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A MODEL OF MANAGEMENT INFORMATION SYSTEM FOR TECHNICAL SYSTEM MAINTENANCE

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Abstract: Technical systems for production are increasingly automate, which means that they have to work reliably. Therefore, the rapidly expanding concept of maintenance, where people would say that maintaining a process that allows the management of the technical condition and reliability during the entire life cycle of the system. Traditionally, maintenance has been considered as a support function, non-productive and not a core function adding little value to business. However it has been noticed that many manufacturing industries have used various approaches to improve maintenance effectiveness. An analysis of the problem of machines and industrial systems maintenance as well as maintenance strategies and maintenance management process is presented in this paper. Furthermore, a development process of traditional and modern maintenance management information system is given. The possibility of development maintenance management, applying decision support systems and expert systems, are presented, at the end.

Keywords: Maintenance, Information system, Decision Support Systems, Expert systems

INTRODUCTION

Maintenance of technical systems must ensure that all technical systems fulfill their function with as little downtime as a longer life cycle and with less maintenance costs. Surroundings, in which the maintenance system builds, is certainly a production, business or other process or system (housing facilities, communication etc.).

In the work [9] is benchmarking of real estate performance is a commonly used tool in the efficient and sustainable maintenance management of existing facilities. Performance needs to be measured and monitored to support stakeholders' core business and maintenance strategies. Many of the performance indicators used to measure real estate are based on the area of the maintained property.

Maintenance can be defined as a set of actions which are carried out to replace, repair and service an identifiable set of manufacturing components, so that the plant continuous to operate at a specified level of availability for a specified time. The main objective of Maintenance is to maximize the availability of machinery and equipments for production. Preserve the values of the plant, machinery or equipment by minimizing wear and deterioration. Accomplish the above goals most economically on a long term basis. By systematic maintenance it is possible to achieve substantial savings in money, material and manpower as every effort is directed towards avoiding catastrophic failures [8].

High-speed technological innovation combined with severe competition shortens the equipment life cycle and puts equipment under higher stress. In order to deal with this problem, a company's strategic investments in production equipment should not only consider cost and capacity, but also technology trends, flexibility, etc.

Another important aspect is maintenance. Proper maintenance helps to keep the life cycle cost down and ensures proper operations and smooth internal logistics. The decision on the required maintenance concept and a thorough and easily accessible technical knowledge are crucial here [13].

The growing importance maintenance of technical systems in the last decades of the twentieth and beginning of the twenty-first century is related to the mass automation, computerized and robotization in all areas of industry and requirements for reliable operation of such systems as a prerequisite for the competitive ability of the organization. In some the industry has long been the number of employees in maintenance is greater than the number of employees in production, at the same time and with higher level of professional engineering knowledge.

Furthermore, next to the energy costs, maintenance costs can be the largest part of any operational budget. Yet, the main question faced by the maintenance management, whether its output is produced more effectively, in terms of contribution to company profits and efficiently, in terms of manpower and materials employed, is very difficult to answer [2].

Over time, the role of maintenance in the manufacturing sector has become increasingly important. Globalized markets are forcing organizations to compete not only in quality or price, but also in technology, reduced lead times, innovation, reliability and information technology[4].

In this information age, data has become one of the most important resources to organizations. The effective and efficient management of large quantities of data is a common problem found in many industries.

The study [7] is carried out to design, development and implementation of a computerized maintenance management information system (CMMIS) according to the requirements of a medium scale industry, with an intention

to assist the maintenance and other activities of the industry in an organized manner.

Reviews overall models for maintenance management from the viewpoint of one who believes that improvements can be made by regarding maintenance as a "contributor to profits" rather than "a necessary evil". The reasons why maintenance is such a "Cinderella function" are largely historical and can mostly be overcome by new information technology (IT) and its falling cost [10].

The paper [11] deals with the topic of facility management focusing on maintenance area and its importance for increasing company competitiveness. The importance of functional company facility management has risen dramatically in recent years. The reason for this is the increased pressure on cost reduction and additional value to the core business of the enterprise. The paper introduces a current theoretical literature-based framework for this topic in order to examine and analyze the supporting activities and processes connected with production facilities and maintenance particularly.

