

# MODEL OF INTEGRATED COMPREHENSIVE MAINTENANCE SYSTEM

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In terms of practice, maintenance is carried out to ensure the desired reliability of production systems so that the total cost of the operation of such systems are the lowest. Article describes the benefits and advantages of the integration of complex system maintenance and example of its application. The main objective is familiar with the problems of maintenance and failure of machinery and equipment, as well as a generalization of the integration system maintenance. The article describes the different steps and examples of integration solutions. It addresses the complex maintenance of CNC machines and robotic systems.

## KEYWORDS

*maintenance, integrated, comprehensive, machine, diagnostics.*

## 1 INTRODUCTION

Until recently, the main focus of operation of production systems was put on the technological aspect of production. But often there was a neglect of issues related to the problems of failure and maintenance. Operation of large enterprises is requiring large amounts of closely related activities. These activities are requires highly specialized assistance by IT systems. Purchased software is not nearly enough. For integration of the maintenance system it is crucial to find the connection between data from disparate areas and to establish coherence and interdependence between them. In the maintenance management often has attempted to reduce the failure rate, regardless of their possible consequences. The result is an inefficient way of managing in the form of over- or underestimates the state of machines.

## 2 A COMPREHENSIVE APPROACH TO MAINTENANCE

Equipment failure is the termination of the ability of the object to perform the desired function. Management of maintenance management is therefore seeking to ensure maximum availability of equipment by reducing the number of failures and downtime. Without taking into account the severity of effects predictive or preventive strategies for reducing the number of failures, these measures are ineffective and often liquidating. In the management of maintenance, it is important to take into account the failure probability and consequence, which describes all the possible impacts that may occur during its creation. These impacts into account safety aspects, environmental aspects, the duration of the downtime and costs associated with the financial demands on troubleshooting [Pacaiova 2009].

In maintenance management is an important factor assessment of risk. It must be the relation (Eq. 1), which includes the aspect of failure and consequence of all possible impacts that may occur upon its formation.

$$R = P \times C \quad (1)$$

where:

- R - represents the size of the risk,
- P - probability of failure,
- C - a consequence of failure.

This means that the maintenance manager to be based on two basic facts:

1. Specification of reliability and safety aspects of the implementation of commissioning.
2. Planning a maintenance strategy based on the optimal design of maintenance management [Pacaiova 2009].

Comprehensive maintenance system must be based on the security of procedure for planned and unplanned maintenance. The planned maintenance has the task prevent unforeseen machine failure and thus shutdowns of production facilities. The unplanned maintenance determines the way to with purposeful measures achieve the fastest possible operational reliability. The key in this case is always the maintenance centre. It must prioritize troubleshooting and at weaning more devices at the same time, to prioritize remedied [Valencik 2010].

Management of complex maintenance is not only troubleshooting, or prevent them. It is the management of all technical and administrative activities during the lifecycle of the object, to restore and maintain the status of the machine to perform the desired function with respect to cost, safety, environmental and quality [Pacaiova 2009]. Maintenance management takes over report about failures directly from the person responsible for the device (operation). Based on this report it must prioritize troubleshooting and the decommissioning of multiple devices simultaneously, prioritize the removal of faults on the basis of the following criteria:

- the importance of the facility from the perspective of complex production
- time interval of devices shutdown
- extent of the problem [Valencik 2010].

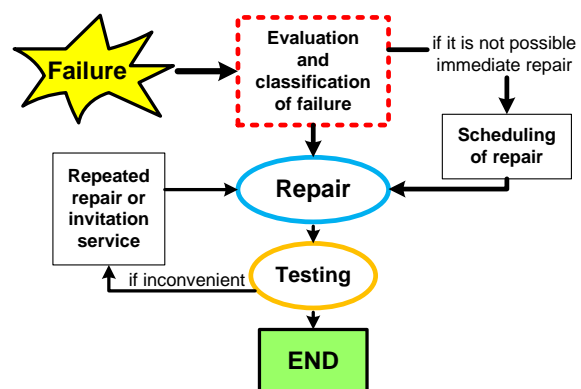


Figure 1. Simplified graph of complex system of unplanned maintenance

## 3 INTEGRATION OF COMPREHENSIVE MAINTENANCE SYSTEM

Comprehensive maintenance system uses planned and unplanned maintenance as the basis for its objective of this system should prevent unforeseen machine failures on the basis of planned and in case of unplanned maintenance should be its activities to achieve operational reliability in the shortest

