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The control of the setting up of a predictive maintenance programme using a system of indicators

M. Carmen Carnero Moya*

Technical School of Industrial Engineering, University of Castilla-La Mancha, Avda. Camilo José Cela s/n, 13071 Ciudad Real, Spain

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Abstract

Predictive maintenance is one of the maintenance policies which is revolutionising the industry, due to the increase in security, quality and availability which is on offer to an industrial plant. However, the implantation of a predictive maintenance programme (PMP) is a strategic decision, and to date the analysis and study of questions relative to its setting up, management and supervision have not been carried out sufficiently. This paper proposes a system composed of indicators to control the setting up of PMPs which should facilitate the early detection of anomalies which can appear during setting up, thus avoiding the failure of these programmes. The system developed can be considered a predictive control of the PMP.

Keywords: Predictive maintenance; Control; Indicators; Decision making

1. Introduction

The increase in competition, globalisation of businesses, moves towards total quality management, constant technological changes, the supremacy of security and the implication of industry in environmental questions, are some of the factors which have brought about great changes in the structure of companies. These modifications have been carried over to the production area, as this is the one most directly involved in the efficiency and sustainability of the industrial processes. This concern has been transferred to maintenance, traditionally considered a source of costs, and now associated with more strategic issues, from an approximation based on the concept of sustainability, thereby pursuing the strategic consensus defined in Boyer et al. [1].

The implications in production and maintenance [2] suggest the need to change the focus of maintenance policies, traditionally centred on short term issues (use of resources, costs, etc.) towards the consideration of longer term goals (competitivity, sustainability and strategy).

Predictive maintenance is a maintenance policy in which selected physical parameters associated with an operating machine are sensored, measured and recorded intermittently or continuously for the purpose of reducing, analysing, comparing and displaying the data and information so obtained for support decisions related to the operation and maintenance of the machine [3].

The benefits which can be obtained by introducing a predictive maintenance programme (PMP) are: an increase in the availability and safety of the plant, improvements in the quality of products [4] and of maintenance [5] as well as in the quantity and quality of the information available about industrial machinery, the increase in the programming capacity of maintenance activities, optimisation in management of the store for spare parts, support in the design and improvement of industrial machinery, [6], reduction of maintenance costs and capacity to research the root causes of breakdowns [7], improved image as the time needed preceding delivery to the client is reduced, etc. As explained in Christer et al. [8], it is necessary to identify maintenance needs in advance in order to maintain the normal functioning of production systems.

Multiple models have been developed for the optimisation of maintenance. Cassidy et al. [9] propose a system whereby the decision-making centre can choose between

* Corresponding author. Tel.: +34-926-295300; fax: +34-926-295361.
E-mail address: carmen.carnero@uclm.es (M.C. Carnero Moya).

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multiple maintenance options, such as minimal repair of faulty components, replacement of faulty components and preventive maintenance. Murthy et al. [10] suggest a model to obtain optimum decision making in a maintenance service operation. McKone and Schroeder [11], describe the factors which contribute to the setting up of total productive maintenance programs (TPM), determining which contribute most to the development of maintenance systems. Deris et al. [12] and Wang [13] describe the timing of programmed replacement of components or consumables, and Sheu's [14] objective is similar in relation to minimum costs. Triantaphyllou et al. [15] develop a model for classifying different criteria relating to industrial maintenance, including availability, reliability, etc.

Developments have also arisen concerning the decision to carry out the maintenance process in an individualised way, or co-ordinating maintenance activities in various components with the aim of minimising maintenance set-up costs, like the heuristic algorithm presented in Wijnmalen and Hontelez [16], in Wildeman et al. [17] and in Dijkhuizen and Harten [18]. However, whilst an effort has been made to construct mathematical models for optimising the preventive maintenance policy, we should point out the absence of tools for optimising and checking the predictive maintenance policy.

The aim of this paper is to contribute to research by developing a model which will allow to evaluate the setting up of a PMP, an aspect that has not been analysed until now, as research in predictive maintenance has focused mainly on the development of new diagnostic techniques. Hence there is a marked lack of models for analysing the problems of PMPs with respect to evaluation, management and control. The model proposed will be applied in industrial maintenance, an area in which mathematical developments are of complex practical application [19] due to the lack of information, insufficient understanding of mathematical models by the staff required to apply them in an industrial plant, or to the difficulty of applying new models when the company does not provide additional resources to adapt to the new situation.

This paper continues in Section 2 with an explanation of some concepts relating to problems in setting up PMPs. Section 3 explains the characteristics of PMPs. Section 4 includes a description of the indicators which make up the control system for setting up of PMPs. Section 5 presents the main empirical findings. Section 6 gives the conclusions.

2. Problems in setting up PMPs

The suggestions put forward in Hipkin and De Cock [20] regarding the setting up of TPM and reliability centred maintenance (RCM) programmes can be extended to the setting up of a PMP. PMPs lack a standardised methodology to facilitate set-up.

The level of effectiveness of the PMP during the design, planning and adaptation phases is low, since reliable measurements of the condition of the industrial machinery are not available. However, the company management expects to obtain favourable results, and it therefore has a negative influence on the other phases in the set-up of the PMP which then contributes to the loss of confidence in the programme, with the subsequent reduction in resources allotted to PMP or even its elimination [21].

An adaptation period should be established between the theoretical models and procedures of the PMP, in its technical and management aspects, in order for them to adapt to the peculiarities of the industrial organisation. During this stage there should be unconditional support for the programme from the whole organisation.

The processes of acquiring predictive data may be obstructed by the productive process. Among the aspects to be studied are: the absence of information, the fact that information may have been obtained under different processing conditions, the influence of traditional policies on predictive control parameters, etc.

Companies may aim to maintain the policies and structures established to date alongside innovative policies. However, the PMP set-up team should encourage the suppression of the traditional maintenance model of the organisation in favour of the introduction of a dynamic system of maintenance policies in direct dependence on the predictive policy.

When different predictive techniques are applied, the information for obtaining higher results in the PMP is not integrated [22]. The absence of integration may be caused by the fact that each predictive technique is performed by different sections of the organisation, and therefore by different staff members, who do not establish any exchange of information. This may also be due to the difficulty of having computer programmes which integrate different predictive techniques.

It is essential to carry out a suitable assessment of the dimensions of the project according to the human resources and techniques available to the industrial organisation. This factor generally implies the restriction of research to one family of machinery or sector of the industrial plant.

Predictive diagnostic techniques require the use of complex mathematical tools which in turn demand the acquisition and analysis of historical data during the set up period of a PMP. However, the industrial organisation can act well in advance of the development of a catastrophic breakdown by means of the predictive maintenance plan. Nevertheless, the PMP requires historical information about the break-points which define the limits of evolution towards a new state of the industrial machinery, that is to say unsatisfactorily and unacceptably severe states.

A PMP may lack information tools or efficient automatic means for the acquisition and treatment of the predictive information. The potential of the predictive technology is optimised by the use of coherent information resources at the technological level of the technique applied. However,