MODERN APPROACHES IN THE INDUSTRIAL MAINTENANCE MANAGEMENT - THE CONDITIONAL TYPE MAINTENANCE

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ABSTRACT: *Modern solutions from the industrial type management consist in using informational systems, sustained by means of measure and control of the main equipments from the technological flow. The paper presents several solutions in applying management in the conditional type maintenance activity. Conditions for a optimal work flow specific to this type of maintenance assume covering several analysis phases and the systematic examination of the range of means of measure and control. Application of Informatics in the conditional type maintenance also implies using methods for deploying systems of technological equipments work pursuit, taking into consideration the complexity of the means used and the deployment and using costs.*

KEY WORDS: *maintenance; informatics; systems; management; costs*

JEL CLASSIFICATION: *L00*

1. THE PREREQUISITIES OF CONDITIONAL TYPE MAINTENANCE APPLICATION

The prerequisites for using the conditional type maintenance of the industrial technological equipments, presume two main conditions:

- on the one hand, the issue of existing the technical possibilities of application, respectively, of the means of grasping representative signs for an evolutionary degradation of a certain type of technological equipment, signs that should manifest through a slow evolution in time

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and which are the basis for identifying the nature of that degradation and its localization;

- on the other hand, conditions of economical profitability for such a step are required, respectively, conditions for introducing a system that would insure the continuous measuring for certain functioning anomalies in the absence of imperative security criteria.

For this, studying the technical feasibility for application of the conditional maintenance is necessary in order to establish if resorting to informatics' means of deployment for a continuous supervision system represents the most efficient solution.

In the state of designing an informational system, which must suit the requirements of applying the conditional maintenance, it will refer to the fact that the system which will be proposed should represent an efficient instrument for investigating the quality of equipment working and should allow at the same time the improvement of reliability, maintainability and, respectively, their operative reserve.

Thus, the proposed system must be a mean through which it will be possible to systematically investigate the working state of equipments on the basis of specialized devices (transmitters) through which the control and measurement of the proposed parameters for conditional maintenance is guaranteed.

The management applied in industrial undertakings [1] assumes, generally, using informational systems with the role of means of measurement and control of output appliances and technological equipments, because within using these may be insured the solution for two problems, namely:

- the management of the process referring to the output activity, respectively of the production technology
- anomaly detection for the technological equipments and facilities, specific to the conditional maintenance function.

These systems are named "integral maintenance systems" from the viewpoint of the maintenance management, and the great firms from developed countries use such systems specialized in activity fields. For example, Citroën works from Rennes uses for the XM type cars assembly section the SIMONA model (Simens monitoring system for automation).

Generally, such systems can insure:

- immediate establishment of work equipments faults and conveyance of data to the output activity management dispatching;
- possibility to inform about the nature and causes of the disturbance;
- conveyance of the pieces of information to the qualified person who can insure maintenance;
- obtaining data from systematic preventive maintenance;
- visualization of the faults in the synoptic form at the dispatching of the unit, that can warn through the system peripherals from the maintenance shop or directly the person responsible for the maintenance of the equipment out of order.

2. CONDITIONAL TYPE MAINTENANCE DEFINING MODEL

As it is shown in the article „Using Expert Systems in the Management of Industrial Equipment Maintenace" [3], these systems present a major interest for the industrial undertakings in pursuing functioning key equipments, because they may offer data referring to historical events regarding stops or disturbances appeared for the respective equipments precisely since they were put into service. In fact, this represents the use of the experience obtained in the maintenance of these equipments by stocking in the informational system database the historical data from the analysis for the work of the equipments been in productive use in the moment of the analysis. These analyses and experiences enable establishment of the reliability database of the technological equipments necessary for the data marshalling process of maintenance.

Depending on the likely or possible advantages of the conditional maintenance concerning systematic maintenance or the interest in looking for, by priority, the application of the most efficient methodology to perform the maintenance for the equipments for which drops must be avoided, defining a conditional maintenance policy [2] supposes covering several phases of the analysis, this methodology being shown schematic in figure number 1.