time [Valencik 2012a, Cacko 2014]. The introduction of a system of maintenance is the best way to ensure the effective implementation of maintenance work. This means the most effective use of human, financial, and physical resources that we have available. This represents a power stabilization of machinery and equipment, increasing safety, reducing distortions of machinery and equipment as well as the adverse impacts on the environment [Tolnay 2008, Ragan 2012].

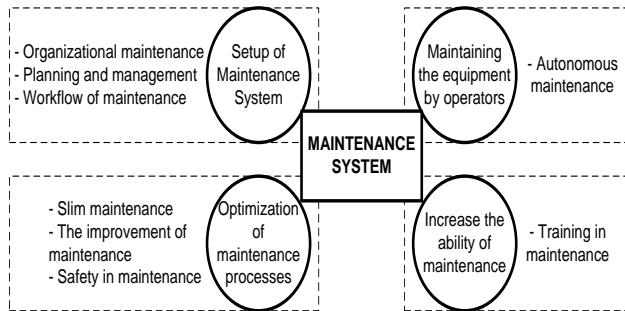


Figure 2. Example of implementation of the maintenance system

Integration of the maintenance system has its basis in the use of modern systems of management of maintenance. One of the many trends in maintenance management in enterprises is also computerized maintenance management system - CMMS. Introducing maintenance management with IT support (CMMS) companies are able to streamline the use of resources (human resources, inventory ...). Computerized maintenance management system is a type of software for the management of maintenance activities, which serves as the support of management and monitoring of operations and maintenance. The operation management system automates most of the logistics functions organized by maintenance. It comes with many options and compared over manual maintenance systems have many benefits [Valencik 2012b].

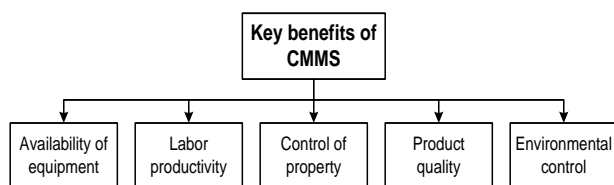


Figure 3. Key benefits of CMMS

#### 4 BASIS OF INTEGRATION

Integration of maintenance system has its foundation in the use of modern systems of management of maintenance. Currently, the maintenance management is using IT technologies in particular. However, the desired effect doesn't have to be achieved by buying a computer system. Firstly, issues of inputs to the system must be solved. It should be important to perceive the difference between preventive and predictive maintenance. Preventive maintenance includes planned activities based on knowledge of the behavior of the damaged parts and is carried out for the purpose of improving the system or prevention of decline equipment. Preventive maintenance requires the following with respect to individual devices:

- Identify equipment for preventive maintenance programs,
- Define the activities to be carried out in the preventive maintenance,

- Specify time intervals between defined activities,
- Establish a system of effective planning sub activities of preventive maintenance,
- Establish standards for creating and managing documentation arising from preventive maintenance.

Predictive maintenance is a method of testing machines, which is based on the diagnostics. Benefit of properly established predictive maintenance program is primarily the elimination of the need of haggling. Contents of predictive maintenance program are:

- testing the operability of equipment,
- determination of the place of occurrence and causes of equipment failure,
- prediction of the next operability [CMMS 2010].

#### 5 INTEGRATION STEPS

According to actual conditions in the theory and practice of maintenance can be the integration program made in five phases of development, from basic care of the equipment to various business systems and their integration with other systems. With the integration is necessary to start at the very beginning, ie at the plant and machine operators, through the maintenance personnel, to actual management.

