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Elaboration of an advanced method called "|PKPGA|" for maintenance decision making

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Abstract— In this article, we provide an original contribution to the science of decision. We elaborate a new method dedicated to making decision in the maintenance science. This method is named |PKPGA|. It is an evolution of the method ¬PKPGA, this latter was elaborated in this paper by the fusion of two efficient methods in the science of decision, namely the method PKPGA and the method CBA. The method |PKPGA| give us the best results of the two methods PKPGA and ¬PKPGA. The method |PKPGA| will permit the manager to tack an efficient decision in order to reduce the cost of investment in the maintenance and to increase the productivity of the company.

Index Terms— Pareto, science of decision, Industrial Maintenance, PKPGA, CBA, Knapsack Problem.

1 INTRODUCTION

TODAY, the science of decision in the industrial maintenance is very important in order to ensure the proper functioning of machines in the company and therefore to have a high productivity.
The statistical data show that over one third of company expenses come from maintenance costs of unnecessary or poorly executed transactions. These costs can be reduced by taking the good decisions in a certain situation. The most important decisions is the choice of method of maintenance management directly influences the cost of expenditures in the maintenance.
For this reason, the manager must choose the best several decision support tool to provide a satisfactory solution. In this sense, lot of method was elaborated [1][2][3][4][5][6][7][8][9].
In the laboratory LTI, many researches was elaborated in the subject. The most important are [3][4][5][9].
The paper [5] presents the method PKPGA which combines three methods, namely ABC method, Knapsack Problem and Greedy algorithm in order to provide the best choice of how a machine should be maintained. This method has been approved by testing in the industrial manufacturing; the results of the method "PKPGA" are very satisfying.
The article [3] mention that the classification A, B and C in Pareto method does not give the desired results for all the times. The authors inverse the classification "A, B and C" to "C, B and A" and in the end of the paper, the authors suggest to compare the two classifications and use the best of them in every case study.
In this paper, we propose a new method by combining the two methods PKPGA and CBA in order to elaborate an efficient method in decision-making in the science of industrial maintenance, in order to minimize the cost of maintenance and to increase the productivity in the company. Thus, we will formulate this new method in science of decision.

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The rest of this paper is organized as follows: Section 2 provides the method PKPGA. Section 3 formulates the Knapsack Problem, and Section 4 presents DIAGRAM CBA. Section 5 formulates our contribution, and finally, section 6 draws conclusions.

2 METHOD PKPGA

The method "PKPGA" is developed by combining the ABC method, Knapsack Problem and Greedy algorithm. The algorithm of the method PKPGA is the following [5]:

Step 1: Calculate the percentage of cumulative breakdown of each machine
Step 2: Calculate the percentage of the intervention cost for each machine
Step 3: Calculate the efficiency value for each machine
Step 4: Sort the efficiency value by descending
Step 5: Choose the machines by this order
Step 6: Apply the method of the Knapsack Problem.

3 KNAPSACK PROBLEM

The knapsack Problem (KP) or rucksack problem is a problem of combinatorial optimization. It is described as follows: Given a set of elements, with a mass and a value each, it determines the element to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible. It derives its name from the problem faced by someone who is constrained by a fixed-size knapsack and must fill it with the most valuable elements [1],[2],[6],[7],[8] then the parameters may be the volume of the bag or container and the value or price.
The data of the problem can be expressed in mathematical terms. Objects are numbered by index i varying from 1 to n. Numbers Wi and Pi are respectively the weight and the value of the object numbered i. The capacity of the bag will be noted W.
There are many different ways to complete the Knapsack. To describe one of them must be indicated for every element whether it is taken or not. We can use a binary coding: the state of the element i will have the value xi = 1 if the element is in the bag, or xi = 0 if it is left out. A way of filling the bag is completely described by a vector called vector content, or simply content:

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X = (x1, x2... xn), and the associated weight or value of this filling can then be expressed as a function of the vector content.
For a given content X, the total value in the bag is naturally:

$$z(X) = \sum_{\{i, x_i=1\}} p_i = \sum_{i=1}^{n} x_i p_i$$

Similarly, the sum of the weights of selected objects is:

$$w(X) = \sum_{\{i, x_i=1\}} w_i = \sum_{i=1}^{n} x_i w_i$$

The problem can be then reformulated as the search for a content vector X = (x1, x2, ...,xn) (for which the components have the value 0 or 1), achieving the maximum total value function Z(X) under duress (1) :