From the analysis of the conditional maintenance defining model, shown in figure 1, result:

- In the first stage, the stocktaking of fundamental technological equipments will be fulfilled from the viewpoint of two categories of problems:
  -staff and working equipments security
  - regarding the output waste for the undertaking in the case of disturbance of these equipments.
- As part of the second stage, the critical elements of these essential equipments will be identified; thus, from the analysis laws of distribution of disturbances for technological equipments will result that a number of critical elements are mainly responsible for most of the drops of these equipments. These drops will be possible to avoid by introducing the data marshalling in the use of conditional type maintenance. Further on, it goes forward to establishing the most likely drops, proceeding from extant likelihood estimates and from the unavailability cost that will result in the case of application of corrective type maintenance.
- In the third stage, the type of disturbance will be examined. Thus, we have:
  - progressive disturbance, case in which the conditional type maintenance can be taken into consideration; this requests existence of the possibility to pursue a slow enough evolutionary degradation for which there is an auspicious moment for a repair as far as the working state of the equipment. This evolution duration of the identified parameter represents an important element of the decision to establish the maintenance policy;

- abrupt disturbance, case in which we have only one alternative, respectively, to apply a corrective type maintenance.

- In the fourth stage, there will be worked out a list of flaws depending on the possible modalities to go out of order of equipments, classified in the order of the disturbance hazard defined through the product between "disturbance probability" and "unavailability cost".
- In the final stage, the faults to which is to be applied the conditional type maintenance will be established. For this, there will identify for each of the established faults if significant and noticeable symptoms exist or not, as well as means of control and measure of the beginning of the degradation or disturbance of the equipment, case in which the conditional type maintenance can be applied. These establishments and data can result from the analysis of each fault and of the informational system of maintenance extant or suggested for deployment.

Application of the conditional type maintenance [4] also assumes the systematic investigation of the range of means of measurement and control extant in internal production or on the external market. These means are generally known under the name of "Box of instruments" of application of conditional type maintenance.

Concerning the deployment cost of an informational system for conditional maintenance, first of all it depends on the number and cost of the means of technical and informational supervising, as well as on other factors, such as: the period of service of the means of measure and control, the number of critical elements supervised for a certain equipment; possibilities of upkeep for informational means etc. Thus, we noted with "g" the cost to put into practice the conditional type maintenance. This cost, that includes: the acquisition cost and the exploitation one, has the nature of a global cost of use of a control and measure device.

Within the framework of the analysis a comparison between the average costs of the three types of maintenance noted with c1, c2 and c3 was achieved, proceeding from the analysis scheme from figure 1. The calculus relations of the three costs are:

$$c1 = p + P \cdot f(t) / m(t) \tag{1}$$

$$c2 = p + g / k \cdot MTBF \tag{2}$$

$$c3 = p + P / MTBF \tag{3}$$

where:
p – the direct cost of a preventive type maintenance operation
P – the supplementary cost in case of fault
m(t) – average equipment work duration
g – the cost to put into practice the conditional type maintenance
k – operation time average adjustment coefficient (≈1)
MTBF – good working time average

