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SOME CONSIDERATIONS ABOUT APPLICATION OF MODERN DIAGNOSIS TO COGENERATION PLANTS

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Abstract- **In this paper is pointed the importance of a modern, correct diagnosis for the cogeneration plant. Diagnosis is a part of the maintenance program. Significant savings in operation costs of the cogeneration plant can be realized by optimally scheduling plant maintenance and minimizing down time. The task for the model based diagnosis 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. The implementation of this modern technique 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.**

Keywords: Cogeneration plant, maintenance, model based diagnosis, fault detection and diagnosis

1. INTRODUCTION

Cogeneration systems are complex systems, which needs implementation of a good maintenance program. This program must satisfied 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. These things are 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 apprise. Predictive maintenance is that in which the intervention is made only if it exists an imminent risk or the performances of the system are strong degraded. The replacement decision of the failure elements depends by the diagnosis studies results.

2. ACTUAL STADIUM OF DESIGNING AND IMPLEMENTATION OF A MODERN DIAGNOSIS FOR COGENERATION SYSTEM

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.

The cogeneration plant represents systems involving many electrical and mechanical components whose operation must be planned, monitored, analyzed and controlled. The amount of information to be processed will continue to increase for a number of reasons. The high pressures and temperatures of a cogeneration plant involves a large throughput of fuel and energy, thus even a small increase in efficiency can result in significant saving. The high pressures and temperatures involved in cogeneration plant operation can result in significant damage to property and loss of life in the event of a system failure.

Today a large percentage of cogeneration 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.

A lot of cogeneration plant is 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 behavior) (I);
- Anticipated further behavior 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 pf power plant decrease at other operating loads.

A majority of the existing on-line process monitoring schemes for cogeneration 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.

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.

3. THE IMPORTANCE OF MODERN DIAGNOSIS FOR A COGENERATION SYSTEM

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

In general, *fault* is a deviation from the normal behavior in the plant or its instrumentation. A complete definition is “fault is a non permitted deviation of a characteristic property, which leads to the inability to fulfill the indented purpose”[4].

The faults of interest belong to one of the following categories[1]:

- additive process faults (fig.1 a),
- multiplicative process faults (fig.1b),
- sensor faults,
- actuator faults.

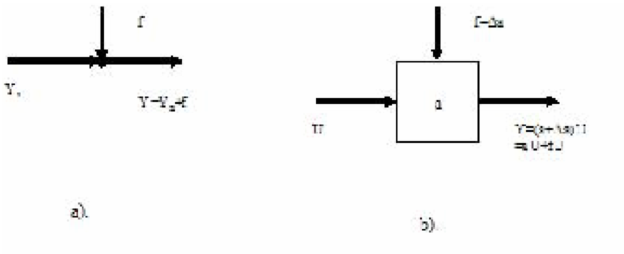

Fig.1. Categories of faults: a). additive fault, b). multiplicative fault.

The time dependency of faults can be distinguished, as shown in Fig. 2, abrupt fault (stepwise), incipient fault (driftlike), intermittent fault.

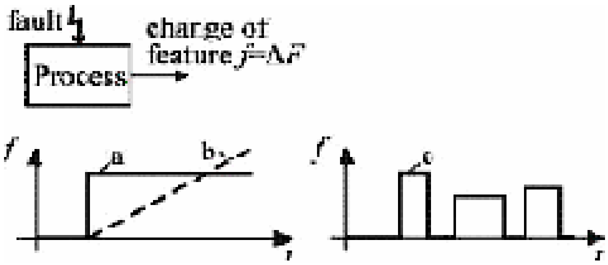

Fig. 2. Time-dependency of faults: (a) abrupt; (b) incipient; (c) intermitten

For the improvement of reliability, safety and efficiency advanced methods of supervision detection and fault diagnosis become increasingly important for cogeneration plants. The performances of a fault detection and diagnosis system (FDD) are giving by:

- Detection promptitude- faults detection very quickly after its happened;
- Sensitivity to fault- FDD system ability to detect small errors;
- Robustness- FDD system ability to operate in the presence of noise;
- Correctitude – avoidance of incorrect identification of fault components;
- Classification error estimate-the diagnostic system could provide a priori estimate on classification error that can occur;
- Adaptability –FDD system ability to adapt at process;
- Explanation facility-FDD system ability to explain how the fault originated and propagated to the actual situation;

- Modeling requirements- the modeling effort should be minimal possible;
- Storage and computational requirements;
- Multiple fault identification – FDD system ability to identify multiple faults.

In the last years a lot of different approaches for fault detection using mathematical models have been developed. 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.

Fig. 3 shows the basic structure of model-based fault detection. Based on measured input signals **U** and output signals **Y**, the detection methods generate residuals **r**, parameter estimates **θ** or state estimates $\hat{X}$, which are called features.

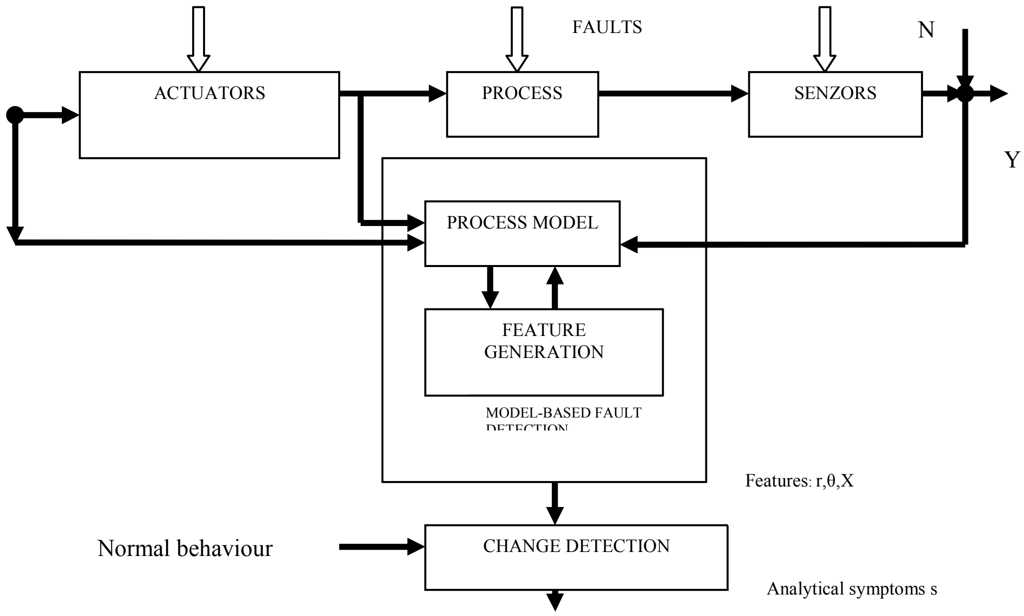

Fig. 3. Scheme of process model-based fault detection and diagnosis

By comparison with the normal features, changes of features are detected, leading to analytical symptoms **s**.

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.

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

The parameter estimation based techniques estimates parameters such as: flow rates, friction coefficient (physical parameters). A fault appears when some physical parameters have changed from its normal value. In [3,4] are presented implementation of this technique. The diagnostic of abrupt failures such as sensor faults and actuator faults is not easy using parameter estimation since these drastic faults can not be represented very good by changes in parameters.

The state estimation technique incorporates a state estimator or observer to predict the evolution of the system states. A fault is signaled when the estimated/ observed states deviate from the measured state.

4. CONCLUSIONS

System failures in power plant can results in serious accidents because of the large amounts of energy transfer, high temperatures and pressure involved in power plant operation.

It is thus essential for an on-line process monitoring system to be an integral part of any power plant control system.
The implementation of this modern technique 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.

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.

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