96NJ10.M1998.64, Korea, Feb. 1998.

[2] U.S. NRC, "Requirement for Monitoring the Effectiveness of Maintenance at Nuclear Power Plants", 10CFR50.65, July 1991.

[3] "RCM Evaluation, Maintenance Technology Training Material", EPRI TM-1002, Feb. 1995.

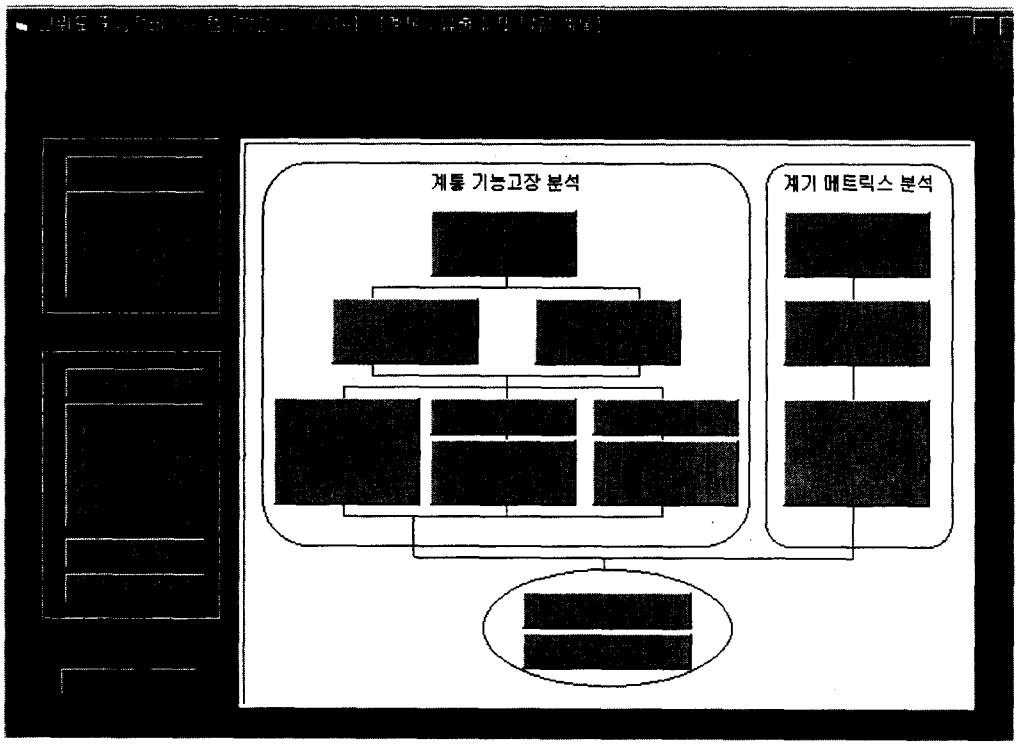

Fig. 1 Main screen of RCM analysis software (KRCM) for optimization of preventive maintenance tasks.

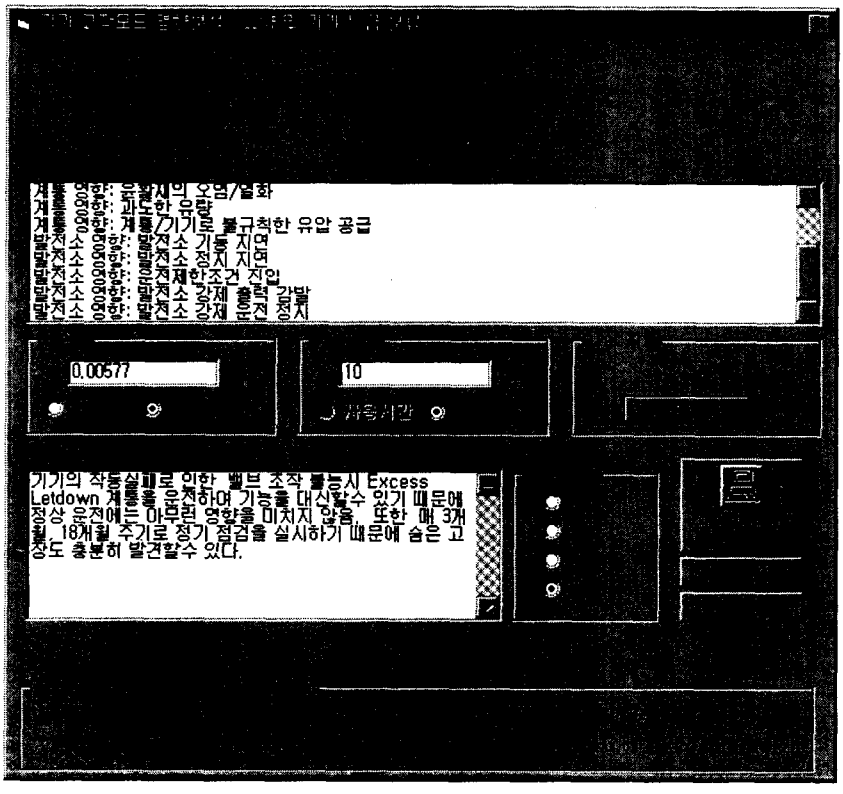

Fig. 2 A FMEA summary screen.

