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Improving Scheduling Manufacturing Work Orders Using AHP Method-Case Study

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Abstract: - Due to the benefic results of using decision making, it has become a very important discipline in different field of life. Decision making had demonstrated its efficiency in different fields such as medicine by improving the health and clinical care of individuals and assisting with health policy development, or politics by predicting election results .It had also showed its importance in other important fields such as logistics, and manufacturing. Among different existing multiple criteria decision making methods, there is the Technique for Order of Preference by Similarity to Ideal Solution, Measuring Attractiveness by a Categorical Based Evaluation Technique and Analytic hierarchy process. In our case study we will evaluate multiple criteria decision making method in a manufacturing environment. Scheduling and planning manufacturing orders is one the case of use of a multiple criteria decision making method. Therefore, in this paper we will study the use of the Analytic Hierarchy Process in an aircraft manufactory especially in scheduling and planning. The study aims to compare number of manufacturing order scheduled before and after the use of the multiple criteria decision making. In the study we will apply analytic hierarchy process to get priority order of scheduling constraint with the help of two manufacturing expert.

Keywords: - *Analytic hierarchy process, decision making, scheduling manufacturing orders*

I. INTRODUCTION

Decision making is a crucial and a vital field in business world. It allows industries to make good decisions in the opportune time. One of the fields of using decision making in industries is planning and scheduling. Planning and scheduling work in industries is not evident especially in manual industries, because before scheduling a job to the employee, it's necessary to verify the availability of work constraints in order to maximize quantity of work and optimize resources. To become more performant, the verification should begin with the most important and global constraint before verifying the rest. So we begin by verifying the important constraint, if it's verified we move to the second, if not we will move to schedule another manufacturing order (MO) without losing time to verify the rest of the constraints. Also if we verify the very important constraint one by one, scheduling will not be blocked by verifying a non-important constraint. This way of verification will optimize planning and scheduling result, time and performance. Therefore it's important to have the good priority order of each work constraint before scheduling. In this paper we will evaluate, in an aircraft manufactory, the effects of the use of AHP to establish planning constraint priority order before planning and scheduling and we will compare its results to those given by an old manufacturing method which the manufactory uses to schedule its MO. The organization of this paper will be as follows. Section 2 presents some multi criteria decision making. Section 3 introduces AHP decision making. Section 4 describes the old scheduling method used by the manufactory. Section 5 presents the application of AHP to establish priority order of planning constraints. Section 6 is a comparison before and after the use of AHP. The last section concludes the paper and provides future directions for further research.

II. MULTIPLE CRITERIA DECISION MAKING METHODS

The earliest known reference relating to Multiple Criteria Decision Making can be traced to Benjamin Franklin (1706- 1790), who allegedly had a simple paper system for deciding important issues. Among different multiple criteria decision making methods (MCDM), there is the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), developed by Hwang and Yoon in 1981, is based on the concept that the chosen alternative should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH) is an interactive approach that requires only qualitative judgments about differences to help a decision maker or decision-advising groups quantify the relative attractiveness of options. Analytic hierarchy process (AHP) is a multiple criteria decision technique that can combine qualitative and quantitative factors for prioritizing, ranking and evaluating alternatives. In this work, we will evaluate AHP in scheduling manufacturing orders of work. The choice of AHP as a multi criteria decision making method is due to its capacity to compare both qualitative and quantitative criteria.

III. ANALYTIC HIERARCHY PROCESS

The analytic hierarchy process is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then.

The steps of application AHP method as defined by T.SAATY are as follows.

- Define the problem and determine the kind of knowledge sought.
- Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).
- Construct a set of pairwise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.
- Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtained.

To make comparisons, we need a scale of numbers that indicates how much an element is important over another with respect to the criterion or property of comparison. Table 1 shows comparison scales.

After getting all priority orders, we calculate the Eigen vector of each alternative in order to obtain the rank of solutions.

TABLE 1. FUNDAMUTAL SCALE OF NUMBER

Intensity of Importance	**Definition**
1	**Equal Importance**
2	**Weak or slight**
3	**Moderate importance**
4	**Moderate plus**
5	**Strong importance**
6	**Strong plus**
7	**Very strong**
8	**Very, very strong**
9	**Extreme importance**
Reciprocals of above	**If activity *i* has one of the above non-zero numbers assigned to it when compared with activity *j*, then *j* has the reciprocal value when compared with *i***
1.1–1.9	**If the activities are very close**

IV. OLD SCHEDULING METHOD

Scheduling method in our case had been given by an old manufacturing manager. He had classified scheduling constraints reposing to his experience without any use of a MCDM method. The scheduling method will be named in the rest of article by "Old scheduling method". We will use AHP method with two manufacturing expert, to get priority order of scheduling constraint and we will evaluate scheduling using the old manufacturing method and the two manufacturing methods resulting to the application of AHP method.

