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Management and planning of tools maintenance activities in a metalworking

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Abstract

This paper presents an ongoing project in the metalworking section of a company that produces metal parts, responsible for the development and maintenance of production equipment tools. A tool is composed of several parts or punches whose failure causes production stoppage.
The project's main goal is to make the planning and programming of activities to be performed by the section to be more efficient and reduce production downtime. In particular, it is intended that the maintenance work on the tools becomes preventive rather than corrective. The first step in the project realization was to design, develop and implement a computer application to collect the data needed to plan preventive maintenance actions, to monitor the work carried out by the technical area and to determine performance indicators.
This paper presents the computer application and outlines the methodology to be adopted for setting the frequency of preventive replacement of parts, which consists on grouping of parts of the same tool to proceed with group replacements, thus limiting the number of production stoppages.
The definition of part replacement frequency will allow planning and scheduling the activities of the metalworking, including the development of wear parts whose need is calculated based on the quantity of product units to be produced, the reliability of the part and the preventive replacements frequency.

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1. Introduction

Production systems are facing a demanding and highly competitive market. The lack of planning and rigorous application of management methodologies may compromise the economic and financial health of industrial companies. It is common that companies operate solely based on compliance with delivery times, to ensure the satisfaction and loyalty of its customers, sometimes increasing operating costs due to not identifying critical situations.

The acceptance of ever shorter delivery times, and of orders increasingly small in order to ensure the survival of the company in the market means sometimes conducting operations without any prior planning, including the maintenance activities required for the proper functioning of equipment.

In these operating conditions, preventive maintenance actions are sometimes relegated to second place, and the organization act reactively to minimize the effect of failures. The delaying of preventive maintenance creates the idea of increasing production capacity in short-term, although it will certainly increase costs and reduce the production capacity in the medium and long-term. The production capacity loss may be compensated by increasing overtime and consequently with the increase in operating costs. The reactive maintenance requires the interruption of ongoing work and the repairs quality may be less than desired and may even compromise the quality of the final product.

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The project described in this paper is developing in a company that produces metal parts and aims to define the planning and scheduling of maintenance activities to be performed by the metalworking in order to improve their efficiency. The metalworking is dedicated to the maintenance of the tools of production equipment and the development of components for these tools, which wear over time with the production of metal parts. The approach is essentially reactive and dictated by technical experience.

Several steps for the realization of the project were defined. The first consists in determining the periodicity of the components replacement taking into account the distribution of their lifetimes. In this paper, we describe the work done in this first stage which includes the design and implementation of a computer application for the collection of data required for the planning of maintenance actions, and the definition of a methodology for determining the preventive replacement interval of the components.

Each component is considered a non-repairable system since its repair in order to fulfill its function properly is not advantageous for economic and time reasons. Therefore, the failure times of these components are modeled by probability distributions that will be used later in the maintenance model used to determine the frequency of replacement.

This paper is organized into six sections. The first defines the scope and project objectives. The second section presents a literature review about failure times modeling and parts replacement models. The problem and the steps to achieve the established objectives are explained using IDEF0 methodology, in the third section. The fourth section describes the developed computer application. In section five, the proposed methodology for the planning of maintenance is presented. The last section presents the conclusions and points out the future works that will be developed.

2. Literature review

2.1. Data gathering and reliability estimation

The first step to establish an effective preventive maintenance program is to decide the data to be gathered and the method to collect it. This first step, in some situation, was already started in the past and company has already an historical record. However, in this case, some adjustment should be done frequently due to lack of data, unreliability of the recorded data or inadequate records.

For modelling failure times, two different approaches have been used [1]:

- Theory based modelling where the modelling is based on the established theories for component failures. This kind of model is also called physical model or white-box model.
- Empirical modelling where the failure data forms the basis for the model building. This kind of model is also called data dependent model or black-box model.

Barabadi [2] proposed a methodology with five steps for empirical modelling:

- Step 1: collecting data.
- Step 2: preliminary analysis of data.
- Step 3: model selection.
- Step 4: parameter estimation.
- Step 5: model validation.

According to [2] the data collected in Step 1 are basic data, consisting in time between failure (TBF) for repairable systems and time to failure (TTF) for non-repairable system, all factors that influence reliability of the system (such as temperature, dust, humanity, etc.), failure mode and failure mechanism. Failure data can be classified as complete and censored data. In complete data, the date that a system is installed and the date that it is failed are known, allowing the calculation of the TTF or TBF. For censored data one of these dates is not known. For instance, when a non-repairable system is replaced before its failure, the failure date is not known. However, censored data is also useful since it gives information about a time without failure.

For modeling the failure time of non-repairable system or the time between failures of repairable system, the two-parameter Weibull distribution has been extensively used [3]. A large number of models have been derived from the two-parameter Weibull distribution and are referred to as Weibull models. They exhibit a wide range of shapes for the density and hazard functions which makes them suitable for modeling complex failure data sets.

2.2. Parts replacement

The age replacement policy and block replacement policy models are possible policies for parts replacement [4]. In the age replacement policy, the preventive replacement occurs according to a defined and fixed age of the system or when a fault occurs. In the replacement block policy, the substitution occurs at regular time intervals, regardless the age, or when the failure occurs [4]. The block replacement policy has been applied to optimize replacement intervals of identical equipment parts and the replacement interval is determined for an entire group of parts [5]. Talukder and Knapp [5] proposed a heuristic method for grouping equipment into blocks within a series system, based on group technology concepts in order to minimize the total maintenance cost.

As referred by Kim et al. [6], most preventive maintenance plans are based on costs. However, there are models that take into account other optimization criteria apart from the costs, as the availability of the system [6].

Das et al. [7] present a combined multi-objective model for maintenance planning in a cellular manufacturing environment, where the preventive maintenance costs and the probability of failure of each system are considered to achieve a balance between the two criteria. The developed model is based on the block replacement policy.

3. Project phases

A typical maintenance process management system includes four basic stages: Performance Examination; Maintenance Planning; Maintenance Scheduling; Maintenance Execution and Feedback.