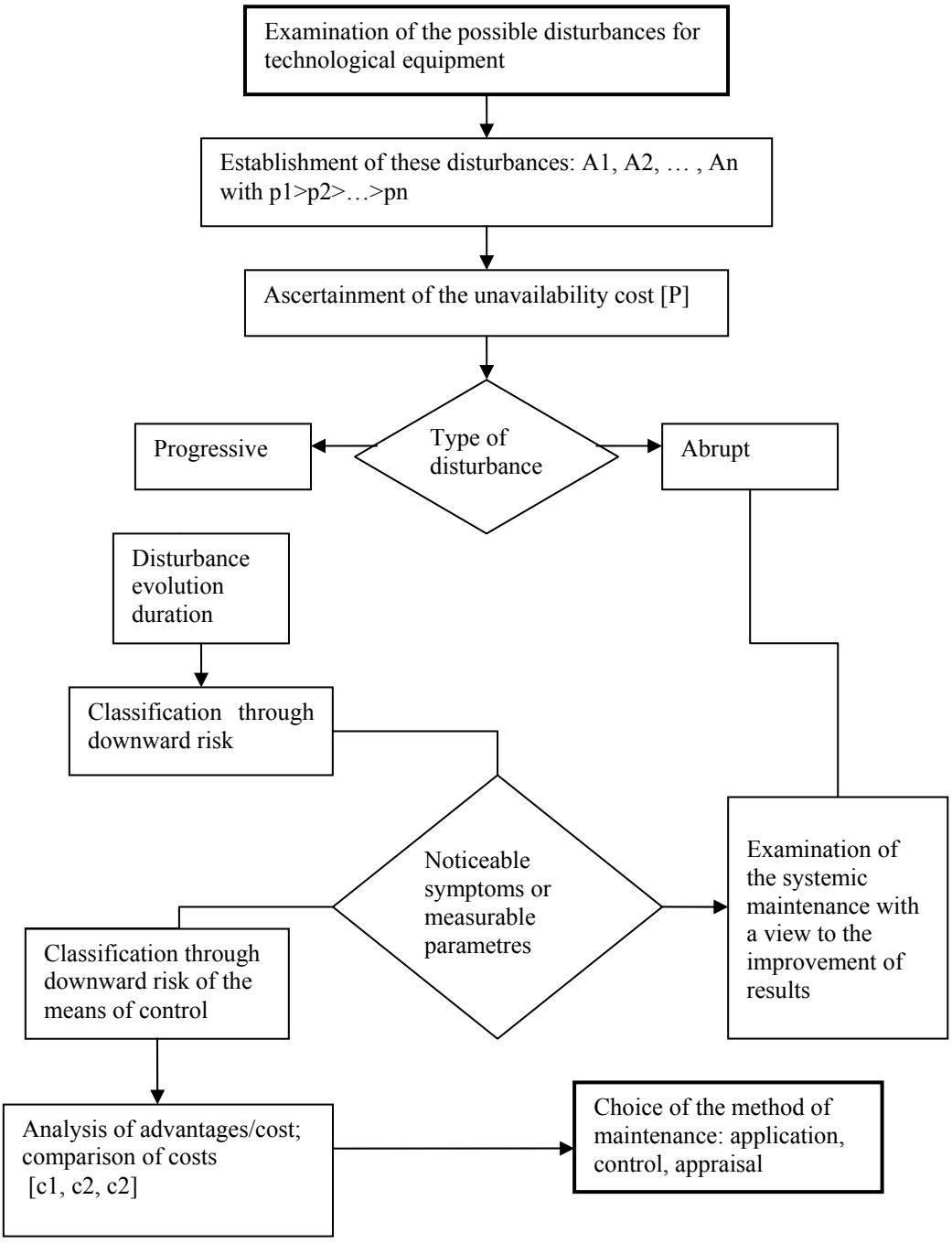

Figure 1. Model of analysis for the application of the conditional type maintenance

3. ROLE OF INFORMATICS IN THE CONDITIONAL TYPE MAINTENANCE

Data marshalling of the process of essential technological equipments work pursuit forms a fundamental change of the role of the operating staff; this change mainly consists in supervising and controlling the proper working of the respective appliances and equipments by pursuing the indications (respectively the pieces of information) conveyed by the measure and control devices fixed on these. At the same time, both the operating staff and the equipment and the appliances maintenance one will be trained regarding the correct interpretation of these pieces of information in accordance with the instructions established by the team of experts who realized the system deployment.

