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Multi-criterion analysis technique in a process of quality management

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ABSTRACT

Purpose: The aim of this paper is to present the critical analysis of some multi-criteria techniques applied in the area of quality management. It is strongly stated that some solutions in this scientific area characterizes the non-methodological approaches.
Design/methodology/approach: The research methodology, in presented work, has been based on the theoretical analysis of the quality tools management and on the empirical researches.
Findings: The proposals of improvement the main quality tool, the FMEA technique, have been presented. These results show that it is very important to join theoretical results of methodological researches and practical applications of specific methods.
Research limitations/implications: The area of multi-criteria methods is very wide so the researches have been narrowed to the analysis of the FMEA. This is a very popular quality tool and could be treated as three-criterion analysis.
Practical implications: It has been showed that the results obtained in the classical FMEA technique could be ambiguous in same cases. The changes, proposed in this paper allow eliminating this ambiguity. It broadens the area of application of this method.
Originality/value: The presented improved FMEA technique and propose PEA technique are the original author solutions.
Keywords: Quality Management

1. Introduction

In the area of quality management it has been applied a variety of different quality tools [1, 2, 3]. The quality tools have been designed both for professional quality advisor and for ordinary production team members. This situation caused that the level of methodological analysis of these tools is different. Some of them fulfill all methodological requirements and some reveal shortcomings (comp.: [4]). On the other hand this situation is consider with the fact that some quality tools have been elaborated in industrial conditions without any methodological analysis and is a form of a specific industrial quality procedure what involves the need for the critical analysis of the quality tools.

The analysis of these shortcomings is very important because it helps to understand results obtained using the quality tools. This is important especially for so called modern quality tools like: Ishikawa diagram, FMEA technique or QFD technique [5, 6].

2. The FMEA technique

The Failure Modes and Effects Analysis (FMEA) technique is one of the most broadened quality tools. It is consider with its simplicity of application and analysis. As a result of this technique one obtains the number of a quality risk.

The general risk number is computed as a product of three factors: P1 (failure severity), P2 (failure occurrence) and P3 (failure detection). These factors could change from 1 (ideal situation) till 10 (the worse situation). These factors could be treated as single criteria in three-criterion analysis. So the problem could be analyzed as a problem of three-criterion decision making [7]. It must be pointed out that many quality problems are solved using this approach [8].

The general risk number is, according to the multi-criterion analysis, a non-weighted, multiplication complex note. Moreover it is possible to determine this note as a hyperbolic one.

It must be stated that there is no clearly determined the limit showing the risk situation. The preferable value of this number balance between 75 and 125. And what is important the value is related to the analyzed problem. It suggests that different problems are solved using different FMEA approach. Moreover results of the FMEA technique are also explained in different ways.

Analyzing the idea of a FMEA technique, it is possible to point out some important features of this approach. Firstly it is important to determine precisely the note of each factorial criterion. Secondly it is important to understand that 1 is the invariant of multiplication so the notes 1 do not change the general risk number.

To clearly explain this remarks one could conduct the analysis of the FMEA technique in a form of three-dimensional diagram of three factorial criterion (Figure.1). In this figure two surfaces representing the area characterizes of the same general risk number R are also presented. The number R=166.4 is the limit of a permissible risk. It means that solutions with such a general number (or lower) are the permissible solutions. The value 166.4 has been computed by multiplying three factorial criterions equal to 5.5 (what is the value of an average note). Similarly the value of R equal to 34.3 has been determined for criterions equal to 3.24 (1/4 of the criteria range). This value shows the limit for solutions of low risk.

Basing on such described FMEA analysis one can conduct simple investigations of the FMEA technique. Let's consider the case of producing a car without a steering wheel what happens quite frequently. It is a very serious fault. Let the severity note will be equal to 10 (a very important fault), the occurrence note will be equal to 5 (average frequency) and the detection number equal to 1 (easy to detect). The general risk number is equal to 50 what suggests that this is a less important problem not needed to correct. This example show that in extreme cases the FMEA could product ambiguous results.