1. Basic care of the property: in particular, maintenance activities, repairs, inspection and lubrication activities.
2. Integrated predictive maintenance technologies:
  - EAM (Enterprise Asset Management) - enables with information technologies for process managers to model the principle of operation of the organization.
  - CMMS (Computerized Maintenance Management System)
  - Multimodal diagnostic chain - is designed for continuous monitoring of the root causes of failures of production machinery and equipment. It allows you to integrate previously autonomous diagnostic methods (ultrasound, tribotechnics, vibration, temperature, geometry).
  - Proactive diagnostic system
  - Interconnect technology - replacing dial-up connection with an Internet connection.
3. Diagnostics and prognostics:
  - Basic prognostics - uses the processing data derived from the monitoring of operating equipment.
  - Advanced prognostics - prognostics that is formed by statistical methods based on past experience.
4. Optimizing the maintenance program
5. System integration with other enterprise systems: systems with enterprise-wide integration divide the program of overall reliability requirements for critical points of the company.

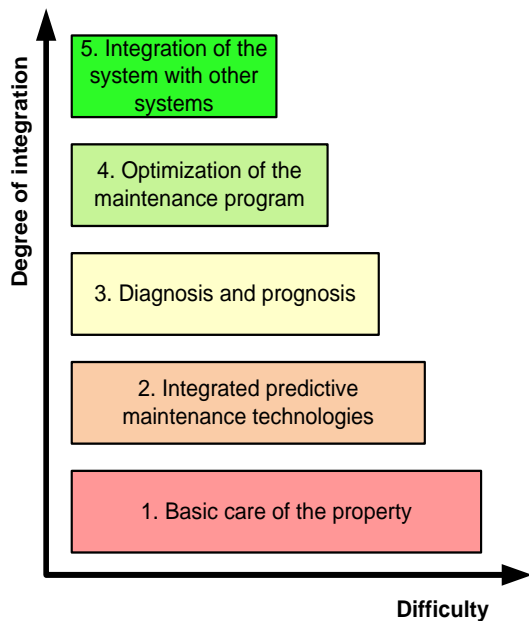


Figure 4. Integration steps

## 6 INTENTIONS OF INTEGRATION

The main objective of integration of the maintenance system is maintenance based on condition. The device status is monitored by sensors placed directly on the machine. Enable the scanning performance characteristics and predict failure and thereby reduce downtime due to equipment failure. Today, the maintenance of the conditions includes the estimation of the current status, based on the degree of machine wear. Watchdog Agent provides answers to these needs of companies through multi-sensors [NSF I/UCRC 2002]. Watchdog Agent and prediction are based on different approaches assessment of the state in order to facilitate the maintenance process based on the analysis and detection of machine condition using sensors.

## 7 EXAMPLE OF SOLUTIONS

Some CNC machines are already equipped with features for tracking technology and operating conditions of the machine and also a predictive diagnostic system, because any delay or downtime means substantial losses, either at the production plant or by shareholders. It uses the principles of active control of the machine and the relevant methods and techniques for remote diagnostics. The appropriate communication program installed on a PC allows contacting a service technician who

gets through remote connections to CNC machines and can remotely switch the screen to change the settings or drive as if it were in the control panel of the machine and transmit data in two directions [Radjou 2002]. At present it is not standard, the CNC machine is equipped with comprehensive diagnostic system. For system integration, it is important to equip the machine with sensors and their common interconnection, which improves the observability physical effects and their evaluation [Krenicky 2011]. Sensors that determine the level of mergers are based on individual evaluation and anticipating of process performance from each sensor. Such sensors process the information through a proportional signal line, which is available using a sensor in the model, or by using artificial neural networks.

