COMPARISON OF THE APPLICATION OF PRODUCTION MANAGEMENT TOOLS AND TOPSIS-AHP METHODS: BEARING MAINTENANCE PROCESS

SUMMARY
There is no doubt that in the industrial environment decisions become more and more complex tasks for managers. Decision analysis methodologies also make up the arsenal of techniques and tools that can be used for better answers, combined with other classic quality and problem solving tools. Decision makers should not make them instinctive, based on feelings and hunches, but using analytical and quantitative tools. In this context, methods such as Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Analytic Hierarchy Process (AHP) become useful tools for decision making. This article presents a case study of a large bearing maintenance process used in the steel, mining and sugar-energy industries, where from the application of production management tools; which at a certain level; are purely exploratory and poorly structured approaches to decision making; and of Decision Making Aid Methods (MCDM) allow to obtain similar responses in the prioritization of actions to eliminate or mitigate the effects, from the treatment of possible causes.

Keywords: production management, TOPSIS, AHP.

1. Introduction

For Pasqualini; Lopes; Siedenberg (2010), Production Management is the set of activities to manage scarce resources and processes that produce and deliver goods and services, aiming to meet the needs and/or desires of quality, time and cost. The application of quality tools and/or processes in production problems aims at understanding, identifying possible causes and generating an action plan to mitigate or eliminate the possible cause.

Decision Making Aid Methods (MCDM) according to Miranda (2008), are qualitative/quantitative methods for decision making based on various criteria, is a sub-discipline of operational research that explicitly evaluates various conflicting criteria in decision making and is in the middle of the continuum that separates the purely exploratory and unstructured approaches to decision making; as Brainstorm and Discussion Groups; and the rigidly structured quantitative models of Operational Research, focused on the optimization of objective functions, subject to a set of constraints such as Linear Programming or Dynamics.

The comparison of the results of these approaches in the treatment of a real problem constitutes the object of this article. This allows us to treat process problems in a more balanced way, free of purely exploratory approaches and rigidly structured quantitative models.

2. Literature review

2.1 Production Management

Production Management is the activity of managing scarce resources and processes that produce and deliver goods and services, aiming to meet the needs and/or desires of quality, time and cost of its customers (Pasqualini; Lopes; Siedenberg, 2010)

Every organization, regardless of its size, aims at profit or not, has in its structure, a production function, to generate some "value package" to its customers, even if, within the organization, the production function does not have this name.

According to Slack et al. (2008), one can say that production management is, above all, a practical matter that deals with real problems, because everything we wear, eat and use goes somehow through a productive process, and organizing this process effectively and efficiently is the goal of Production Management of Goods and Services.

Still for Pasqualini; Lopes; Siedenberg (2010), the main function of production is to efficiently use its resources and produce goods and services in a way that satisfies its customers. In addition**,** be creative,

innovative and vigorous to introduce new and improved ways of producing goods and services in order to give the organization competitive advantage and means of long-term survival.

2.2 Technique for Order Preference by Similarity to Ideal (TOPSIS)

A method widely used in supply chain management. For Lombardi (2018) TOPSIS and AHP methods have common steps in their application. In TOPSIS there is a three-level hierarchy, absolute measurement and ideal synthesis; or "linear normalization", however, normal synthesis can also be employed. However, the most significant difference between these methods is the fact that in TOPSIS there is no equal comparison of criteria. The TOPSIS method is also similar to Data Envelopment Analysis (DEA) or Goal Programming (GP), considering that they are MCDM methods with "objective, reference level approach or aspiration".

2.3 Analytic Hierarchy Process (AHP)

According to Lombardi (2020) apud Ressiguier and Alves (2016), the AHP method was created by Professor Thomas L. Saaty in the 1970s. It is a method that is characterized in the elaboration of a model that approaches the functioning of the human mind in the process of evaluating alternatives when faced with a complex decision problem. The method allows dealing with problems involving tangible and intangible variables, with the establishment of measures for qualitative variables based on subjective judgments. This makes it possible to accurately assess issues that require not only data, technical knowledge allied to practice but also the consideration of behavioral values, social and beliefs; so present in the application of decision making methods.

According to Brunelli (2015) the AHP should be placed at the intersection between decision analysis and operational research. The theory of decision analysis is designed to help the individual make a choice among a set of pre-specified alternatives.

Still for Brunelli, as long as the AHP is used as a technology to aid decisions, it seems that his study belongs to decision analysis.

Saaty, the main developer of the AHP, in one of the first textbooks, brings curious and instigating definition about operational research. It was defined as "quantitative common sense" and, perhaps with the intention of underlining its limitations, as "the art of giving bad answers to problems to which otherwise worse answers are given.

AHP can be applied to a range of decision making problems involving a finite number of alternatives. In a decision process, there is a goal and a finite set of alternatives from which the decision maker is asked to select the best.

3. Hypotheses / Objectives

The motivation for this research is to ask if Decision Making Aid Methods (MCDM) can be used in the decision making process in Production Management problems and if there is adherence to the actions defined by the application of Production Management tools and MCDM methods.