(1) $$w(X) = \sum^{n} x_i w_i \leq W$$

This is to say that the sum of the weights of the selected objects does not exceed the capacity of the Knapsack.
In general, the following constraints are added to avoid singular cases:

$$\sum^{n} w_i > W$$

: We can not put all the objects;

$$w_i \leq W, \forall i \in \{1, \ldots, n\}$$

: no object is heavier than the bag can carry ;

$$p_i > 0, \forall i \in \{1, \ldots, n\}$$

: any object has a value and brings a gain ;

$$w_i > 0, \forall i \in \{1, \ldots, n\}$$

: all objects have a certain weight and consumes resources ;
Terminology:
Z(X) : is called objective function;
Every vector X satisfying the constraint (1) is said to be feasible;
If the value of Z(X) is maximum, then X is said to be optimal.

4 DIAGRAM CBA

Our research objective is to make the best decision in order to improve the productivity of a company. The Pareto method is among the best known methods in decision making, but this method does not always give the expected 20/80 result; hence it is necessary to improve it or find a new way to have a more optimal decision. In this paper, we propose to classify elements in decreasing order to find a right decision. We propose to make the following steps:

1. Identify the problem to solve.
2. Make a data collection or use existing data.
3. Sort the data into categories and define a category "Miscellaneous" for categories with few items.
4. Total the data in each category and determine the percentages of the total.
5. Sort the percentages by decreasing value.
6. Calculate the cumulative percentage
7. Determine a suitable scale with which to draw the graph.
8. Place columns (bars) on the graph, starting with the smallest on the left
9. Once all the bars have been placed, plot the cumulative percentages

5 CONTRIBUTIONS:

The idea of this paper is to combine the CBA and the PKPGA. The CBA method is ABC method (Pareto method) with reverse order of zones A, B and C. We will name the CBA method by "¬P". The method PKPGA is the combination of the Pareto method, Knapsack Problem and Greedy Algorithm. The new method will be called "¬PKPGA".

5.1 ¬PKPGA

The method "¬PKPGA" is developed by combining the ¬P method, Knapsack Problem and Greedy Algorithm. The algorithm is as follows:

Step 1: Calculate the percentage of cumulative gravity (downtime) of each machine
Step 2: Calculate the percentage of the cost of intervention of each machine
Step 3: Calculate the efficiency value for each machine
Step 4: Sort the efficiency value in ascending order
Step 5: Choose the machines by this order
Step 6: Apply the method of the Knapsack Problem.

5.2 Synthesis

In the article which developed the ABC method, the authors notified that the classification CBA does not give all the time the best result to maintain the system. After several tests of the method CBA the original paper reveal three cases:

Case 1: CBA give results better than ABC results
Case 2: ABC give results better than CBA results
Case 3: ABC and CBA give the same results.

For this reason, they propose to apply the both methods and choose the one that provides the best results. If we follow the same reasoning for our method ¬PKPGA with the method PKPGA, we will find the three cases:

Case 1: ¬PKPGA give results better than PKPGA results
Case 2: PKPGA give results better than ¬PKPGA results
Case 3: PKPGA and ¬PKPGA give the same results.

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In the end of the paper of method CBA, the authors propose the following logigram:

