DIAGNOSTICS AND PREDICTIVE MAINTENANCE IN THE TECHNOLOGICAL PROCESSES

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ABSTRACT

In the area of control systems, especially in technological processes, there are requirements for very good safety of these systems placed. The safety providing of maintenance and other partial characteristics represent the complete system reliability. These characteristics, particularly the providing of maintenance, they don't concern control system only, but controlled technological process too. With a right choice of maintenance strategy is then a cutting of operating costs, an increase of safety of control system and thereby a safety of operation (individual devices in the process) reached [1].

The article concentrates on the maintenance with a predictive strategy. For correct function of this maintenance type it is necessary to select diagnostic system appropriately (a principle), together with monitoring of individual devices in the process. The term "monitoring" means measurement, transfer, storage and potential processing of important input and output quantity values of given device. The main idea of this paper is to use common data for control of technological process just for maintenance purposes (as inputs to the diagnostic system).

1 INTRODUCTION

Most of companies which use some control system or don't, they try to cut operating costs to the minimum, with respect to the strong competitive environment. This requirement isn't every time the best solution. The operating costs have not to be minimal, but they should be optimal, with a regard to safety of operation mainly [2].

In the present control systems for the technological processes there are high safety requirements placed. To ensure a safety of such a control system and also a safe operation of all devices in the process, a maintenance subsystem is used. It is necessary to choose right maintenance strategy to fulfill a condition of low production costs and to preserve or rather to raise the safety of the entire technology (control system, field instrumentation, controlled devices) [2]. However the important component of the maintenance subsystem is also a diagnostics (diagnostic methods) together with a monitoring of individual devices in the process (see Fig. 1).

2 MAINTENANCE SUBSYSTEM

On the control of the technological process can be look from several levels (see Fig. 1). The transitions among these levels are formed by layers. The inputs to these layers are a data from previous level and the outputs are a data entered to the next level.

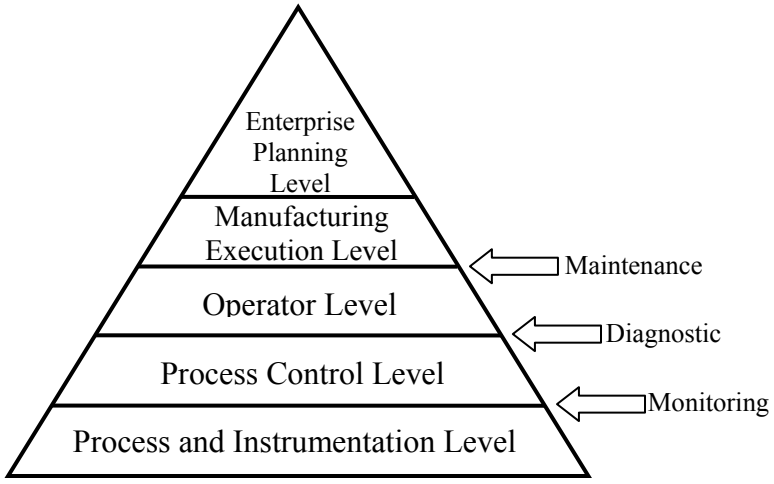

Fig. 1: *Monitoring, diagnostic and maintenance layers*

2.1 MAINTENANCE STRATEGY

A predictive maintenance as an initial strategy was selected. The usage of this strategy in contrast to other strategies (preventive, after failure) can give the highest saving of total maintenance costs. This fact is given thanks to elimination of still functional components replacement costs – by preventive strategy, and thanks to significant costs cutting which arise by abrupt unexpected failure or even by control system (technology) breakdown – after failure strategy [3].

2.2 SAFETY AND MAINTENANCE COSTS

It is convenient to point out that a part of the total maintenance costs is not only price of spare components of machines or of other devices in the process, also:

- Auxiliary material and instruments for pursuance of maintenance,
- Human resources for pursuance of maintenance,
- Time losses (downtime of devices in the period of maintenance),
- Time losses (downtime of staff in the period of maintenance).

If some failure or even breakdown of device occurs, it is necessary to calculate with danger of human health (human life), of an environment, to calculate with possibility of damage of technology devices and of the product itself too [2].

2.3 DIAGNOSTICS FOR PREDICTIVE MAINTENANCE

In the technological process it is needful to distinguish between two situations by diagnostics pursuance:

a) In the technology there are already included extra devices for diagnostics

b) In the technology there are not included extra devices for diagnostics

To these extra (above standard) devices belong components for thermo-diagnostics, vibro-diagnostics and tribo-diagnostics. The maintenance costs then increase with buying of additional sensors, cabling (bus system), auxiliary material for installation, devices – for example thermo-cameras, analyzers, etc. It is impossible to omit potential downtime and human resources costs by installation of these extra devices and their prospective maintenance or repairs costs too.