Maintenance has gained in importance as a support function for ensuring equipment availability, quality products, on-time deliveries, and plant safety. Cost-effectiveness and accuracy are two basic criteria for good maintenance. Reducing maintenance cost can increase enterprise profit, while accurate maintenance action can sustain continuous and reliable operation of equipment. As instrumentation and information systems become cheaper and more reliable, condition-based maintenance becomes an important tool for running a plant or a factory [5].

The paper [5] presents a novel condition-based maintenance system that uses reliability-centered maintenance mechanism to optimize maintenance cost, and employs data fusion strategy for improving condition monitoring, health assessment, and prognostics.

Forecasts of some analysts are that this activity in the twenty-first century will be one of the most important because of the growing need for rational use of resources.

Maintenance of technical systems is defined as the process of implementing measures the ensuring properly functioning of the system with competitive performance and minimum duration of interruptions because failures and maintenance activities. This is the most general term criterion function (objective function) the maintenance process.

The state of technical system is changed during exploitation and it is stochastic process that describes the probability that the system will be in properly the state over time ("in the work" as opposed to states "in failure" - factual and "In the conditional failure").

Activities of maintenance and management of maintenance are inevitable because failure of the system during operation, as a natural occurrence, as a result of the increase entropy of the system. There are several classifications of maintaining a methodology, and today is considered the most complete one that maintenance is divided into:

- Maintenance by reliability, and
- Total Productive Maintenance.

In the first case, the goal is maximum reliability, and in the second case, the maximum economic efficiency where operators assess the state of the system and undertake action to maintain "when is sufficiently clear" that will reach to failure (Japanese philosophy that is applicable eg. in serial production).

Traditional maintenance methodology is:

- Corrective maintenance,
- Prevention maintenance, and
- Combined maintenance.

In the second and third case, it is particularly important the maintenance by state of the system, with the use of diagnostic methods.

STRATEGIES OF MAINTENANCE AND MAINTENANCE MANAGEMENT

The type and content of the process within the maintenance of the system identifies selected method of maintenance (selection of the best models of maintenance). Without a good strategy and functioning all elements of the process, the maintenance of the system is not effective. Absence achievement of the objective of the system is expected.

During the last decade, many companies have made large investments in the development and implementation of enterprise resource planning (ERP) systems. However, only a few of these systems developed or installed have actually considered maintenance strategies.

Maintenance is a complex process that is triggered by planned periodic repair (scheduled or planned maintenance), equipment breakdown or deterioration indicated by a monitored parameter (unplanned or emergency maintenance).

This process requires planning, scheduling, monitoring, quality assurance and deployment of necessary resources (workshop, manpower, machines, equipment, tools, spare parts, materials). The proper design and integration of maintenance management into ERP systems enable enterprises to effectively manage their production planning and scheduling, as well as to analyze their maintenance history so as to carry out cost analysis and produce future projections of failure trends [6].

Maintenance management using the maintenance strategies as a set of policies that specify procedures for advance maintenance lick situations based on maintenance planning and implementation of maintenance plans.

These planned maintenance strategies can be applied in the maintenance by state of the system, monitoring changes of the parameters of state of the system and the level of reliability.

Monitoring the state parameters can be carried out continuously or periodically, and for each parameter will determine its value and in that way achieve preventive maintenance that meets the most practical situations and types of technical systems.

Maintenance management, however, is a much broader process. It includes activities:

- Forecasting and prediction,
- Planning,
- The execution and coordination of maintenance actions,
- Control of deadlines and quality performance of maintenance actions,
- Control the output achieved performance of the system and
- Control of maintenance costs and the current maintenance and investment maintenance (The investment maintenance is funded from amortization, while the current maintenance is financed as and production).

Maintenance Planning is the key function of maintenance management here. The maintenance plan must be in accordance with plan to produce, and horizon of planning in most of the system is one to two years.

The maintenance plan contains maintenance actions, and the plan spare parts, plan personnel and other resources, while elaborating preventive maintenance activities as a special program of preventive maintenance.

INFORMATION SYSTEM FOR MAINTENANCE MANAGEMENT

Management information systems for maintenance are crucial "tool" for maintenance management. Maintenance is one of the most important functions of the total logistic support (integrated logistics) industry organizations.

Information technology (IT) could be an important tool for reaching efficiency and effectiveness within maintenance, provided that correct and relevant IT is applied.

In this paper, a conceptual model for identifying maintenance management IT requirements is developed, with its practical application in a process for the IT requirements identification for maintenance management. The process is exemplified in two real-world cases [3].