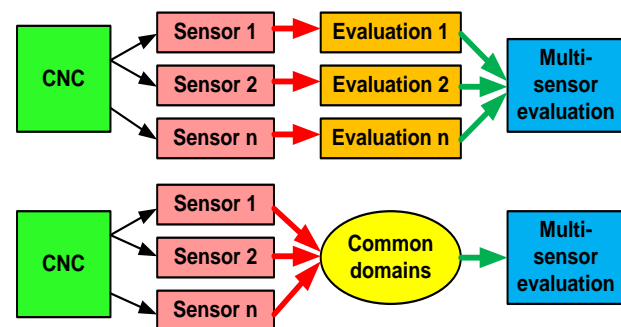


Figure 5. Decisions and properties of merged sensors

Module of evaluation of performance evaluates overlap between recently recorded signals and those who obtained during normal machine operation. This overlay is expressed by the means of a confidential value in the range between zero and one. In case there is a failure of signal processing, fusion sensor can be adapted to the values obtained from erroneous data. The concept of integrated maintenance system is based on the Watchdog Agent for assessing and predicting performance. Watchdog Agent assesses degradation by more sensors, which measure the critical properties of the process or machine. The measured values are sent to the Watchdog Agent, which then detects these changes and record them. Prognostic watchdog function is implemented through the trends and statistical modeling watched descriptions of the sensor or model parameters, which allows predicting future behavior of processes. Besides these diagnostic functions Watchdog Agent has other options, such as remembering important patterns and descriptions in order to detect situations that have been observed in the past or situations that were not previously observed [Ni 2003].

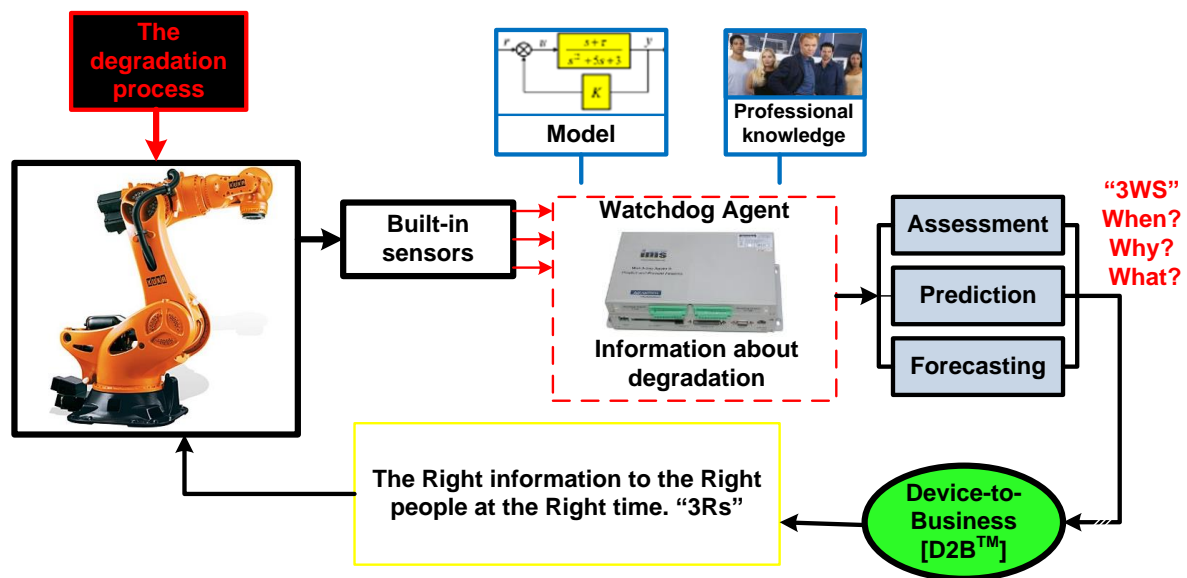


Figure 6. Intelligent maintenance system of robots

## 8 CONCLUSION

Modern systems of maintenance and diagnostics are constantly being developed and for their wider dissemination must be encourage a proactive approach to maintenance management in manufacturing enterprises and enhance efforts as possible to appropriate technical ideas to avoid disturbances. Successful implementation would significantly improve the financial and technological condition, as well as quality of life.

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