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Mainformatics for Condition Monitoring Based Predictive Maintenance

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1. Introduction

Maintenance, or simply repairing, may be born with the beginning of industry. If it were not for maintenance, we could not keep the pace of industrialization because of excessive resource waste. While maintenance always exists, its meaning is getting more focused as the industry is more matured, more competitive, and more significant, which is apparently taking place in nuclear industry. In Korea, ~30% of the operating NPPs are older than 20 years. According to NUREG/CR-6679, [1] the average degradation rate has increased from 0.065 to 0.24 during the past decade, which may be applicable to Korean NPPs. The economics of NPPs is always controversial, but its role in producing stable and cheap electricity is currently more emphasized.

Maintenance is typically placed in either side of reactive manner or proactive manner. We call the reactive way of fixing as 'corrective maintenance', and the proactive way as 'preventive maintenance.' Unfortunately, both maintenance strategies are expensive or unnecessary. Because the component does not necessarily require it, thus the maintenance cost is wasted. And worse, the unnecessary maintenance can cause the introduction of failure catalysts into properly working components. Therefore, the maintenance framework that maximizes cost-benefit has been steadily asked, so one of the currently discussed keyword may be condition monitoring based corrective maintenance. Corrective maintenance is placed somewhere between corrective and preventive maintenance, so it can take the advantages; reducing resource waste and reducing downtime from the both sides. It turned out the condition monitoring based corrective maintenance covers the extremely wide range of technology and is not well-equipped in NPPs since 1) it is difficult to verify or validate the developed technologies, 2) it is complicated to be integrated with a former system, 3) the hardware including sensors and information-technology equipment is lack, and 4) the software for appropriate signal processing, analysis, or diagnosis is deficient.

This study will skim through the entire framework related to the condition monitoring based corrective maintenance. This should be closely associated with information-technology so we will propose a new academic terminology, mainformatics, integrating maintenology and informatics. Ultimately this study aims to suggest a practical method to efficiently implement the condition monitoring based corrective maintenance in nuclear industry.

2. Methods and Results

2.1. Definition of Mainformatics

Mainformatics comes from the combination of maintenology and informatics. While informatics is well known as information science, maintenology looks unfamiliar. Maintenology was originated from maintenance engineering supported by theoretical aspects, which means maintenance is no more a just experienced-based practice. Maintenance is now science and information science contributes on the theoretical aspect of maintenology.

2.2 Technical Core – Just-In-Time Warning

The definitive purpose of mainformatics or the condition monitoring for predictive maintenance must be to determine equipment condition, to predict potential failure, and to warn such a failure 'just-in-time.' Just-in-time is equivalently considered as a measure of cost-benefit effectiveness of maintenance and should be determined by a number of variables as follows:

- Performance and risk equivalent worth when a system is continuously running and unexpectedly failed
- Resource for maintenance and its compensation
- Methodology and uncertainty related to monitoring and/or diagnosis

While the first two variables are connected with the PSA model or the efficiency model of a specific plant, [2] the last can be independently derived from a general condition monitoring problem. Mainformatics in this study will be focused on only the monitoring techniques in the last one.

In principle, the monitoring (or detection) should be quick, accurate, and robust to secure just-in-time warning capability. 'Quick' is a matter of response time. 'Accurate' is a matter of uncertainty. 'Robust' is a matter of availability of the methodology adopted. Three natures are highly coupled, so it is not easy to provide an almighty method to eliminate their contradiction. As a current candidate to balance these principles, the combination of the process or equipment state estimation and the statistical monitoring is recommended. [3, 4, 5] The backbone of this framework is to set a dynamic threshold value taking into account of system's condition, and to monitor the residual between the threshold value and an actual observation in a statistical manner to lessen the impact of uncertainty. The process or equipment state estimation is normally based on the flowchart shown in Figure 1. As the process monitoring techniques, sequential analysis or statistical charts are representative. Some references well delineate how to optimize three principles as stated above. [4, 6]