The paper [3] suggests that the factors of goals, purpose and use should be considered on organizational and individual level in order to identify the IT demands. Correct level of IT applied, i.e. IT consisting of correct functionality required for planning, conducting and following up maintenance activities according to the state of maintenance and the strategy adapted, will contribute to successful maintenance management. Moreover, paper [3] promotes the use of a structured procedure for the identification of IT requirements for maintenance management.

Information is an essential resource for setting and meeting management objectives. The role it plays within the organization is of vital importance as it helps to build knowledge and measure the overall performance of the organization. As a result, information systems (IS) are no longer used to supply support to the operation of a business, or in the case of maintenance, to collect and analyze data. The IS must contain modules that can provide management with value added information necessary for decision support and decision making [1].

The main tasks of the information system are:

- Data collection of all relevant events during operation of the technical system and its maintenance,
- Data processing in order to obtain information for diagnosing,
- Forecasting,
- Planning,
- Decision-making,
- Realization and control of corrective and preventive maintenance.

The information is used to manage the supply of spare parts, cost, training workers to increase the reliability of the whole technical system and not just its components.

The functional scheme of flows of data and information in the process of maintenance management is presented in Figure 1.

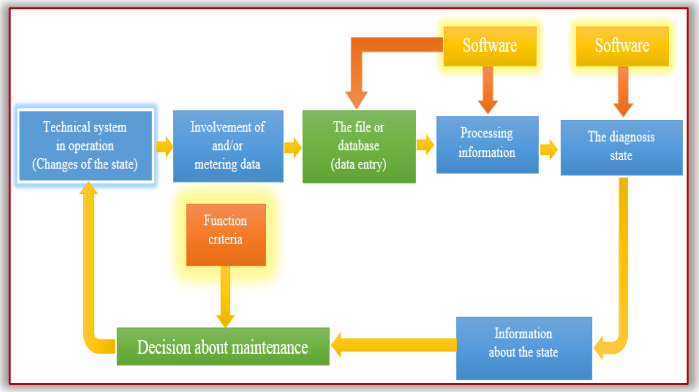

Figure 1. The process of maintenance management using information system for maintenance

The function of goal (function criteria) is determined by the requirements of the owner (user) of a technical system. It can be defined maximum the reliability (eg. In the case of aviation) or maximum economic efficiency, minimal cost maintenance and maximum productivity (eg. In the case of machine tools), and the like.

Data refer to failures, malfunction, parameters of the state of system and the reliability is established inspections and measurements, the maintenance operations maintenance costs, etc.

Holders of the original data are different documents on the forms created for information system on plain paper (but can be and magnetic media) such as map failures, reports of inspections and the like.

For entering data from source documents (which are coded) is used a mask (the software is created corresponding mask for each group of data).

Information system in a logical sense reflects real (technical) system and presents a model of operation and maintenance of technical systems.

Information system architecture consists of the following segments:

- The data model that contains information about the states of the technical system because they are the basis of the information system.
- Model the process describes the physical flows of the data, entering data into a computer as well as generating.
- Model Support, which contains physical support elements (equipment installation) then the manpower, training of workers and the like.

For the analysis and design of information systems important are three tools:

- Vocabulary data wich contains tabular systematic review (inventory) of all data by function (parts) of technical system is maintained.
- Chart of flows data is established vocabulary of data (document workflow).
- The program for processing data including files or databases.

The basic files are those which referee to the failure, orders for maintenance operations, and reports of executed maintenance operations.

The content output information and the database are the most important features of the system in general. The content output information must be adapted to the type of decisions that will be made and are expressed in the form of tables and diagrams etc.

Conventional information system "dramatically" reduces the amount of tedious routine work on the monitoring process and decision-making.

It enables to constantly comparing actual results with the expected and planned results, and to undertake a possible corrective actions.

The life cycle of a project system with delivered outputs of each stage is presented in Figure 2.

