

MODERN MANAGEMENT METHODS FOR EQUIPMENT MAINTENANCE

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ABSTRACT: The concept of maintenance in the field of complex equipment was developed in the USA being quickly adopted by European countries and Japan. The American maintenance concept has the significance of creating a support system for industrial equipment functioning. Functional maintenance is one of the most frequent used methods in maintenance management for industrial enterprises. This paper tries to present some aspects related to the systemic approach of the functional maintenance model, starting from technical elements of the maintenance process but also taking into account the economical perspective i.e. maintenance-related expenditure. The final part of the paper presents a systemic method of representation of the model, taking into account the two mentioned aspects.

Key words: functional maintenance, system, management

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Introduction

The theoretical and practical basis of the need for an industrial equipment maintenance system relates to the following aspects:

- the functional maintenance of technological equipment represents a component of the production function, but with independent tasks and responsibilities;
- a connection must be established between manufacturing technologies and tools and equipments maintenance;
- the economical efficiency of maintenance and interventions activities must be linked to the real productivity of each equipment as well as to the quality of the products that are being manufactured;

The functional maintenance model[5], considers technological equipment maintenance as an integrated function of the production process. Thus completing the tasks of a productive section while respecting quality, cost and time constraints, implies an analysis of the following factors:

- Personnel training, including production personnel but also maintenance and intervention personnel. Activities coordination, organization and monitoring in the system has to have a tight connection to professional competence C_p that depends on:
 - personnel professionalism (P): knowledge of the activity type, established norms and solving all functioning problems of equipment being used or maintained;
 - personnel aptitudes (A_p): aptitudes regarding task completion and capacity to address a complete range of requirements;
 - technical aptitudes (A_t): aptitudes related to the technical and economical responsibility of the activities being undertaken.

Thus the functional model of professional training can be represented as:

$$C_p = f(P, A_p, A_t)$$

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- Technological analysis of the technology being used relates to two main groups – *product manufacturing technology and maintenance and intervention technologies for the manufacturing equipments*.

Gaps in the correlation between the two technology groups mentioned above can generate production loss, quality decrease, cost and consumption increase and overall efficiency reduction. By using this model, a strong correlation between the two groups is ensured – applying advanced manufacturing technologies implies immediate modernisation of the maintenance and intervention technologies.

- Manufacturing activities management, in relation to equipment maintenance and intervention implies the design and implementation of methods and techniques that ensure the accomplishment of fundamental objectives of functional maintenance such as:
 - recording statistics in relation to technological equipment functioning quality;
 - using new monitoring techniques such as vibration measurement, temperature recording or oil analysis.
- Design and development of a specific informational system that acts as a synthesis tool that allows the monitoring of main activities and the assessment of the risk of each scenario. This subsystem has to keep up-to-date the dashboard of the maintenance responsible by:
 - grouping all relevant information in relation to programmed activities;
 - presenting in a structured manner the information required for technical and economical analyses;
 - offering a timeline of phenomena with associated information;
 - warning with regard to possible negative phenomena;
 - presenting the necessary information for the decision-making process in various signaled scenarios.

By using the new maintenance model [4] in industrial enterprises, some of the following results are expected:

- The reduction to a minimum of defects, that would lead to an overall efficiency increase of the enterprise by:
 - using a preventive maintenance system that would allow a better monitoring of current equipment wear, weak spots detection, usage uncertainty and defects prevention;
 - increasing the quality of maintenance and intervention activities;
 - optimal exploitation of technological equipment, according to their technical specifications.
- The optimisation of the repair time frame, as a consequence of:
 - application of methods based on operational research such as network timeline, critical path method, PERT, simulations, statistical and mathematical analyses, cost optimisation etc;
 - coordination and organisation of the activity for each intervention group or for each person that belongs to the mechano-energetical sector;
 - preparing interventions from a technological point of view, materials and spare parts provisioning;
 - using modern techniques to establish wear degree for different components of sub-components of the equipment undergoing repair;
 - using an operative information sub-system that will take over all information regarding repairs but that can also provide employees with the information they require.