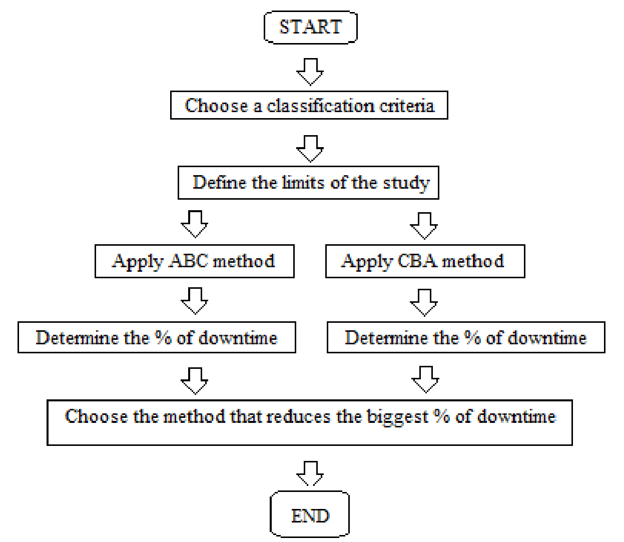

Fig. 1. Algorithm to choose the one that gives the best

This algorithm does not make us satisfied by the new method ¬PKPGA, but it drives us to follow the same analysis. This analysis will permit us to elaborate a new algorithm |PKPGA|. This algorithm combine the method PKPGA and ¬PKPGA in order to have the best strategy for taking the decision in the maintenance science.

5.3 |PKPGA|

The method "|PKPGA|" is developed by combining the "¬PKPGA" method and "PKPGA" method. The algorithm of "|PKPGA|" is as follows:

Step 1: Define the budget to operate in the maintenance (B).
Step 2: Make a data collection or use existing data of downtime for each machine [ref of machines (M) and total downtime for every machine (DTM)].
Step 3: Calculate the total of downtime data and determine the percentages of the total (PDTM).
Step 4: Calculate the costs of maintenance for each maintenance operation (CM)
Step 5: Calculate the total of the maintenance cost data and determine the percentages of the total (PCM).
Step 6: Calculate the efficiency value for each machine.
Step 7: Sort the percentages by decreasing value
Step 8: Choose the machines to maintain with the same method of choice for the greedy algorithm
Step 9: Apply the method of the Knapsack Problem.
Step 10: Calculate the total of percentage of downtime machines chosen to be maintained.

Step 11: Save this result with the name TPDM1
Step 12: Sort the efficiency value in ascending order
Step 13: Choose the machines to be maintained with the same method of choice for the greedy algorithm
Step 14: Apply the method of the Knapsack Problem
Step 15: Calculate the total of percentage of downtime machines chosen to be maintained
Step 16: Save this result with the name TPDM2;
Step 17: Compare the value of TPDM1 and the value of TPDM2
Step 18: If M<MB then apply the method ¬PKPGA
Step 19: If MB<M then apply the method PKPGA

5.4 Algorithm-flowchart of |PKPGA|

To simplify the comprehension of our method, we will modulate in algorithm-flowchart. The algorithm-flowchart of |PKPGA| is very big, so it will be illustrated in four figures.
The fist figure presents the steps 1, 2, 3, 4, 5 and 6.
The second figure presents the steps 7, 8, 9, 10 and 11.
The third figure presents the steps 12, 13, 14, 15 and 16.
The last figure presents the steps 17, 18 and 19.

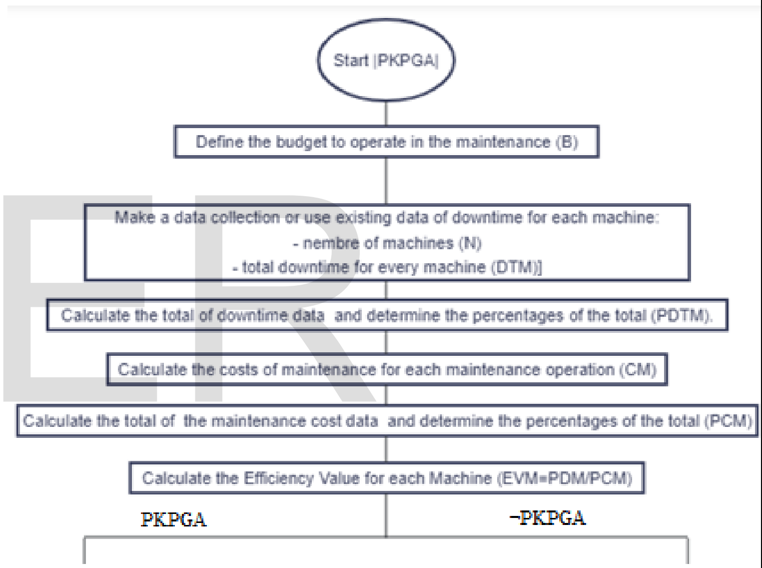

Fig. 2. This part of algorithm-flowchart present the steps 1, 2, 3, 4, 5 and 6. In this phase, we collect the data and calculate de efficiency of the problems.