On these terms, the operator of data marshaled and automated equipments must be capable to note the beginning of the degradation of equipments that are found in his responsibility area. This, in accordance with the principles proposed by the Japanese method of maintenance type TMP [7] considers that the role of the operator, besides the one to pursuit the devices for measure and control of automized equipments, is also the one of a "human pick-up" who has multiple means of control and decision, thanks to the five senses that grant the human's own possibility of analysis and synthesis.

Another possibility [5] to perform the conditional type maintenance for technological equipments is the one of equipment inspection, which supposes performing recurrent calls for ware check and represents at the same time a mean of control and detection of the anomalies in the work of equipments. This manner of accomplishment of the conditional maintenance is recommended for the equipments with a reduced degree of complexity for which the work anomalies that have a appearance frequency lower than the one established for performing the control, but in this case, too, resorting to informational systems will be beneficent, because in this way a centralization and stocking of the data registered following the checks is insured.

Thus, all the data are obtained from the simplest means of control and automation, like, for example: the measurement of power absorbed by the main electric driving engine or the measurement of the pressure from a hydraulic circuit, to the most complex means which are found fixed on the equipments whose work is totally or partly assisted by computer. Within the framework of this process several transmitters (connected with the informational system of maintenance insurance), through which a permanent control of the parameters for good work is realized, to which data resulted following the inspections can be added. All these measures build the main (key) technological equipments supervising process, named "monitoring".

Also, a modality to act in the direction of the deployment of a technological equipments supervising system [6] results from the choice between <to do> and <to do – to do> (< faire> et <faire – faire>), respectively to proceed to the company deploying a measure and control system for technological equipments, through its acquisition by the company (variant presented until today), or, on the contrary, to appeal to a society specialized in performing measurements and controls for the respective equipments by using its own apparatus and staff. This modality is used by the enterprises that do not

have neither perfected apparatus and devices and specialized staff for using and interpreting recordings, nor the financial resources necessary for such an investment.

Application of Informatics in the conditional type maintenance of technological equipments must begin with the stocktaking and analysis of the solutions possible to be applied, solutions which can be classified in terms of the application costs, of obtaining data necessary for the <elimination> of diverse causes of disturbance of the critical elements that form the respective equipments. For performing such a stocktaking and analysis we propose a tabular model which is presented under a general form in table 1.

Table 1. Matrix of selection and analysis of priorities in the conditional type maintenance

No.	**Classification in terms of increase in the cost of the means of control put into operation**	**Classification of disturbances of critical components depending on the diminution of the disturbance risk degree**					
		C1	C2		…		Ck
1.	Use of measure and control means for technological equipments: E1 E2 E3…	 * 	 *	 	 	 *	 * * *
2.	Controls through equipment exploitation operators: - E 10 - E 11…	 *	 * 	 	 	 * 	 *
3.	Recurrent controls with equipments work check: - E 20 - E 21…	 * 	 	 * 	 	 	 * *
4.	Automized measure and control systems for checking the work of the main technological equipments: - E 30 - E 31…	 	 * 	 *	 	 	 *
5.	Appealing to specialized societies - E 41 - E 42…	 	 * *	 	 	 	 *
6.	Monitoring appliances - E 51 - E 52…	 	 * *	 * *	 	 * *	 *

In table 1 we presented a number of six methods of deployment of technological equipments work pursuit systems classified depending on the complexity of the means used and on the deployment and using costs. For each one of the equipments included within the framework of the pursuit process the critical components arranged in terms of the disturbance risk degree will be established; generally the number of components subdued to supervision increases depending on

the complexity of the method applied. Thus, it can come that in the case of the deployment of a monitoring system (in accordance with position 6. from table 1) all the work parameters are pursued, which means including all the critical components of the respective equipments within the framework of the system.

4. CONCLUSION

The application of a optimal policy in the maintenance management requires a comparative analysis of the conditional maintenance deployment programmes with the corresponding programmes of the corrective maintenance, with the likely comprising of the optimal systematic maintenance actions, for equipments for which the conditional type maintenance can be applied by priority, respectively for the equipments for which the disturbance instalment is increasing in time.

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