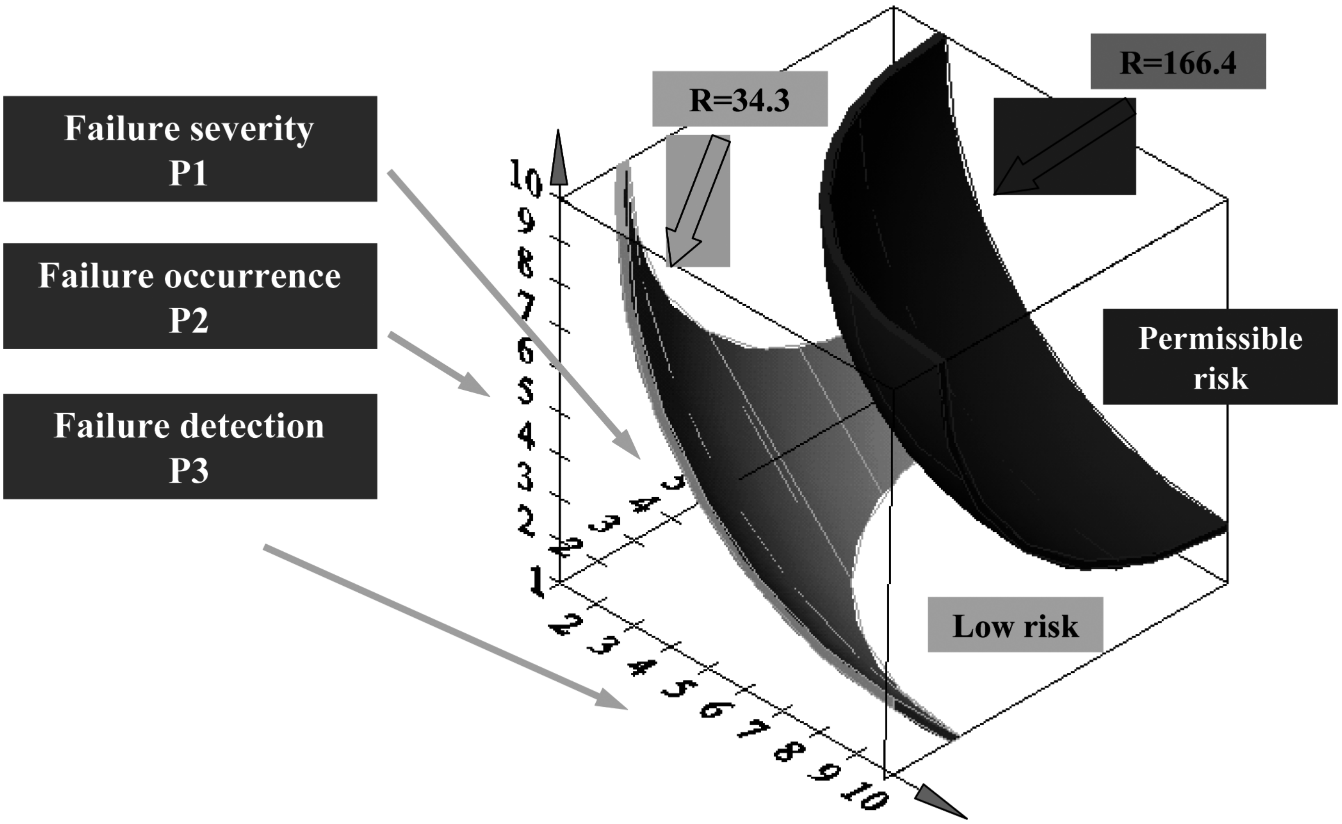

Fig. 1. Three-dimensional notes space in a FMEA technique

3. Changes of the FMEA technique

Analysis of presented above problems one could show two methods of improving the FMEA algorithm. Firstly one can change the scale of notes. Of course this change involves the change of the algorithm of determining the general risk number. Secondly it is possible to change the form of the general risk note, from hyperbolical one to another. Presenting these ideas one can start with the idea of izonote.

3.1. The izonote

The izonote is a place in a space that groups all points with the same value of the general risk number. For the two-dimensional space the izonote is a line, for a three-dimensional one it is a surface (what presents Figure1).

Let's consider a two-dimensional space of notes (Figure.2). The izonote IN is a hyperbolical curve determined according the equation presented in the Figure 2. It has been determined two izonotes for sufficient and requirement solutions. The value of the first izonote is IN = 30.25 (5.5x5.5). The value for the second izonote is IN = 10.5625 (3.25x3.25).

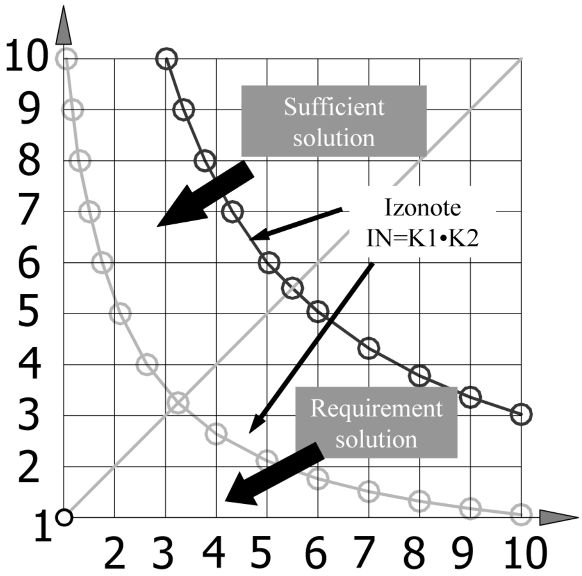

Fig. 2. Two-dimensional hyperbolical note space

It should be also stated that the diagonal of the note space is also important. As it is presented in Figure 2 the more preferable solutions are these that are farer to the diagonal. To show that it is needed to compare the distance between point (1, 1), marking the ideal situation and the point common for the izonote and the diagonal. This distance is smaller then the distance between the point (1, 1) and the end of izonote. This suggests that the non sustainable general notes (solutions) are preferable. This tendency is at variance with a rational approach.

