MANAGEMENT OF PREVENTIVE MAINTENANCE AS A FACTOR OF SUCCESSFUL TECHNOLOGICAL PROCESS

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Summary: Preventive maintenance should lead to reduction in failures, i.e. it should create such conditions that break-downs do not occur at all. Preventive maintenance is one of the ways of preventing break- downs or deadlocks while performing technological operations during business operations, and it also reduces the number of break-downs. This paper presents parts of organizational guidelines (procedures) that deal with preventive maintenance, and it also shows the diagram of the cost of preventive inspections.

Key words: preventive maintenance, preventive inspection, interventions.

INTRODUCTION

Maintenance of machinery systems is a very important function; realization of technological processes in any production depends on this function. With new technologies coming along it is necessary to develop new technologies of maintenance. It is widely believed that it is exactly the new maintenace technologies that will become a very important segment in the future increase of productivity. We already, in a whole range of industry sectors, use most of the adopted technologies of maintenance of technical systems, but in order to improve and use to the fullest such a large number of various maintenace technologies it is necessary to organize multidisciplinary activities of specialized engineers who are equipped with all the necessary knowledge and expertise regarding maintenance jobs.

Therefore, the need to create mechanisms to adopt new knowledge in the area of technical systems is a very actual and realistic need, as is the need to define steps in technological maintenace in order to meet all the demands (needs) of all those who use technical systems in their production processes.

Utility value of any technical system is explicitly dependant on all its technical characteristics regarding maintenance, as well as on the quality of the very process of maintenance. Maintenance of a system (machinery) consists of a whole string of steps and activities with the aim to prevent occurence of break-downs (failures), as well as to bring the system back into the 'operational' mode after the 'failure' mode had appeared.

Preventive maintenace results in extended life scope of equipment and in reduced number of break-downs, and all this means better and faster performance of technological operations and improved business operation in the company as a whole,

MAINTENANCE AS A TERM AND AS A FUNCTION

Maintenance of technological systems consists of a whole string of actions that actively include both the manufacturer and the user of the technological system (machinery). The main

task for technical maintenace is to keep the machinery system in operational mode in order to perform all the technological steps in the process of production, Fig. 1. [1]

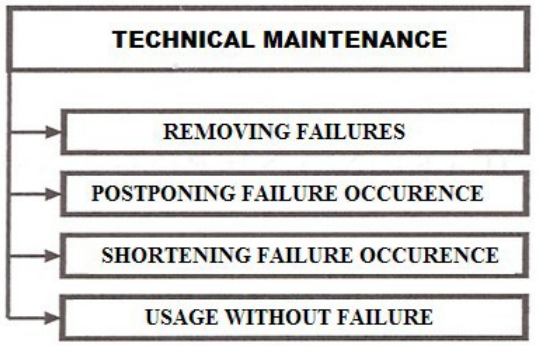

Figure 1- Phases of work in maintenance process

Cost of maintenance and of break-downs in the process of production should be as low as possible, and the quality of final parts and production productivity should be as high as possible. Per product unit, total costs due to designing, manufacturing, exploitation and system maintenance (through planned life scope of a system) should tend towards minimum, disregarding where and when those costs were created. The main function of technical system maintenance is to perform all the necessary procedures so that the technical system remains operable (in working mode), and that it remains operable within required parameters of reliability, productivity and economy during its projected life scope.

The main tasks of maintenance are: [1]

- to provide that the technical system operates within desired state of reliability during its exploitation,
- to provide that total costs of maintenance remain minimal,
- to limit and prevent that technical system becomes obsolete,
- to provide better quality of the system,
- to increase the level of work motivation,
- to deliver products to consumers on time,
- to increase productivity of production, etc.

Maintainance of the system with regard to its contents and dynamics must be coordinated with real needs; otherwise we get unwanted effects. Development of new sciencies, specially cybernetics, theory of system, informatics... has contributed considerably to the change in the process of maintenance of technical systems. Technical system is not perceived as an aparatus or machinery, but as an integral part of the general system of nature that is subject to general and special laws, common to all other systems in nature as well.

1) The concept of maintenance is the feature of maintenance, and it influences the overall quality of the system of maintenance.
2) Organization of maintenance systems defines relations between several levels. i.e. places – factory plants, where procedures of maintenance are executed.
3) Technology of maintenance defines procedures of maintenance and the way of executing procedures of maintenance – how to perform certain steps, with what tools, in what order, in what time-frame – and this technology is valid for all the

levels of maintenance separately, and for all the allocated (planned) procedures of maintenance as well: [1]

- basic maintenance by worker in charge – technical supervision;
- preventive periodical inspections, without special tools,
- inspections regulated by law and regulations,
- lubrication,
- technical diagnostics,
- preventive change of parts
- location and removal of weak spots,
- repair and refurbishing of worn out parts
- preventive periodical repair,
- general periodic repair and modernization.