The objective of this article is to demonstrate that the application of Decision Making Aid Methods (MCDM) and production management tools; in a large bearing maintenance problem, allow to obtain similar answers in the prioritization of actions to eliminate or mitigate the effects, from the treatment of possible causes, where the element of comparison is defined by the hierarchy of actions, obtained in the application of each method.

The simultaneous application of the MCDM TOPSIS and AHP methods in the research problem aims to refine and validate the response to the problem through the MCDM method, generating a more reliable response given the adherence of the problem to the production management tools.

4. Research Project / Methodology

Figure 1 presents the research methodology, forming the criteria described below:

Figure 1: Methodology used
Source: Author

As for the research, it is classified according to the purpose, as Applied Research, because the acquired knowledge will be used for practical application aimed at solving real problems. From the point of view of its objectives, this research is classified as Exploratory, because it aims to provide more information on the subject under study. According to the nature, this research is classified as Subject Summary, because it is based on more advanced work. And as for the object, this research is classified as Bibliographical Research, as it was elaborated from material already published.

The following sequence is used to apply production management tools and Decision Making Aid Methods (MCDM) to a bearing maintenance problem.

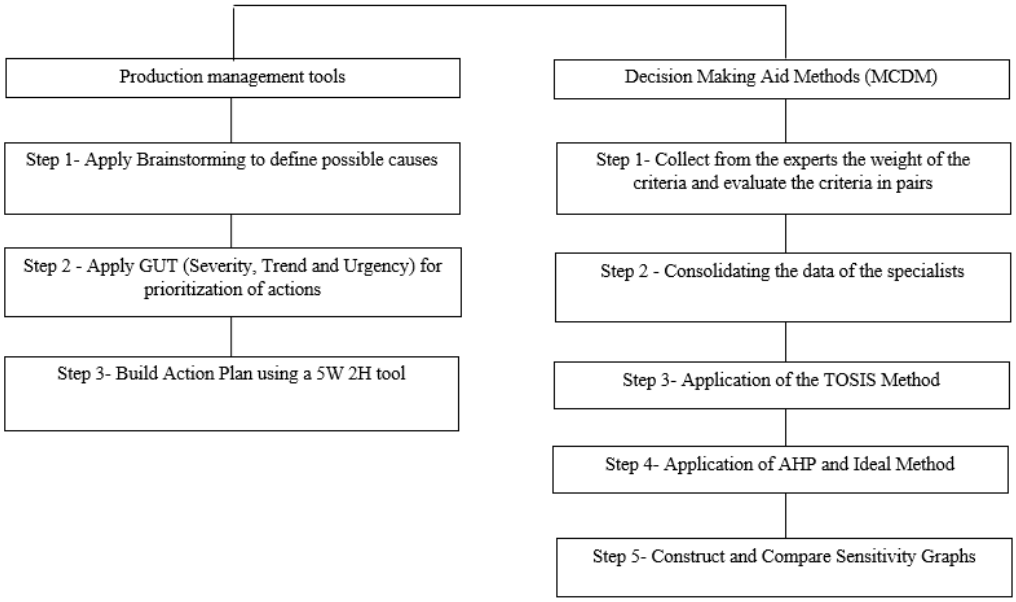


Figure 2: Methodology used
Source: Author

It is worth mentioning steps 1 and 2 of the application of the Decision Making Aid Methods, where from the evaluation of three specialists of the weight of the criteria and the comparison by pairs of criteria, the evaluation data were consolidated using arithmetic media.

5. Data Analysis / Model

From the application of production management tools; in order; Brainstorming for defining possible causes, GUT Matrix for hierarchizing actions and 5W and 2H for building the action plan, the actions and priorities defined to mitigate the problem from the treatment of possible causes were:
1º. Creation of a monthly maintenance plan on the parts washing machine and weekly checks;
2º. Creation of automatic spreadsheets to generate the labels of the approved parts simultaneously to the measurement process;
3º. Creation of setup for each item series, thus excluding the need to create programs every time you would be measuring batches;
4º. Review in the process flow;
5º. Generation of a new layout appropriate to the department's arrangement.

For the MCDM, TOPSIS and AHP Original and Ideal Methods, from the consolidation of the judgment by the specialists of the comparison to the pairs and weight of the criteria, and the consequent application of the methods. Box 1 demonstrates the application of the Ideal AHP method:

Box 1: Calculations of the application of the Ideal AHP method

AHP Measurement (pairwise comparisons) - Global Priority of Suppliers				
Supplier	Time	Costs	Productivity	Gobal
	40%	20%	40%	
Automatic spreadsheets	100%	26%	64%	71%
Maintenance plan	44%	100%	100%	77%
Measurement setup	44%	26%	100%	63%
New layout	9%	7%	33%	18%
Review in flow	18%	7%	33%	22%