3.2. Rectangular izonotes

As it was stated above one of method of improving this tool is changing the izonotes type. The izonotes that could be better fitted to this way of analysis are the rectangular izonotes (Figure 3). Analyzing this Figure one can see that the most preferable solution are that located on the diagonal of the note space. The non sustainable solutions are less preferable. Moreover the areas of both sufficient and requirement solutions are strongly smaller then on the Figure 2. It allows better grouping the positive and negative solutions.

On the other hand this method has one difficulty. Namely hyperbolic izonote (one equation) is changed with an izonote consisting of two equations. So it is needed to change one general risk number with two limits of note of single criteria.

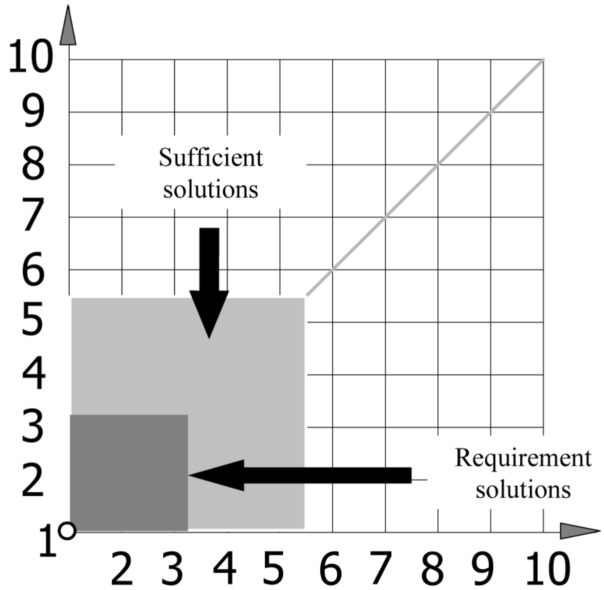

Fig. 3. Note space with rectangular izonotes

The other solution of the problem consider with the classical FMEA is changing the scale of notes (reversing it).

3.3. Reverse scale of notes

Reversing the scale of notes one looks the positive solutions among solutions with high values (Figure 4). As it is shown below the izonote for sufficient solutions is the same. The value for requirement solutions is equal to IN = 60.0625 (7.75x7.75). Comparing the range of the positive solutions and the role of a diagonal one can state that they are correct.

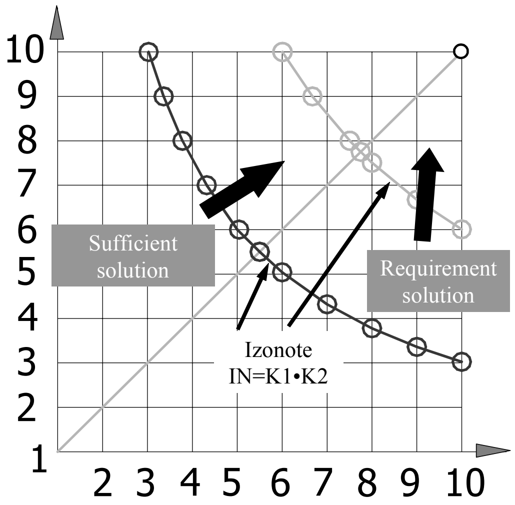

Fig. 4. Reverse space of notes

4. Conclusions

Proposed above methodology has been applied for preparing the tool which could help in analyzing the risk of pollution. The problem of ecological management is continuously more and more important [9, 10, 11]. Nowadays it is important to integrate the quality and ecological problems into one management system. This drown to the other philosophy of manufacturing processes [12, 13].

The proposed technique is called the Pollution Effect Analysis (PEA). It is presented on Figure 5. It is presented in a form of table because in this case the note space is four-dimensional.

Pollution types	Pollution harmfulness	Pollution detection	Pollution frequency	Pollution removeability	**Risk number**
	scale 1 - 10	scale 1 - 5	scale 1 - 5	scale 1 - 10	
Mercury pollution	1	4	5	6	120
Pollution with glass	9	5	2	8	720
Sodium pollution	6	2	4	7	336
Metal pollution	9	5	3	9	1215

$R_{sufficient}$ = 5,5•3•3•5,5 = 272,25 $R_{requirement}$ = 7,75•4•4•7,75 = 961

Fig. 5. Exemplar analysis of pollution risk

The Figure 5 presents the analysis of pollution of four factors that could be found during manufacturing fluorescent lamps. The most risky is the pollution with mercury (120). The most safety is the pollution with metal parts of fluorescent lamps. So the most important problem is the decreasing the pollution level of mercury.

Concluding one should point that such tools could be important in modern manufacturing process management particularly when it is important to eliminate harmfulness pollution factors [14, 15].

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