

THE IMPORTANCE OF MODEL BASED DIAGNOSIS APPLICATION TO POWER PLANTS

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Abstract. An on-line process monitoring system is essential to be an integral part of any power plant control system. Model-based methods of fault detection were developed by using input and output signals and applying dynamic process models. The task is to generate symptoms indicating the difference between nominal and faulty status. It will follow fault diagnosis procedures, determining the fault.

Keywords.

Power plant, maintenance, model based fault diagnosis, fault detection and isolation

1. INTRODUCTION

Power plants and cogeneration systems are complex systems, which need implementation of a good maintenance program. This program must satisfy safety and availability level and economical requirements. The application of a maintenance service is a good and long behavior in service and, in the same time, attenuation of exploitation costs. This thing is possible only by the reduction of failure numbers. There are two great types of maintenance policies: corrective maintenance and preventive maintenance. Corrective maintenance is used for plant recuperation after failures and preventive maintenance is for failure appraisal. Predictive maintenance (or conditional maintenance) is that in which the intervention is made only if it exists an imminent risk or the performances of the system are strongly degraded. The replacement decision of the failure elements depends by the diagnosis studies results. Significant savings in operation costs can be realized by optimally scheduling plant maintenance and minimizing down time.

There has been considerable work presented in the literature in the areas of optimization, modeling, advanced control and fault diagnosis of dynamic system. The implementation of these modern techniques requires a significant amount of computing resources, efficient data storage and retrieval capabilities and the archival of huge amounts of historic data of plant condition.

Today a large percentage of power plants are controlled by analog control systems. These have very limited computing and data management capabilities, consequently it is very difficult to implement most of the modern techniques in the existing analog control systems.

Advances in computer technology have resulted in the development of extremely sophisticated process control systems with vast computing and memory capabilities. Advances in database technology have enabled the efficient archival and retrieval of large amounts of historic plant operating data. These advances have facilitated the implementation of complex algorithms, on-line monitoring schemes and optimization algorithms.

A majority of the existing on-line process monitoring schemes for power plants consists of simple limit or trend checks on the process operating parameters. Although these are adequate for signaling abnormal operation of the plant they provide minimal information about the nature of the fault and are of marginal use in fault diagnosis. In most cases limit and trend checks are able to detect severe deviations from normal operating conditions but are

usually not useful for monitoring slow plant degradations. Most of simple on-line process monitoring systems currently in use provide very little predictive capability and often cannot predict the severity of the system degradation at some future time.

2. A SHORT BRIEF ABOUT ACTUAL SITUATION IN POWER PLANTS

The power plant is a complex nonlinear dynamic system. The dynamic characteristics of the power plant change considerable as the operating load varies. Thus a model which accurately represents the system dynamics at full load may not accurately represents the system dynamics at other operating load. The power plant system dynamics has hard nonlinearities and is also subjected to degradation due to phenomena such as heat exchanger fouling. The occurrence of the plant degradation changes the dynamics of the power plant over time.

Within the automatic control of power plant systems, supervisory functions serve to indicate undesired or not permitted process states, and to take appropriate actions in order to maintain the operation and to avoid damage or accidents. The following functions can be distinguished:

- (1) monitoring: measurable variables are checked with regard to tolerances, and alarms are generated for the operator;
- (2) automatic protection: in the case of a dangerous process state, the monitoring function automatically initiates an appropriate counteraction;
- (3) supervision with fault diagnosis: based on measured variables, features are calculated, symptoms are generated via change detection, a fault diagnosis is performed and decisions for counteractions are made.

A majority of power plants are controlled by multiloop PID control systems. These have three basic components (P-proportional, I- integrator, D-derivative), which realized next basic function:

- Adjusted output control system in concordance with amplifier factor(P);
- Eliminated errors from steady states (static behaviour) (I);
- Anticipated further behaviour of the process (D).

In most cases the control system is tuned to optimize performance at full load. However since the system dynamics changes considerably with power output the efficiency of power plant decrease at other operating loads.

3. MODEL BASED FAULT DIAGNOSIS

In general, *faults* are deviations from the normal behaviour in the plant or its instrumentation. The faults of interest belong to one of the following categories:

- additive process faults,
- multiplicative process faults,
- sensor faults,
- actuator faults.

The time dependency of faults can be distinguished, as shown in Figure 1, abrupt fault (stepwise), incipient fault (driftlike), intermittent fault.