- The complete provision with spare parts taking into account the time frame, required quality and quantity for various types and dimensions as a result of:
 - using specific methods to determine the spare parts necessary;
 - implementing an efficient storing and movement system for spare parts based on mini-max type stock variations. This model has as criteria choosing from more options an action that would decrease the extremes. In decision problems regarding stock it is recommended the adoption of a strategy that minimizes the maximum risk for component unavailability.

Systemic approach on functional maintenance management

The functioning of technological equipment in specific safety conditions implies: a technological preparation of interventions based on real and complete knowledge of the equipment wear, planned monitoring of safety status by periodical technical inspections, professional training of the personnel etc.

The desire to use advanced techniques and methods in maintenance and intervention management must be supported by a financial, material and human effort to ensure the development of the technological and informational base required.

In this context, the model of functional maintenance represents a new approach on equipment maintenance and intervention management based on the interdependence between the systems' elements and on their critical analysis.

The fundamental components of the functional maintenance model include:

- management of maintenance and intervention activities;
- the actual technological process of maintenance and intervention activities connected to the tero-technical system of activities;
- the existence of an information sub-system with a database of processed data that ensures the connection between the managing mechano-energetic system and the managed system in relation to terotechnical processes and to the assurance of a feed-back connexion needed for regulation based on decisions or self-regulation in the case of more evolved systems;
- economical analysis of maintenance expenditures and analysis of methods to recover such expenditures in the course of the production section.

The adjustment of the new model must be made on the basis of the *cause ↔ system ↔ effect* elements. In the case of phenomena from the area of technological equipment use, the adjustment from the cause implies the adoption of a positive reaction i.e. evolution monitoring in the constraints the equipment needs to function.

The evolution of the system in a specific direction under the influence of certain positive constraints can be adjusted based on control actions such as:

- planned periodic technical inspection that must aim to detect weak spots of the equipment undergoing monitoring;
- operative monitoring of repairs for which there has been a network-graph developed based on critical path;
- operative monitoring of capacity loading for the manufacturing of spare parts for the existent equipments;
- monitoring the evolution of spare parts consumption;
- economical analysis of maintenance and intervention costs for each equipment.

The adjustment of phenomena evolution in comparison to the effect registered at the system output is based on information regarding system output from a feed-back connection. Thus any disturbance - consisting in deviations from preset functioning parameters and discovered at system output – has to be used in the adjustment of its evolution.

The approach on maintenance and repairs on systemic basis shows the existence of successive levels of objectives conforming to management levels. Thus each level sets its objectives

and resources requirements, and the objectives control will be done in an opposite direction through the feed-back connection, starting from the final results to the mechano-energetic section management.

The role of the information system in the management of the enterprise and thus in the management of the mechano-energetic section consists in having a continuous perspective on resources and objectives on the activities model and on all the factors that can influence maintenance and repair activities in a certain direction.

The functional maintenance model must also be adapted to the structures of the other functional subsystems of the enterprise such as material and technical provisioning or personnel training.

Further considering the terotechnical system of activities specific to maintenance and repairs we can state that terotechnics[1] has the purpose to “take care” i.e. it is wider than maintenance engineering since it includes the complete process of assembling, *putting into service maintenance, reparation, replacement, organisation as well as technological standards for personnel training, information processing methodologies, various analyses and the increase of equipment reliability.*

The economical concept of functional maintenance implies that decisions related to interventions are based on the following criteria[3]:

- safety of operation, criteria that has no constraints and does not take into account the duration or cost of intervention;
- preset budget for maintenance expenditures as well as the cost for interventions has to be included in the general budget approved by the section management;
- the duration of interventions is variable; thus some interventions can be requested as an emergency in this case the budget being not set. Optimization requirements are subordinated to the criteria related to the duration of the respective intervention.

The Model implies in most cases a decision-making process related to maintenance and repair interventions based on the correlation of the three fore-mentioned criteria.

From an economical point of view, maintenance costs (C_m) depend on a functional level on:

- the duration of the technological equipment in a safety state (T_s);
- the moment of replacing the worn equipment (M);
- the evaluation of the necessary budget for equipment maintenance for its entire exploitation period (F_e).

The functional relation of expenditure with system maintenance is thus: $C_m = f(T_s; M; F_e)$.

