Deveolpment of Fatigue Evaluation and Monitoring System for Korean NPPs

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1. Introduction

Korean nuclear power plants (NPPs) go on long term operation phase. A series of cases as follows substantiate the fact, that is to say, the continued operation of Kori unit 1 since early 2008 and the refurbishment work of Wolsong unit 1 to extend its operation lifetime. Also, there are six nuclear power plants whose operating years are more than twenty years. Preparatory works of the continued operation for these NPPs need to be considered as from ten years. In order to operate NPPs forty years or more, operational transients occurred during plant's lifetime are subject to be monitored and fatigues on key components and piping should be evaluated. KEPCO Research Institute has been developing Fatigue Monitoring and Evaluation System (FEMS) to cope with long term operation of Korean NPPs since 2007 aiming for practical application in 2014. This paper describes structure, functions, features and system architecture of FEMS.

2. Overview of FEMS

FEMS consists of three key function modules that manage operational transients, calculate cumulative fatigue usage factor on basis of transients and stress respectively. Various operation data such as temperature, pressure, flow, and valve position are received from PI system. Operation data are input into the intelligent cycle counting module (ICC) and signal feature based evaluation module (SFBE) simultaneously. The ICC module monitors the input data and decides whether transients occur or not. In case that operational transient occurs, the ICC module stores transient data and transfer results to the SFBE module to compute cumulative usage factor (CUF). The SFBE module calculates transient signal feature based CUF and stores the results. The operational data input into the Stress-based fatigue evaluation module (SBE) are converted into stress to use stress-based CUF.

FEMS is divided into two main parts largely, namely, software common function part and plant specific customization part. The former handles input data such operational data and is used for any plants in common. The latter functions cycle counting, calculation of CUF on the basis of signal features and stress respectively, and should be customized within the plant specific requirements. Figure 1 shows correlation diagram of key functional modules of FEMS.

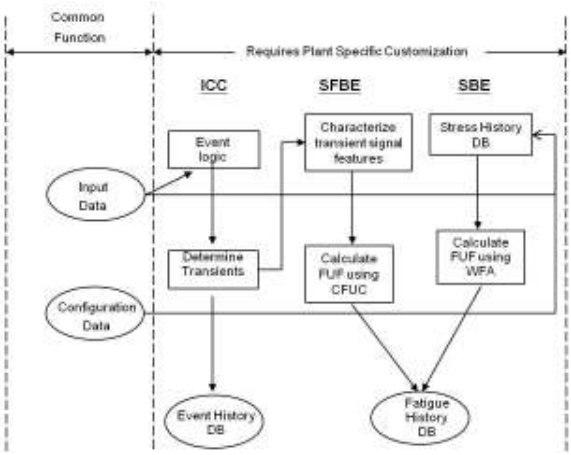

Fig. 1 Correlation diagram of key functional modules of FEMS

3. Program features of FEMS

Advanced algorithms are applied to improve an accuracy and conservatism of results in computation of CUF.

3.1 Characteristic fatigue usage curve (CUFC)

Most of transients occurred in Korean NPPs are operation transients that come short of the design transients by far. Operation transients have an effect much less on fatigue in comparison with design transients. For transient signal feature based fatigue monitoring, a unique curve named, CUFC is applied. CUFC reflect plant operation transients accurately so that can reduce the conservatism of fatigue calculation up to 96 %.

3.2 Advanced Green's function

The advanced Green's function method combined with a weight function is applied to reflect the effects of the flow rate of coolant and the temperature-dependent material properties for stress-based fatigue monitoring.

Using the advanced Green's function produce more accurate calculation results of stress subjected to components by thermal fluctuation.

4. System architecture of FEMS

FEMS is a computational program with web-based on-line real time to monitor transient occurred in NPPs and evaluate fatigue on key components and piping. FEMS may runs on Window XP or above with IBM compatible Pentium IV PC or above and Internet Explore 6.0 or above. Figure 2 shows schematic of FEMS.

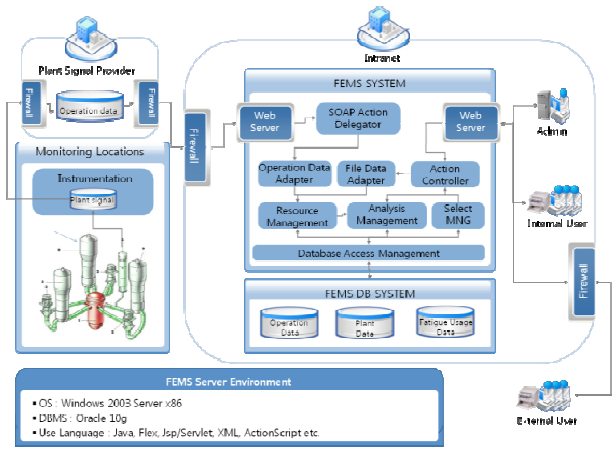

Fig. 2 Schematic of FEMS

Operation data measured from key components and piping is loaded into FEMS with interlock on real time basis after effectiveness verification. Data that fail to load can be imported to FEMS through verification. Loaded operation data is used to compute CUF with fatigue evaluation module and results are loaded in database. Operation data within a certain period of time can be confirmed in form of list and graph and analyzed data can be recalculated by changing fatigue evaluation module. Administrator adds users, authorize access right, add or change components to be monitored, and monitor system error and attempt of unauthorized access using logging information.

FEMS server is located inside firewall and it guarantees system security against outside aggression. Only authorized users can access the system. In order to secure stable system structure during project life cycle from development to maintenance, frame work such as Common, Configuration, Resource, Logging, Database Access and Web(Model 2) is made up of component form.

In Figure 2, FEMS system has internal functions on the basis of programming layer as shown in Figure 3.

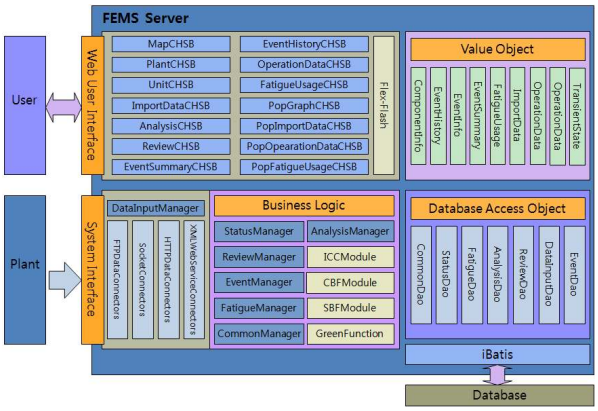

Fig. 3 Functional block diagram of FEMS

This layer compartment maintains system consistency that can provides good results of debugging, maintenance and test.

5. Conclusions

Structure, functions, program features and system architecture of FEMS which is being developed by KEPCO Research Institute have been dealt in this paper. It is expected for FEMS to be applied practically to Korean NPPs from 2014.

FEMS has some advanced algorithms to improve an accuracy and conservatism in computation of CUF using Green's function to reflect the effects of the flow rate of coolant and the temperature-dependent material properties for stress-based fatigue evaluation and using CUFC to reflect plant operation transients for signal feature based fatigue evaluation.

FEMS is web-based on-line user friendly expert system to monitor operation transients and evaluate fatigue of key components and piping with PC. FEMS would make NPPs more safe operation and more long term operation through systematic fatigue monitoring over plant's lifetime.

REFERENCES

[1] KHNP, "Interim Report, Development of Fatigue Monitoring Program for Major Components and Piping in Nuclear Power Plants", July 2010.