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Supporting maintenance scheduling: a case study

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Abstract

This work intends to incorporate in a computerized maintenance management system (CMMS) a scheduling support tool that, given a set of preventive maintenance tasks and the availability of equipment and technicians, returns a scheduling solution for a given time period. The tool is based on an algorithm that aims to minimize the total tardiness. The algorithm sorts, initially, the maintenance tasks by a critically index equipment and by tasks due date. Then the tasks are assigned checking previously if necessary spare parts are available. An application example is provided to show the proposed algorithm effectiveness.

Keywords: Scheduling; maintenance scheduling; preventive maintenace; heuristics, optimization

1. Introduction

Preventive maintenance (PM) is applied at predetermined intervals or according to certain criteria with the purpose to reduce the probability of failure or degradation [1]. PM scheduling aims to establish "when" and by "who" each planned task will be processed and its main concern is to find the best sequence of maintenance tasks for the manufacturing process in each period over a planning horizon [2] so that the company's needs are satisfied. Each preventive maintenance task to be scheduled usually involves technicians, equipment and, frequently, spare parts.

This paper reports part of an ongoing project aimed to improve the computerized maintenance management

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system (CMMS) of an automotive company. In the company, the PM scheduling is performed "manually" by a planner, supported by the CMMS which roles as an information system and solution editor. Therefore, nowadays the maintenance scheduling is a time-consuming activity due to the high number of planned tasks to be considered and the constraints to attend: the technician's availability and their skills; the spare part stock; and, mainly, the downtime of production lines that defines the equipment availability. Consequently, the current scheduling method evidences lack of effectiveness and efficiency.

In the automotive company that works 24 hours a day, the planner elaborates a weekly scheduling concerning the production lines schedule. However, daily, the planner reschedules the tasks to use the unplanned downtime of production lines, since the automotive company does not allocate time exclusively for preventive maintenance, except on the weekends. The daily changes in production plan compromise the application of the maintenance scheduling weekly plan. The tasks allocation process does not follow any method or formal dispatching rule. As an input on the CMMS, there are around 6000 preventive maintenance tasks that need to be scheduled. Besides regular tasks, this input includes tasks with predefined time schedule (for instance a compulsory task to comply with the law) and autonomous maintenance tasks. As output, the algorithm must provide a schedule, which, taking as example one week, establishes the assignment of approximately 600 maintenance tasks to technicians.In the manufacturing area, the different production lines have different utilization rates, where some of them have significantly higher utilization rates than others. Therefore, equipment which is part of the production line with higher utilization rates should be given priority over other equipment since line stops are much less frequent.

The maintenance scheduling requires a method to allocate the maintenance tasks to the limited resources that takes into account the objective function and a set of constraints. The objective function must meet the main goal of the company and the method should be appropriate to solve the problem, achieving a good solution in a short time [3] since the scheduling method might be used several times a day, and the number of task is very large.

Thus, this paper outlines the development of a scheduling support tool based on an algorithm that aims to minimize the total tardiness and an objective function defined by the company. The paper is organized in five sections. Section 2 shows a literature review about scheduling, Section 3 presents the algorithm. Section 4 presents an application example of the algorithm and, finally, Section 5 shows the main conclusions.

2. Literature Review

According to Noemi M. Paz [4], the maintenance scheduling problem can be modeled as a job shop scheduling problem where:

- a job in the job shop problem is the maintenance work order to process;
- an equipment in the job shop problem is a maintenance worker [4].

In this section the adequate objective functions for maintenance tasks scheduling and scheduling approaches are reviewed.

2.1 Objective Function

According to Pinedo [3], due dates, deadlines and periodicity are important parameters on preventive maintenance tasks. These parameters should be respected to guarantee a proper functioning of production lines. The objective functions most related with maintenance task delays and due dates are the minimization of maximum lateness (L_{max}), minimization of number of tardy tasks (U_j) and minimization of total tardiness (ΣT_j) [3,5].

The minimization of maximum lateness is equivalent to minimizing the worst case of the schedule and it is expressed by $L_{max} = \max (C_j - d_j)$, where C_j is the completion time of task j and d_j is the due date of task j (Fig. 1 (a)). The minimization of number of tardy tasks (U_j) is another objective function which represents the number of tasks that were done after due date. However, minimizing the number of tardy tasks can result in a schedule with high delay. The total tardiness measure is another performance measure related with the delay expressed by $\Sigma T_j = \Sigma \max \{C_j - d_j;\ 0\}$ (Fig. 1(b)). It considers the sum of tardiness of all scheduled tasks. However, if it is intended, different tasks may carry different priority weights, where the most critical tasks have the higher weights (w_j). Apart from the tardiness penalization, the earliness completion (E_j) of tasks can be also penalized. The representation of cost functions that consider earliness and tardiness penalties ($E_j + T_j$) is presented in Fig. 1 (c).