A structuring model for the functional maintenance and intervention model [2] is presented in figures 1 and 2 and shows as previously stated the two main subsystems included:

- The maintenance and intervention system (figure 1), that includes: preventive and corrective maintenance components, spare parts and defects; programming, preparation and monitoring of activities; execution of specific interventions; objective controlling; technical analysis of activity execution
- The economical system (figure 2) that includes: monitoring maintenance expenditures and including them in the approved budget, identifying intervention with high costs and costs of defects.

The two types of analyses – technical and economical – will lead to the development of an optimum solution in relation to the decision regarding each equipment maintenance and repair.

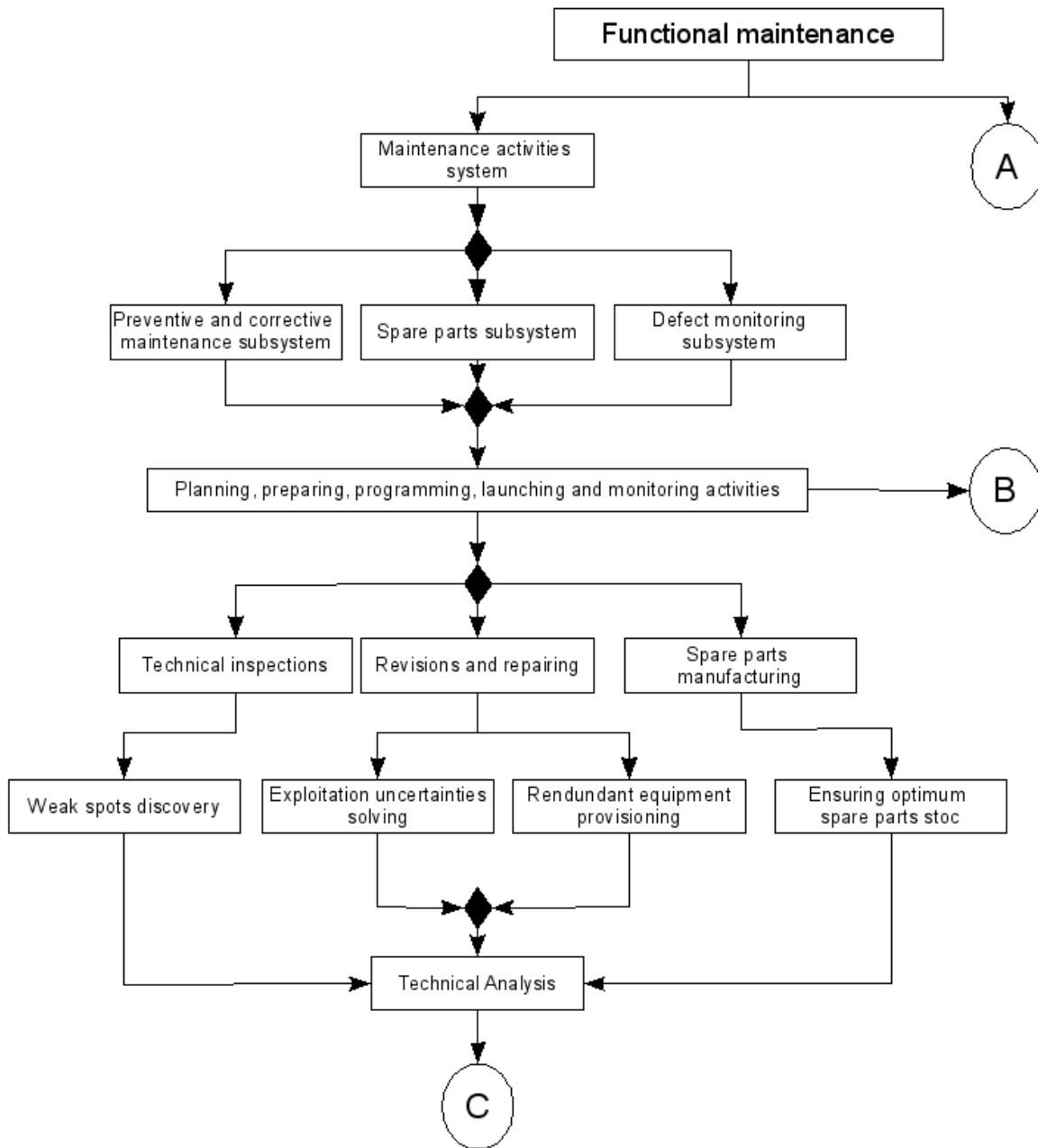


Fig. no. 1: Functional maintenance and repair system

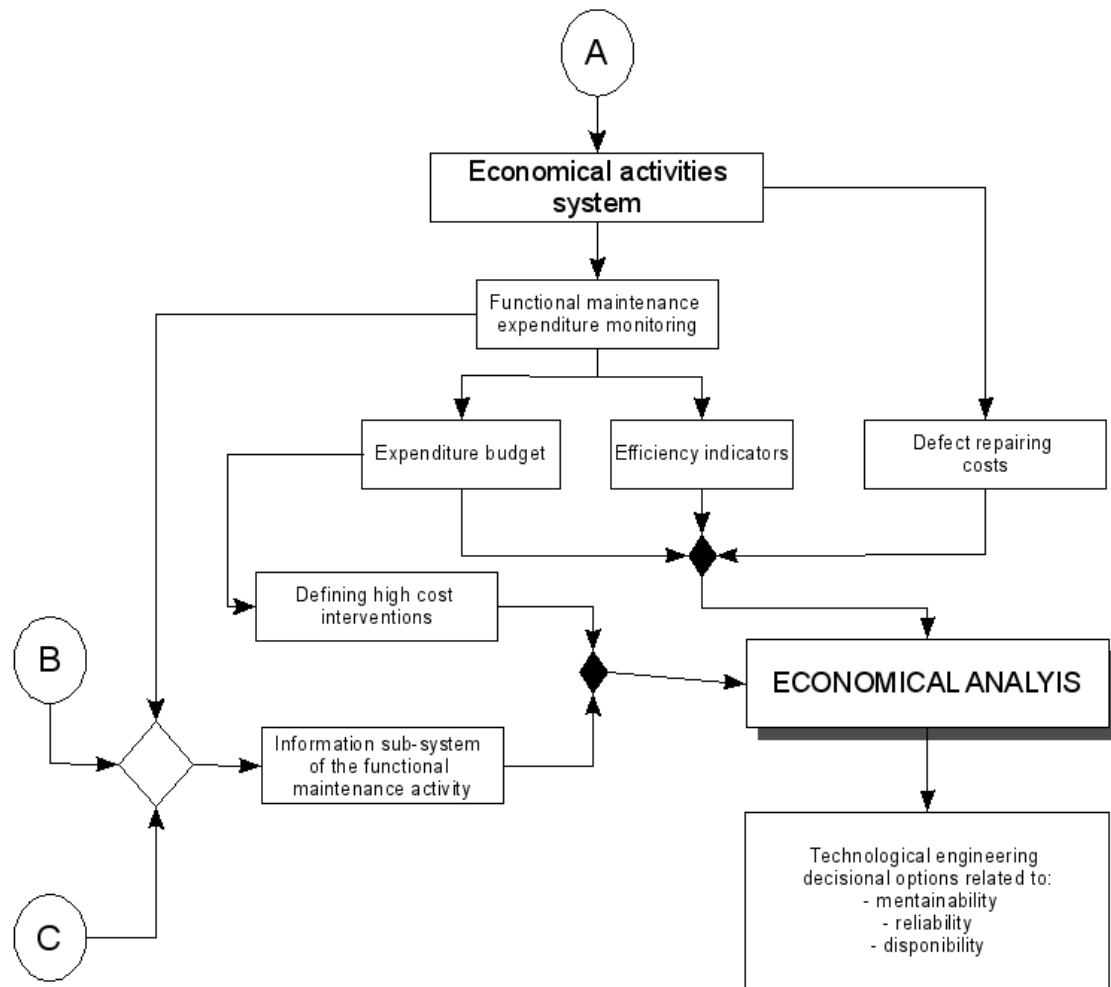


Fig. no. 2: Economical activities system related to the functional maintenance and repair

Conclusions

In the actual economic context, using modern maintenance models that are supported by an adequate informational system can ensure an increased efficiency of industrial equipment exploitation for any manufacturing enterprise. To accomplish this, a significant level of attention must be given to such maintenance models by the management of the organization.

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