4) Designing is based on constant monitoring and control of the main causes of failure and it is based on activities that we undertake to remove failures, or it is based on significant reduction of failure consequences. In the same manner, this concept does treat break-down as a normal or possible state of things, but it undertakes a whole set of measures to prevent failure from occurring (i.e. to provide 'healthy life' for machinery); this way the concept prolongs the machinery life scope to the fullest. [2]

- terotechnology,
- logistics system of maintenance,
- intelligent maintenance,
- maintenace according to present state, and
- overhaul.

Terotechnology – this is a set of activities dedicated to preservation of fixed assets during their life scope. The terotechnology activities include: maintenance of everything manmade: maintenance of factory plants, machinery, buildings, constructions; installations; they also include implementation; modification; replacement. Terotechnology includes specifications and designing, as well as all the other areas of maintenace of physical goods and technical means.

Logistics maintenance system – this is a technical branch that comprises work, functioning and work conditions of technical systems. This brunch comprises all the basic activities during the life scope of a system. Its task is to provide all the necessary factors for realiable work process of a technical system and for its return from 'failure' mode into 'operational' mode.

Intelligent maintenance – this term is used for expert systems as well, and it includes 'general purpose programme, tasked with solving problems by imitating human intelligence.' All the above have their own costs:

- cost of supply (transportation, insurance...)
- cost of labour (work force, energy, building, etc.);
- cost of maintenace (work force, parts, tools, etc.):
- cost of administration

All those total costs can be shown as:

$$C_u = C_v + \int_0^T f(t) \cdot dt + C_k \cdot T \,, \tag{1}$$

where:

C_u – total cost,
Cv – ownership cost,
C_k – cost of use per time unit,
$f_{(t)}$ – density of time function, up to break-down
T – time of use

Nevertheless, total costs can be classified into two groups:

- **direct costs** (activities related to servicing, replacement of broken parts, location of broken parts, periodical preventive repair, technical diagnostics, lubrication, overhaul, etc.) and
- indirect costs (deadlocks, damaged parts in technical means, lower quality of production, rejects, etc.). Graphic representation of the mentioned costs is shown in Fig. 2.

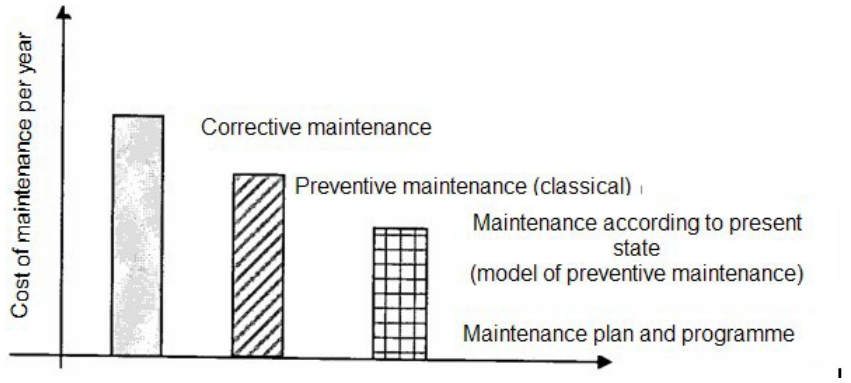

Figure 2 - Cost of maintenance

Maintenance according to reliability – it is based on reliability theory and on system sciences in general; it is based on knowing characteristics of reliability in order to provide prognosis of future states during the operations of technical system, i.e. this serves to foresee failures.

Overhaul – this was introduced in Japan in the 1950s and its aim is to maximize productibility of the system with minimal cost within life scope of the system through elimination of 'the three groups of large losses' that lower system efficiency:

- losses due to break-downs (sudden break-downs and adjustment of equipment)
- losses due to lack of efficiency (idling and small failures) and
- errors in the process (removal of errors during the operations and reduction in income due to losses from difference in initial and stabile production.

SYSTEM MAINTENANCE PROCEDURES

Maintenace procedures differ in high degree and this is shown in Figure 3. [3]

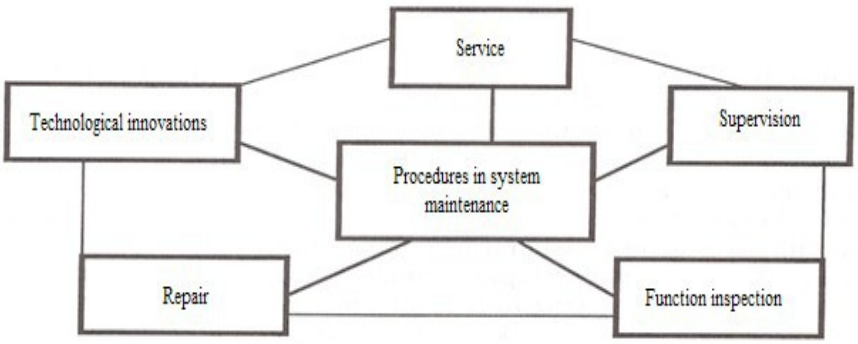

Figure 3 – system maintenace procedures

In this case we differ two different types of maintenance:

1) **Corrective maintenance** – includes the set of procedures necessary to bring the system back from failure mode into operational mode, with the aim of performing given functions within the scope of tolerance.