V. APPLICATION OF AHP

The first step in the application of the AHP method is to formulate the problem. The problem in our case is to schedule the maximum of old manufacturing order by ameliorating the scheduling algorithm. The second step is to decompose the problem into a hierarchy of objective, criteria and alternatives. In our case, we will use two-levels AHP: The objective is to maximize number of old MO scheduled and the alternatives are represented by scheduling constraints.

Scheduling constraints which we need to rank by AHP method are:

- Customer date: is the date given to costumer in which work should start.
- Cooking capacity: is the maximum capacity of ovens, it's a quantitative constraint.

- Cooking times : is agenda of cooking in the ovens
- Operative specialty : is the know-how of operatives
- Operative availability
- Manufacturing tools availability

After defining constraints to compare, it's time to aggregate expert preferences. We had worked with two experts, as cited before, in the same manufacturing domain. We had created a multiple choice questioner like "To schedule a maximum of old MO, how much customer date is important compared to cooking capacity?" The answer choices were like in table 1. Expert's judgments were aggregated in a matrix as shown in table 2 and 3.

TABLE 2. EXPERT 1 JUDGMENT

Expert 1	Customer date	Cooking capacity	Cooking times	Operative know how	Operative availability	Tools availability
Customer date	1	1/3	1/7	3	3	5
Cooking capacity	5	1	3	5	1	7
Cooking times	7	1/3	1	3	3	7
Operative know how	1	1/3	1/3	1	1	3
Operative availability	1/3	1	1/3	1	1	3
Tools availability	1/5	1/7	1/7	1/3	1/3	1

TABLE 3. EXPERT 2 JUDGMENT

Expert 2	Customer date	Cooking capacity	Cooking times	Operative know how	Operative availability	Tools availability
Customer date	1	1/3	1/7	3	7	5
Cooking capacity	5	1	3	3	1	7
Cooking times	5	1/3	1	5	3	7
Operative know how	1/3	1/3	1/3	1	1	3
Operative availability	1/3	1/7	1/3	1	1	3
Tools availability	1/5	1/7	1/7	1/3	1/3	1

Now expert preferences are collected, we have to exploit them by calculating the Eigen vector (table 4 and 5).

TABLE 4. EIGEN VECTOR OF EXPERT 1 JUDGEMENT

Constraints	Eigen vector
Customer date	0.117
Cooking capacity	0.23
Cooking times	0.433
Operative know how	0.084
Operative availability	0.104
Tools availability	0.03

TABLE 5. EIGEN VECTOR OF EXPERT 2 JUDGEMENT

Expert 2	Eigen vector
Customer date	0.178
Cooking capacity	0.349
Cooking times	0.284
Operative know how	0.065
Operative availability	0.097
Tools availability	0.025

The last step is to use the obtained constraints priority order in scheduling algorithm and calculate how many old manufacturing orders are scheduled.

VI. RESULTS AND COMPARISON BEFORE AND AFTER USING AHP METHOD

The application of AHP had given two different raking for scheduling constraints. Table 6 below shows the different ranking given by the two experts.

TABLE 6. RANKING TABLE OF SCHEDULING CONSTRAINTS

	Expert 1		Expert 2	
	Eigen vector	Ranking	Eigen vector	Ranking
Customer date	0.117	3	0.178	3
Cooking capacity	0.23	2	0.349	1
Cooking times	0.433	1	0.284	2
Operative know how	0.084	5	0.065	5
Operative availability	0.104	4	0.097	4
Tools availability	0.03	6	0.025	6

Now the two ranking are given, we will schedule the same list (60 MO) of manufacturing orders three times. Firstly, we will schedule using the old scheduling method which had been established without any use of a decision making method, in the second step, we will schedule using the constraint ranking given by the first expert. Finally, we will use the ranking given by the second expert. Table 7 shows the number of scheduled MO using the three methods.

TABLE 7. RATE AND NUMBER OF OLD SCHEDULED MO

	Number of old MO scheduled	Rate
Old scheduling method (Without MCDM method)	35	58.2%
Expert 1 ranking	48	78.3%
Expert 2 ranking	38	63.3%

VII. RESULT DISCUSSION

Given 60 MO to schedule and using the old scheduling method, we had scheduled 35 MO. The result of scheduling was improved by the use of AHP method with the second expert by 5.1% and by 20% with the ranking obtained by the first expert.
As shown by statistics the use on AHP as a MCDM method in scheduling manufacturing order is important and can fine tune scheduling results.

VIII. CONCLUSION

The Object of this work is to show the importance of using a MCDM in manufacturing behavior by the use of AHP method to rank scheduling constraint before planning. The use of AHP had improved old MO scheduled by 20%. Despites the good results of AHP, it stills a subjective method because the expert priority can influence the results. So, to ameliorate its result and to reduce subjectivity risks, we can use an optimizing algorithm like genetic algorithm after collecting many expert preferences.

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