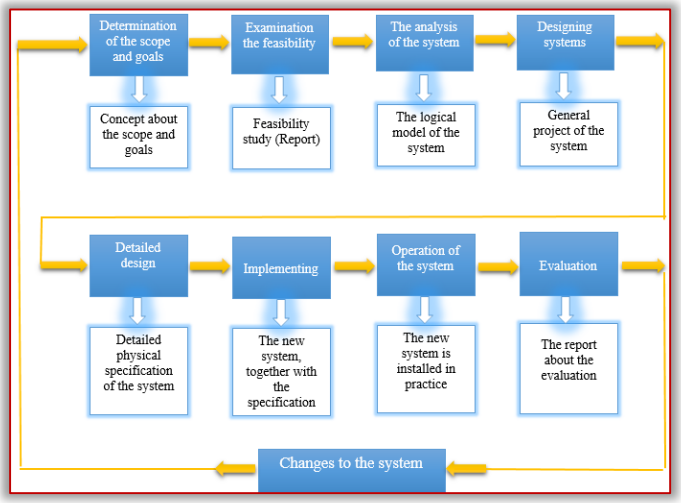

Figure 2. The methodology development of information system

The role of information system as component for interaction with user enables that he formulates your request and immediately receives a response and it is a special important for maintenance management.

The role of components for connecting with important sources of information in the environment that are mostly relevant for tactical and strategic decision making (because these sources of professional are journals and newspapers, followed by industrial statistical surveys, database expert and scientific institutions, etc.).

For the maintenance management is a significantly staff education or for other purposes.

DEVELOPMENT OF INFORMATION SYSTEMS

Information system should be designed so as to be oriented to user and serves to man, to "thinks" like a man when he solves a problem or when makes decisions in managing the process. These are increased requirements compared with traditional information systems.

They can be filled out by the information system is being developed expanded roles. These roles can be [12]:

- The role of monitors,
- The role of filter information,
- The role of the components for interaction "on line" with the user and
- The role of components for connecting with the environment.

In order served as a monitor, information system should be designed so that it continuously monitors key variables of the maintenance process (eg. The number of machines in failure, the costs of corrective and preventive maintenance, etc.), but some variables can serve as predictors in the planning and predictions. So you can automatically undertake actions of maintenance when the variation of some key variables become significantly.

As a monitor of information system, further, can be used for decision-making that are programmed. Using that information and certain decision rules automatically decision-making (eg. calculate) a specific decision that managers can concentrate on non-programmed decision-making. The largest number of technical and fewer tactical decisions are routine, repetitive decisions that can be programmed.

Un-programmed decision making is presented in most of the strategic problems and in the maintenance management of them is not much, but it can be very significantly.

As a filter of information, information system reduces the amount of information that is distributed to the middle hierarchical level, and more reduced amount of information that is distributed to top management, where this information is synthesized. Thus, a vast quantity of information is distributed rationally, with at the same time, increasing functionality of the system.

The high costs in maintaining today's complex and sophisticated equipment make it necessary to enhance modern maintenance management systems. Conventional condition-based maintenance (CBM) reduces the uncertainty of maintenance according to the needs indicated by the equipment condition. The intelligent predictive decision support system (IPDSS) for condition-based maintenance (CBM) supplements the conventional CBM approach by

adding the capability of intelligent condition-based fault diagnosis and the power of predicting the trend of equipment deterioration. An IPDSS model, based on the recurrent neural network (RNN) approach, was developed and tested and run for the critical equipment of a power plant. The results showed that the IPDSS model provided reliable fault diagnosis and strong predictive power for the trend of equipment deterioration [14].

Decision Support Systems (DSS) and expert systems (ES) are even more powerful tools compared with the information systems, which in the management of the maintenance can find wide application. DSS represent a symbiosis between users (engineers and managers) and information systems in decision-making and solving unstructured problems using information and decision-making models, a special software tools and often specific additional hardware tools.

Expert systems in the maintenance management especially in technical diagnosing have found significant application. They have in addition to the database or file and knowledge base that contains sophisticated models of decision-making, that decision process execute as it seems reasoning man.

This is software that solves a problem that otherwise can only be resolved expert.

In Figure 3 are presented as dominant area of application of electronic data processing (EDP), management information systems, decision support systems and expert systems in the hierarchical structure of industrial organization.