The main idea of this article lies in the utilization of data commonly used for technological process control provided that in the technology are not included extra devices for diagnostics – according to case b).

The function of the monitoring layer (see Fig. 1) is to collect and record all data (quantity values) outgoing from and incoming to the instrumentation level and their potential processing. As a source of data can serve:

- Control system outputs,
- Feedbacks (signals from sensors),
- Signals from smart sensors,
- Signals from auto-diagnostic subsystem of control system,
- Operators inputs,
- Data from superior information system.

Data (signals) processing means:

- Statistical evaluation,
- Transformation,
- Comparing with set values and limits,
- Monitoring of control error in steady state and not steady state.

From the monitoring layer to the diagnostic layer come:

a) Direct quantity values,

b) Selected parameters of direct quantity values,

c) Adjusted (transformed) quantity values,

d) Selected parameters of adjusted (transformed) quantity values.

2.4 PROCEDURES IN THE DIAGNOSTIC LAYER

The function of the diagnostic layer lies in processing of above-mentioned quantity values and in determination of diagnosis, prognosis and possibly genesis. The processing represents a passage of selected data from the monitoring layer through a specific evaluative algorithm. Such an algorithm for the diagnostic layer performs a data analysis and for its work can take advantage of following additional tools:

- Artificial neural network (ANN),
- Expert system (ES),
- Fuzzy logic (FL) [4],
- Genetic algorithm (GA),
- Their combination.

The best situation for the algorithm comes into being in the case that through monitoring layer incoming data proceeds from sufficient number of sources. Hence amount of sources depends on the fact whether is used an extra or an additional equipment for diagnostics in the technology (Chap. 2.3). By data processing it is also possible that function of the monitoring layer can partially take over the function of the diagnostic layer.

One idea of algorithm principal is to use the Statistical Process Control (SPC). This method is generally applied for a control system where the results of statistical evaluation (signal parameters as a maximum, minimum, mean, standard deviation, trend, etc.) affect the reaction of control system. In the case of maintenance the statistical results warn of near coming danger.

As it was mentioned above, the data analysis with following diagnosis and prognosis can be performed either with help of tools (ANN, ES, FL, GA) only, or by means of special algorithm and a possibility to use the tools (ANN, ES, FL, GA), or by the algorithm only.

2.5 PREREQUISITES AND TECHNIQUES FOR DIAGNOSTIC LAYER DESIGN

Every technological process consists of one or more devices (systems, components). There are valid following preconditions:

- Every component of given process, such as this, is equipped with mathematical model, possibly with set of limitation for a diagnosis of failure-free functioning of element already from producer.
- There exists an environment for maintenance subsystem design.

Then a designer of maintenance subsystem puts together a scheme for specific process, consist of needful components - models, limitations sets, or their combination. In case the producer does not provide the limitations sets, the designer will assign to the each component some limiting parameters including values. Hence some model of whole process (technology) is created. To the set of limitations is suitable to include and also to monitor following signal parameters: level, trend and frequency.

If the process scheme consists of limitations sets only, it will be possible, within diagnostics, to perform conditions testing (to compare measured and critical values) and a partial

prediction. In case the process scheme includes the components models only, a complete prediction will be allowed (thanks to the monitoring of a deviation between real and modeled signal). If the process scheme contents both the components models and the sets of limitations, then the complete prediction will be supplemented with measured and critical values comparing (see Tab. 1).

Process scheme components	Possibilities of diagnostics
Set of limitations	Conditions testing, partial prediction
Mathematical models	Complete prediction
Set of limitations & Mathematical models	Complete prediction & Conditions testing

Tab. 1: *Possibilities of diagnostics in dependency on components type*

Until is the diagnostic system devised an analysis and a verification by one of the following tools / methods can be used:

- Petri nets
- State graphs
- Block diagrams
- Decision tables
- Structure diagrams
- Temporal logics
- Time diagrams
- Control-flow diagrams
- Higher programming languages

3 CONCLUSION

In all technological processes there is necessary to perform the maintenance of devices that are included. The maintenance costs are significantly changed with the type of maintenance strategy. That is pointed out the impact areas by incorrectly selected strategy. In this article is designed a structure of maintenance subsystem with the predictive strategy, then is subscribed a function of the monitoring and diagnostic layer with putting a stress on the resources (tools) for data analyzing and a diagnosis performance. The chapter 2.5 deals with preconditions and particularly with process scheme for maintenance subsystem assembling, with different diagnostics possibilities (levels).

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