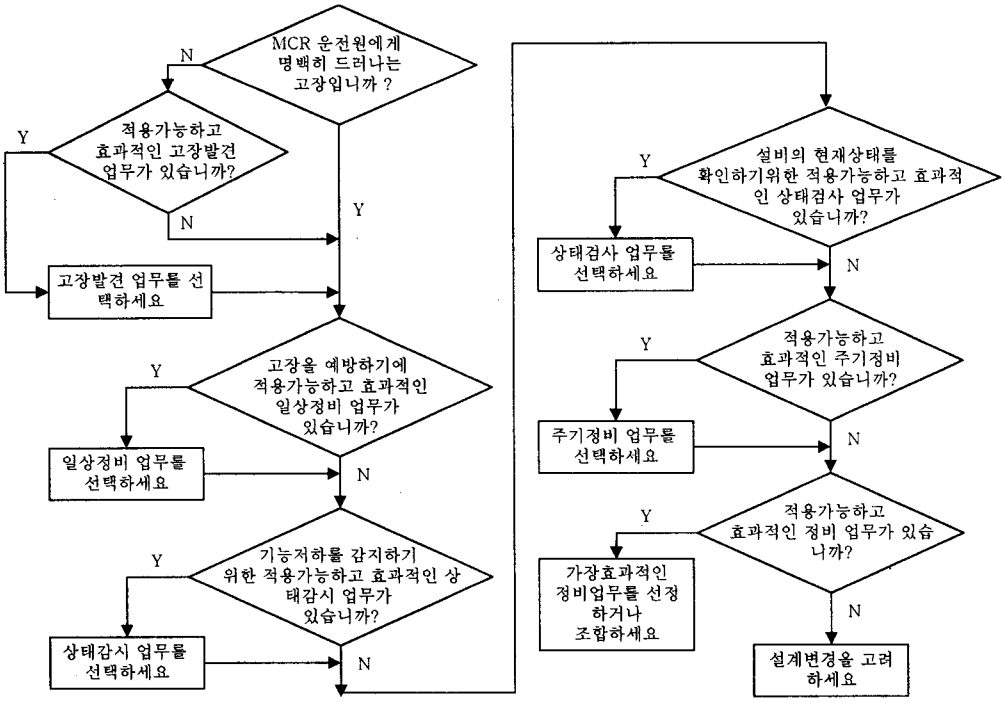

Fig. 3 The flow diagram of MLTA for selecting effective PMs.

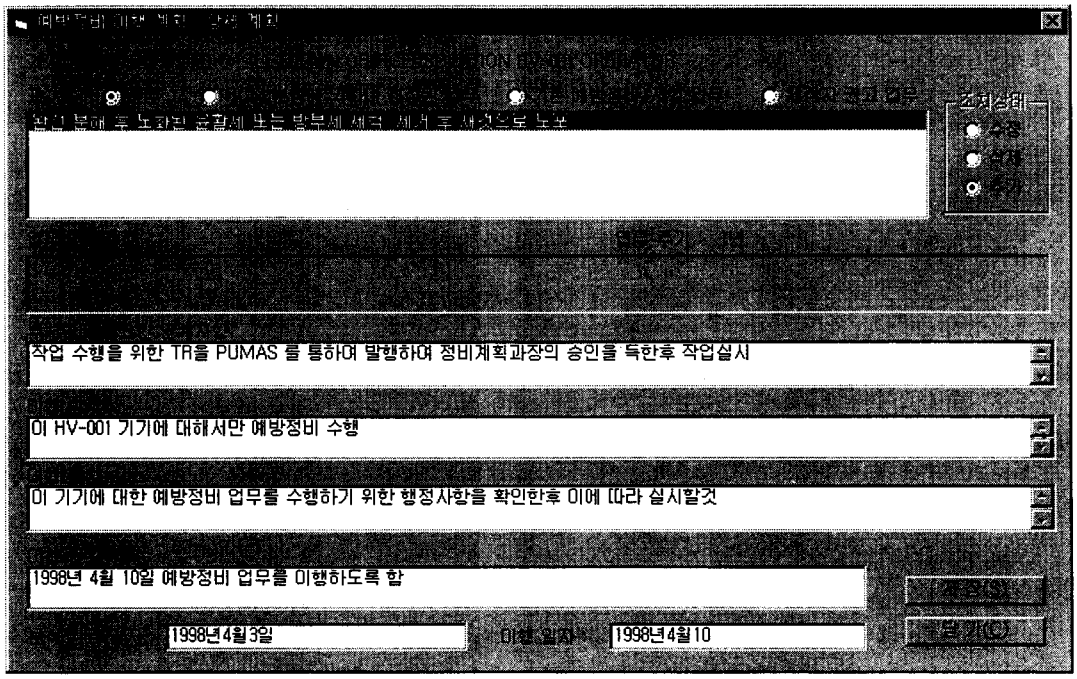

Fig. 4 A screen related to PMs implementation.