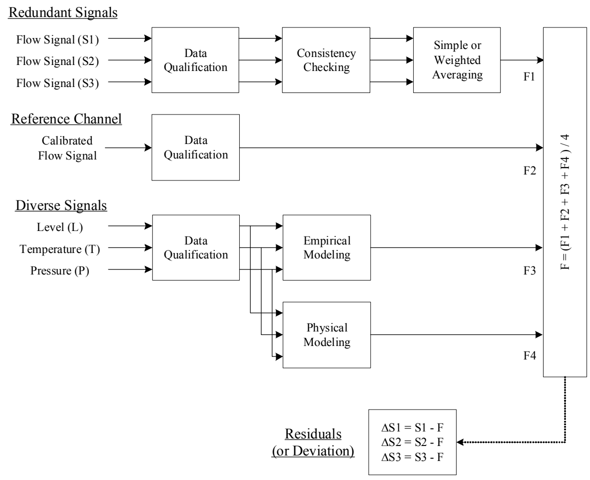

Figure 1. Framework for process or equipment state estimation

2.3 System Integration

It is of importance that the technical core is organically integrated with the entire system architecture to complete maintenance framework. This helps to increase the confidence level of the understanding on the system condition and to extensively support operator's decision making.

The six blocks of functionality and the general inputs and outputs defined in ISO-13374 [7, 8] for a condition monitoring system can be a guideline for this purpose. In Figure 2, the lower three blocks are typically technology specific, for example, vibration monitoring or heat transfer capability estimation and they contain the methodologies involved in the technical core. The upper three blocks combine human concepts with monitoring technologies in order to assess the current conditions of system or equipment, predict future failures, and provide recommended action steps to operations and maintenance personnel.

The framework for a condition monitoring based predictive must take on the task of integrating a wide variety of software and hardware components as well as developing a framework for these components. It is necessary to simplify this process by specifying a standard architecture and framework, which is lack in Korean nuclear industry.

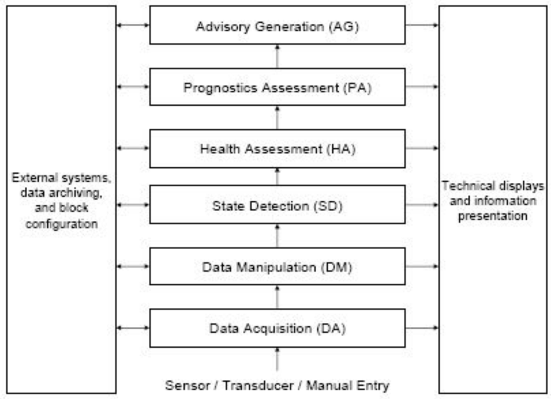

Figure 2. Condition monitoring and diagnostics architecture in ISO-13374

3. Conclusions

This study looked over the entire framework consisting of the condition monitoring based corrective maintenance. Some issues on the technical core and system integration were also discussed. In Korea, it seems to be the time to start developing an overall framework and integrating with hardware and software products which have already implemented.

REFERENCES

[1] J.I. Braverman, C.H. Hofmayer, R.J. Morante, S. Shteyngart, P. Bezler, Assessment of Age-Related Degradation of Structures and Passive Components for US Nuclear Power Plants, NUREG/CR-6679, US Nuclear Regulatory Commission, 2000.

[2] D. Blanchard, W. Brinsfield, P. Szetu, Generation Risk Assessment Plant Implementation Guide, EPRI-1008121, Electric Power Research Institute, Inc., 2004.

[3] H.M. Hashemian, On-Line Testing of Calibration of Process Instrumentation Channels in Nuclear Power Plants, NUREG/CR-6343, US Nuclear Regulatory Commission, 1995.

[4] G. Heo, Condition Monitoring Using Empirical Models: Technical Review and Prospects for Nuclear Applications, Nuclear Engineering and Technology, Vol. 40, No. 1, pp. 49-68, Feb. 2008.

[5] SmartSignal, The Value of Predictive Analysis for Fossil-Fuel Power Plants, Product Brochure, 2006.

[6] J.W. Hines, Technical Review of On-Line Monitoring Techniques for Performance Assessment, NUREG/CR-6895, US Nuclear Regulatory Commission, 2006.

[7] ISO-13374, Condition Monitoring and Diagnostics of Machines - Data Processing, Communication and Presentation

[8] Internet homepage, http://www.mimosa.org