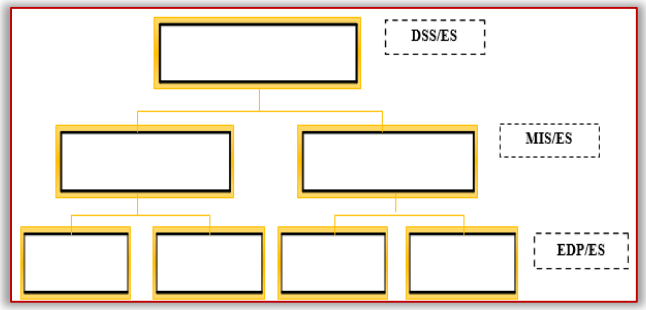

Figure 3. EDP, MIS, DSS, ES in the hierarchical structure of the organization

At the level of top management are relevant DSS (focus on decision-making) in the middle hierarchical level MIS (focus on information) on a basic level EDP (focus on data). Expert systems are relevant to the problems of decision-making at all levels.

CONCLUSIONS

The expediency of maintenance can be seen only through the effectiveness of the basic production process.

Maintenance management has gained in importance in the last decades of the twentieth century and beginning of the twenty-first century, with a tendency of further growth.

IT tools are important, and in many cases invaluable, for reaching the goals of maintenance. This paper suggests that the factors of goals are expressed in terms of efficiency, effectiveness and cost-effectiveness, purpose and use should be considered on organisational and individual level in order to identify the demands of IT.

Automation, computerization and robotics work processes require sophisticated methods of maintenance management and the increasing internationalization of markets requires greater the reliability of production systems and competitive the ability. Without modern information system with expanded roles compared with traditional, and on these challenges can not be successfully respond. Even greater opportunities lie in the application of decision support systems and expert systems.

In the paper is presented a methodological basis for the approach designing specific information system for the maintenance management.

References

[1] Fernandez, O., Labib, A. W., Walmsley, R., Petty, J. D., A decision support maintenance management system: Development and implementation, International Journal of Quality & Reliability Management, Vol. 20, No. 8, pp. 965-979., 2003.

[2] Garg, A., Deshmukh, S.G., Maintenance management: literature review and directions, Journal of Quality in Maintenance Engineering, Vol. 12 Iss: 3 pp. 205 – 238., 2006.

[3] Kans, M., An approach for determining the requirements of computerized maintenance management systems Computers in Industry, 59, pp. 32–40, 2008.

[4] Madu, C.N., Competing through maintenance strategies", International Journal of Quality & Reliability Management, Vol. 17, No. 9, pp. 937-949., 2000.

[5] Niu G., Yang B-S., Pecht, M., Development of an optimized condition-based maintenance system by data fusion and reliability-centered maintenance, Reliability Engineering and System Safety, 95, pp. 786-796, 2010.

[6] Nikolopoulos, K., Metaxiotis, K., Lekatis, N., Assimakopoulos, V., Integrating industrial maintenance strategy into ERP, Industrial Management & Data Systems, Vol. 103, Iss 3, pp. 184 – 191, 2003.

[7] Ramachandra, C. G., Srinivas, T. R., Design, Development and Implementation of Computerized Maintenance Management Information System (CMMIS) for a Selected Medium Scale Industry, International Journal of Science, Engineering and Technology Research, Vol. 2, Issue 8, 2013.

[8] Ramachandra, C.G., Srinivas, T.R., Shruthi, T.S., A Study on Development and Implementation of a Computerized Maintenance Management Information System for a Process Industry, International Journal of Engineering and Innovative Technology, Vol. 2, Iss 5, 2012.

[9] Róka-Madarász, L., Performance Measurement for Maintenance Management of Real Estate, Acta Polytechnica Hungarica, Vol. 8, No. 1, pp.161-172, 2011.

[10] Sherwin D., A review of overall models for maintenance management, Journal of Quality in Maintenance Engineering, Vol. 6 No. 3, pp. 138-164, 2000.

[11] Šlaichová E., Maršíková K., The Effect of Implementing a Maintenance Information System on the Efficiency of Production Facilities, Journal of Competitiveness, Vol. 5, Issue 3, pp. 60-75, 2013.

[12] Šibalija LJ., Architecture of on expert system for quality assurance in individual production of complex mechanical products, Proceedings of the Eleventh European Meeting on Cybernetics and Systems Research, University of Viena, 1992.
[13] Waeyenbergh, G., Pintelon, L., A framework for maintenance concept development, Int. J. Production Economics, 77, pp. 299–313., 2002.
[14] Yam, R.C.M., Tse, P.W., Li, L., Tu, P., Intelligent Predictive Decision Support System for Condition-Based Maintenance, Int J Adv Manuf Technol, 17, pp. 383–391, 2001.

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