Sensitivity Analysis											
Supplier	Time Weight										
	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Automatic spreadsheets	0,51514664	0,56363198	0,61211732	0,66060265	0,70908799	0,75757332	0,80605866	0,85454399	0,90302933	0,95151466	1,00000000
Maintenance plan	0,99900000	0,94276484	0,88652968	0,83029453	0,77405937	0,71782421	0,66158905	0,60535389	0,54911873	0,49288358	0,43664842
Measurement setup	0,75198023	0,72044705	0,68891387	0,65738069	0,62584751	0,59431432	0,56278114	0,53124796	0,49971478	0,46818160	0,43664842
New layout	0,24420000	0,22882286	0,21344573	0,19806859	0,18269146	0,16731432	0,15193719	0,13656005	0,12118292	0,10580578	0,09042865
Review in flow	0,24420000	0,23819279	0,23218558	0,22617837	0,22017117	0,21416396	0,20815675	0,20214954	0,19614233	0,19013512	0,18412792

Source: Author

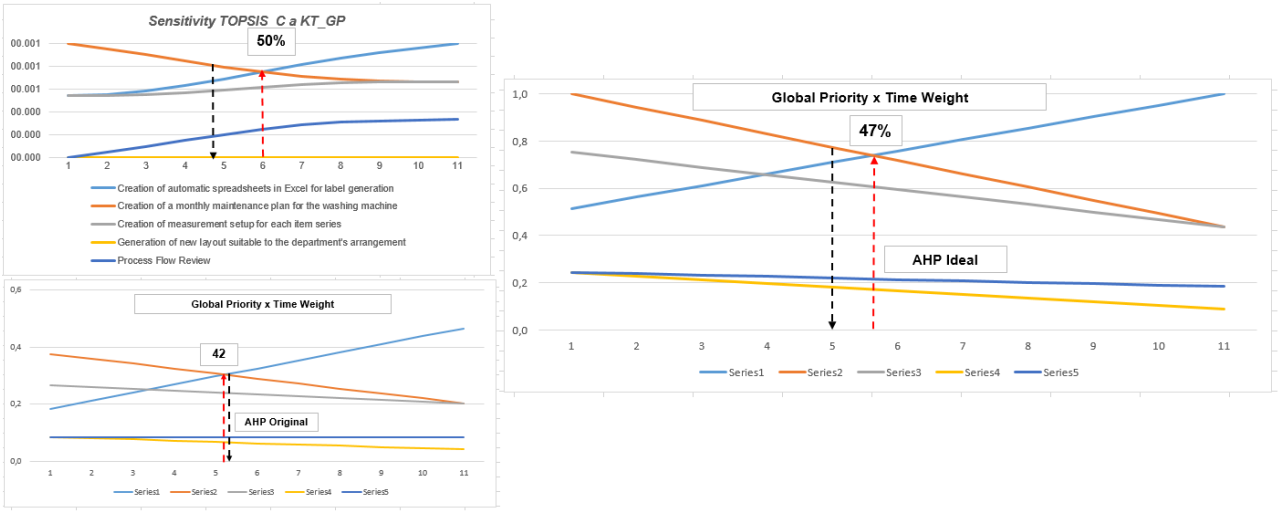
Box 2 presents the results of the methods object of this research:

Box 2: Comparative results of two MCDM TOPSIS E AHP methods

Supplier	TOPSIS	AHP	
		Original	Ideal
Creation of automatic spreadsheets in Excel for label generation	0,671	28,4%	71%
Creation of a monthly maintenance plan for the washing machine	0,812	34,7%	77%
Creation of measurement setup for each item series	0,588	22,6%	63%
Generation of new layout suitable to the department's arrangement	0,000	6,3%	18%
Process Flow Review	0,188	7,9%	22%

Source: Author

For the methods approached the hierarchization of the actions is the same, the action that must be performed first to the detriment of the others is the "Creation of a maintenance plan...", while the action that must be performed second is the "Creation of automatic worksheets..." and so on. The sensitivity analysis, according to the following graphics, shows that the actions "Creation of a maintenance plan..." and "Creation of automatic worksheets..." alternate as priority action depending on the weight given to the time criterion.



Graph 1: Sensitivity Analysis for TOPSIS and AHP methods Original and Ideal
Source: Author

It is observed that in the MCDM TOPIS methods the action "Creation of a maintenance plan...", only ceases to be a priority action, when the weight of the time criterion is equal or superior to 50%. For the AHP method also the action "Creation of a maintenance plan...", is a priority, becoming the "Creation of automatic spreadsheets..." only when the weight of the time criterion is equal or superior to 42% or 47%, respectively for the Original AHP and Ideal AHP methods.

7. Conclusions

The application was successful in an important industrial area, with the possibility to be taken to the evaluation of other processes in complex areas. Relevant the use of consolidated data among specialists, as to the weight of the criteria and comparison in pairs between the criteria.
Mitigated empirical bias so present in multi-criteria analysis, with similar prioritization of actions in the tools used.

8. Key references

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