2) **Preventive maintenance** – includes the whole string of procedures necessary to prevent failure mode, i.e. includes maintenance of function parameters within the scope of tolerances, as long as possible.

Preventive maintenance procedures can be executed as: *maintenace according to present state* (executed by inspection according to current state) and *maintenace by replacement* (executed by replacement of parts, disregarding their quality).

Organization of maintenance process has a decisive role on the overall level of efficiency of the system through following:

- execution of maintenance procedures in as short a period as possible,
- modelling of database in order to achieve higher level of compliance of maintenance system,
- creation of basis in order to place procedures into system testing,
- influence over development of steps for work humanizaton by providing basis for better work conditions, etc.

When allocating budget for maintenance one may specify the scope and type of work, where one may use part of potential of the available work force that can be included into maintenance. If it is some special equipment, equipment that is still under guarantee, then cost plan – as the first level of operational planning – must include all those facts.

PLANS FOR PREVENTIVE REPAIRS

In the process of maintenance of technical systems all the plans are quite similar, therefore we list the following:

Mid term plans – these are usually five-year plans and they are the basis for all the rest plan-making;

- plan of preventive periodical repair of basic technical systems, and

- plan of all the maintenance activities that, apart from preventive repair, contains other tasks as well (e.g. investments, liquidation of fixed assets, etc.).

After mid term plans, one should make yearly plans of preventive and periodical repair. Here we specify details

Then we have *operational plans* which serve to specify activities in shorter intervals, most often for one month, in accordance with yearly plan. Their task is as follows:

- to use to the fullest both the work force and the means of production,
- to make sure that work is not on hold while we wait for spare parts and material,
- to make sure that business flow is not interrupted.

Then we have *workshop plans* that provide for global planning: repair and tasks normally executed by in-house maintenace (no help from central maintenace). This stems from demands for periodical preventive inspections received from other sector (or from production).

Any maintenance planning must strictly be kept within the scope of economic efficiency principles. That means that when creating plans we must keep in mind both economic principles and productivity of work in performing preventive periodical repairs (capacity, work force capacity, machinery and equipment capacity, etc.) With the development of science and technics, i.e. with work almost fully automatized today, more and more people work in the maintenace process. Therefore, the main factors that influence planning of the number of people necessary for the maintenace process are:

- implementation of conventional and modern methods of maintenance (preventive – combined methods, corrective methods)
- procedure for the organization of maintenance function (centralized – decentralized)
- policy of engaging cooperators (externally or internally).

INFORMATION SYSTEM FOR IMPLEMENTATION OF MAINTENANCE TECHNOLOGY

Information system for implementation of maintenance technology is tasked with performing all the necessary maintenace jobs. Data and information on current jobs, necessary workers and executives and their training – these are the necessary information, and more specifically so: [3]

- data on available human resources
- place (factory plant – workshop)
- time
- type of maintenace process
- special workshops or laboratories if necessary
- necessary tools, instruments and means of transportation
- required material and parts
- time (allocated) for maintenance procedures
- coordination and such.

All the parts within an information system cooperate with information sub-systems, but specially with the following:

- production and commercial sub-systems (supplies, sales, accounting and budgeting),
- human resources, etc.

The following should be included in process of designing information system:

- data and information (sources, streamflows and destination),

- data, info and database carriers
- data processing and modeling of information
- steps and analyses from info, as well as steps in the decision-making process.

During the process of designing information system, it is extremely important to establish the necessary and adequate data, their source, steps in their processsing and adequate information for the decision-making process.

Carriers of data and information are the basis that includes the results of the whole process, and at the same time they include means of transportation and data processing with the aim of acquiring reliable information on the current state of the system. Data are presented without any subjective description; the number of carriers and information should remain as low as possible, but still adequate to fulfil the tasks before us. [4]

- list of technical systems
- structural map of the system
- record of work-life of technical system
- record of system over time
- record of reliability indicators,
- Workshop documentation (work order, request for failure removal, technological process, construction documentation, requisition for spare parts, returnee of spare parts, request for material and spare parts, time plan, technical instructions and standards, inspection and time specification, material and spare parts specification, form for recording the handover of orders and check-ins, form for maintenance working groups.)

CONCLUSION

Implementation of the system of prevention into the maintenace process and its rigid follow-up are necessary and they should lead to reduction in number of break-downs, i.e. they should create conditions where we have no break-downs at all. Organizational manual defines in detail procedures, authority, responsibility and all the documents through which preventive maintenance is regulates and executed.

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