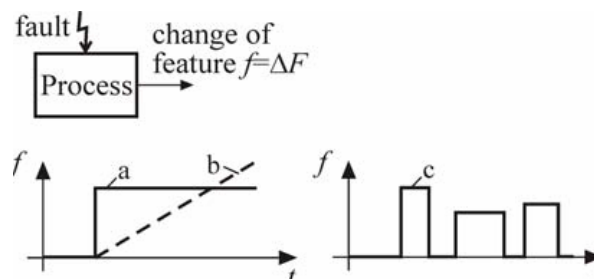


Figure 1. Time-dependency of faults: (a) abrupt; (b) incipient; (c) intermittent

Fault detection and diagnosis (FDD) systems implement the following tasks :

- ✓ *Fault detection (FD)*- the indication that something is going wrong in the monitored system;
- ✓ *Fault isolation (FI)*- the determination of the exact location of the fault(the component which is faulty);
- ✓ *Fault analysis(FA) or identification*- the determination of the magnitude of the fault.

Most practical systems contain only the fault detection and isolation stages (and are referred to as *FDI systems*). Also, in many cases "diagnosis" is used simply as a synonym to "isolation". Usually, the FDI activity takes place on-line, in real-time; the two tasks, detection and isolation, may be performed in parallel or sequentially.

Different approaches for fault detection using mathematical models have been developed in the last 20 years, [2-Issermann005].

The task consists of the detection of faults in the processes, actuators and sensors by using the dependencies between different measurable signals. These dependencies are expressed by mathematical process models. This idea can be extended to the comparison of two analytically generated quantities, obtained from different sets of variables. In either case, the resulting differences, called *residuals*, are indicative of the presence of faults in the system.. Figure 2 shows the basic structure of model-based fault detection and isolation (FDI).

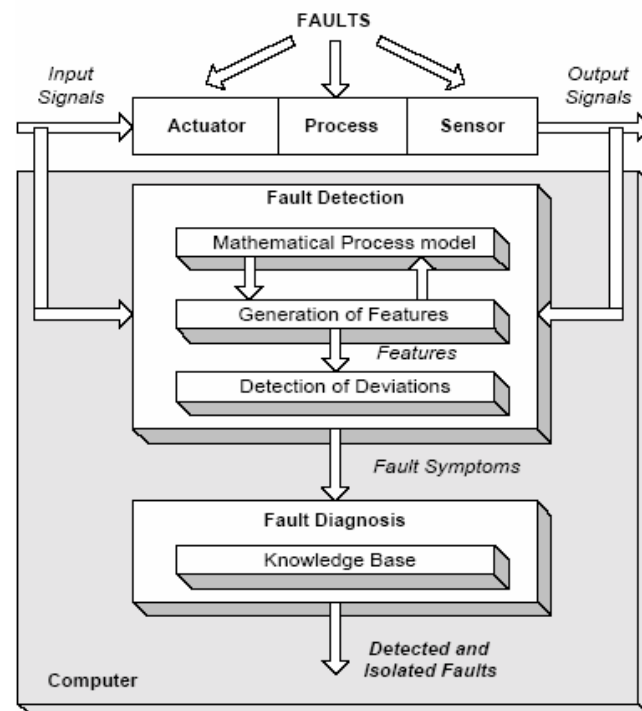


Figure 2. The basic structure of model –based FDI

In the field of fault diagnosis there is a clear trend from the well-established but in their efficiency limited traditional methods of signal based fault diagnosis, towards the model based approaches using analytical and/or qualitative models for residual generation, and modern strategies of residual evaluation including the methods of decision making with the aid of fuzzy logic and neural networks [1].

In general, there are four model-based residual generation methods, somewhat overlapping [1,3]: Kalman filtering, diagnostics observers, parity (consistency) equations, and parameter estimation. To implement FDI practical systems, different methods must be used in conjunction, in order to maximize the FDI performance.

4. CONCLUSIONS

The fault diagnosis scheme must be capable of on-line monitoring of plant operating conditions and signal the onset of faulty operation. The diagnosis system must also be able to classify system faults and monitor their progress. The key requirement of the fault diagnosis scheme is the ability to detect slow/small degradations in the plant operating characteristics. The diagnosis system must also provide satisfactory performance in the absence of an accurate model and must be able to distinguish between modeling errors and system faults[4].

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