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Integrated Approach for an On-line Condition Monitoring of Process Components

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1. Introduction

These days, the basic maintenance strategies are being shifted from a periodic maintenance to a predictive and condition-based maintenance based on an on-line condition monitoring of the deteriorated components, equipments and processes. There are several on-going efforts to monitor and detect the deteriorated components and the disturbed processes. Their efforts are to achieve an optimum safety and economy for an operation and maintenance. Integrated information of the symptom signals emitted from the deteriorated components will provide confidence for an understanding of the health condition of the underlying process components. In order to increase the confidence level of the understanding on the health condition of the underlying processes and components, an integrated and multi-disciplinary approach has been adopted in Alarm Diagnosis-Integrated Operator Support System (ADIOS). It especially, provides the capabilities for a diagnostics and prognostics evaluation of a process disturbance that will detect a component degradation prior to a component failure or a process shutdown.

2. Condition Monitoring of Process Disturbance

2.1. Fundamentals

All of the degradation and failure of a valve, pump and sensor, after all, cause a disturbance of a process related with the degraded components. Such degradation indicates several symptoms, such as a mismatch of a process balance, a mismatch of a thermal energy and an increase or decrease of a process value. Initial indication of such symptoms will be displayed on the alarms. Therefore it is a good means to monitor the disturbed process for a healthy condition of the process components and sensors. Figure 1 shows a configuration of the six modules in ADIOS. [1,2,3,4].

2.2. PMM(Process Parameter Monitoring Module)

Objective of the PMM is to invoke the submodules affected from a process disturbance. It tracks a process parameter, and decides on the entry condition to invoke the submodules related with a process disturbance. Basically, a signal validation and range check are carried out in this module. Their resulting messages are displayed. The monitoring parameters are decided on using an analytic method of the hierarchical Goal-Tree-Success-Ttree(GTST).

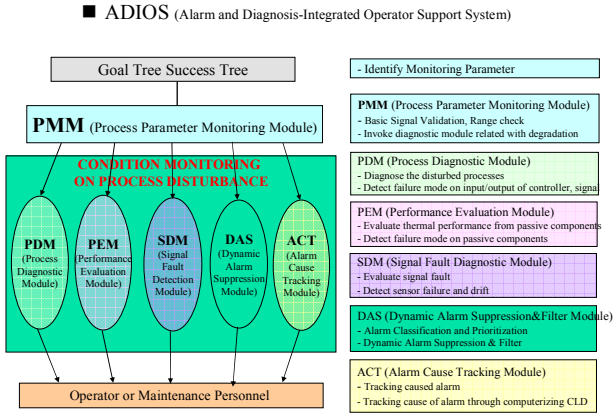

Figure 1. Configuration of the six modules in ADIOS.

2.3. PDM (Process Diagnostic Module)

Objective of the PDM is to diagnose a cause related with a process disturbance. All of the process disturbances occur as a result of sensor failures or hardware failures. A process disturbance becomes more deteriorated if the disturbance is not diagnosed and mitigated. PDM consists of two diagnostic modules, i.e. a sensor fault diagnostic module and a hardware fault diagnostic module. The diagnosis of a process disturbance is started when the alarms of the process monitoring points(diagnostic entry conditions) are fired. Sensor fault diagnostic module diagnoses the sensor fault using the T-H relation of the sensors and using the coherent relationships among the process variables, i.e. conservation equation(mass or energy balance), pump performance curves, control algorithmic equation for the control loops and a correlation between the control valve opening and flow rate. Hardware fault diagnostic module analyzes the fault propagation scheme through a simplified directed graph(SDG) of the target process and then diagnoses the hardware and process faults by matching the failure mode patterns.

2.4. PEM (Performance Evaluation Module)

Objective of the PEM is to evaluate the thermal performance and diagnose a degradation or failure of the

passive components such as the heat exchangers of a feedwater system, moisture separator reheater, etc., using a turbine cycle performance test in nuclear power plants. Generally, simplified performance tests and weekly performance checks in nuclear power plants are being conducted. While some passive components subjected to a turbine cycle will be degraded or failed, their thermal performance will be decreased. The decreasing rate of the thermal performance is to be used as a measurement of the degradation or failure of each component. The difference between the embedded performance analysis modules and the actual performance analysis work is identified. The trend analysis and the correction curves of the essential parameters in a turbine cycle are used as support for a decision-making.

2.5. SDM (Signal Fault Diagnostic Module)

Objective of the SDM is to estimate a noise signal from the sensors. An effective approach to detect and diagnose multiple failures of sensors in a dynamic system is developed for the case where the measurement noise is correlated sequentially in time. It is based on the modified interacting multiple-model (MIMM) estimation algorithm in which a generalized decorrelation process is developed by employing the autoregressive (AR) model for the correlated measurement noise. The enhanced performance of the applied algorithm is demonstrated through a model of a steam generator in nuclear power plants.

2.6. DAS (Dynamic Alarm Suppression&Filter Module)

Objective of the DAS is to suppress and filter a nuisance alarm during some changing operation condition. There are a lot of alarms based on the one sensor - one indicator' approach in conventional alarm systems. Many alarms are temporarily generated according to a changing operational mode or reactor shutdown. But when the operational mode is changed, several alarms appear and disappear in a minute. These alarms are caused by a temporary process disturbance when some pump or valve is turned on or off in terms of changing the demand of an operational mode. Most of these temporary alarms are nuisance alarms that an operator needs not recognize. DAS module suppresses or filters these nuisance alarms.

2.7. ACT (Alarm Cause Tracking Module)

Objective of the ACT is to track the causes of the alarms when generated by a process disturbance as a result of sensor failures or hardware failures. Sensor failures or hardware failures cause a lot of nuisance alarms because of the physical or logical connections between the systems. ACT module uses the logical information acquired from the LDs(Logic Diagrams) and ARPs(Alarm Response Procedures) which include a logical relationship between the alarms and the system states. It uses the logical relationships between the object oriented and visualized logics which are constructed from the logic diagrams and alarm response procedures. ACT provides an operator with the causes of a concerned alarm, the tracking path from the alarm to its causes on the logic diagrams, the precedent alarms and the alarm response procedure with the detected causes, related directions and so on.

4. Conclusion

There are several on-going efforts to monitor and detect the deteriorated components and the disturbed processes to achieve an optimum safety and economy for an operation and maintenance. On-line condition monitoring of processes in nuclear power plants provides the operator or maintenance personnel with information on the health condition of their components, equipments and processes. In order to increase the confidence level of the understanding on the health condition of the underlying process and components, an integrated and multi-disciplinary approach, the Alarm Diagnosis-Integrated Operator Support System (ADIOS) has been developed.

Acknowledgement

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