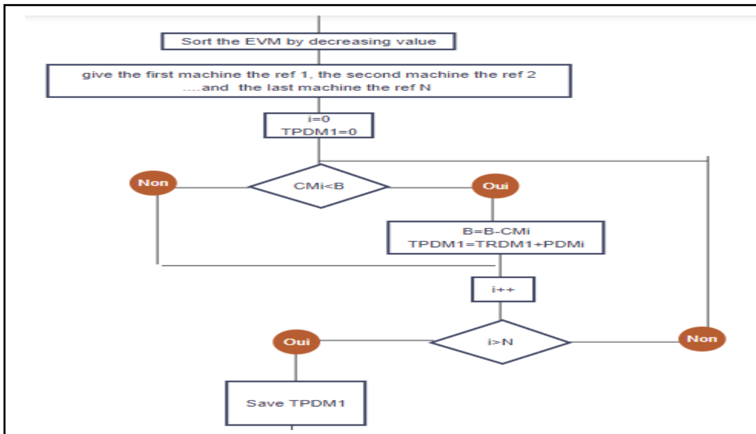

Fig. 3. The second phase is dedicated to apply the method PKPGA and gather the steps 7, 8, Step 9, 10 and 11.

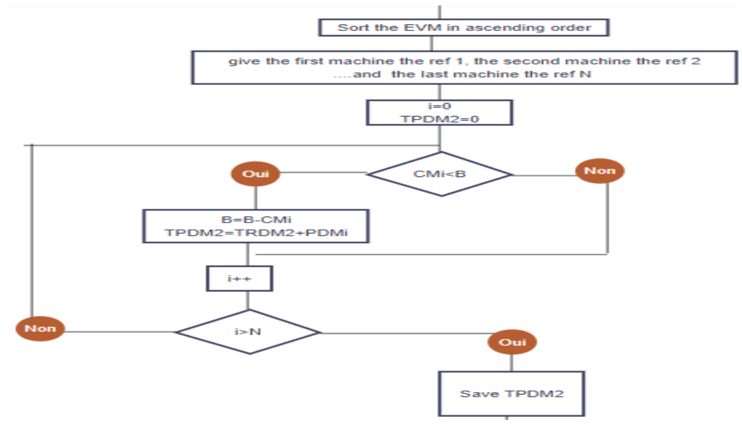

Fig. 4. The third phase is dedicated to apply the method ¬PKPGA and shows the steps 12, 13, 14, 15 and 16.

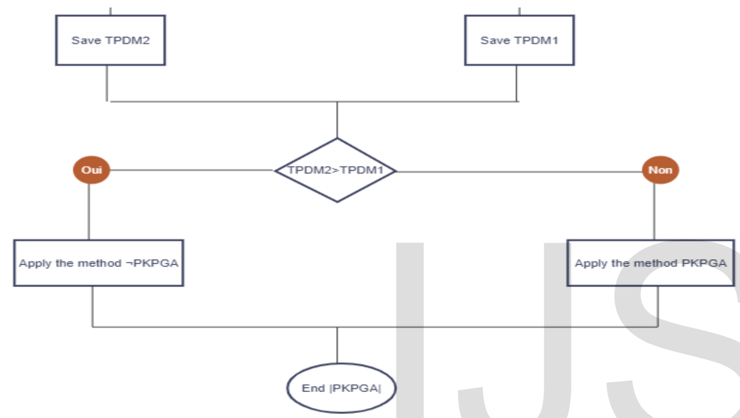

Fig. 5. In the end come the step 17, 18 and the final step 19. We compare the result of two methods (¬PKPGA and PKPGA) and we choose the best.

The resume of this algorithm can be written in the form of this equation:

$$|PKPGA| = \text{Sup}\ ((\neg PKPGA), (PKPGA))$$

6 Conclusion:

This paper presents a new method of decision in the field of industrial maintenance, this method presents the combination of two articles that present a new and effective method in the science of decision, the method CBA and the method PKPDGA. This new method |PKPGA| give us the best of the two methods. It will permit us to have a higher productivity.

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