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Identifying the source of the problem by using implemented the FAHP method in the selected quality management techniques

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Abstract

Making a complex analysis of the problem in order to identify the root of its occurrence, is the process burdened with the risk of uncertainty. This risk is in case of the quality analysis, in which the choice and making a decision is not confirmed by reliable information (number). This risk is in case of the quality analysis, in which the choice and making a decision is not confirmed by reliable information (number). But these techniques do not include the risk of uncertainty, so their sequence should be expanded about the appropriate method, to take this into account. It was considered beneficial to demonstrate that this method is the Fuzzy Analytic Hierarchy Process method (FAHP). The aim of the study to implement the FAHP method in the sequence of traditional quality management techniques (Ishikawa diagram and 5Why method) and proposition new, not practiced yet the method to complex analysis of the problem and identify the root of its root cause. The subject of the study was the furniture front, on which the incompatibility was identified (shortened foil). From the categories to which the potential causes of the inadequate foil were assigned, by using the Ishikawa diagram and the FAHP method in an integrated manner, were defined the most important categories (method and machine) in a precise (numerical) way. Next, using the same tools, the relationship between the potential causes was analysed and selected the main causes of the problem. Then, by using the 5Why method the root of the problem was defined (lack of the new machine and failure to comply with labor standards). The obtained results could differ depending on the subjectivity, however, the method itself proved to be effective and can be used to solve other types of the problem.

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1. Introduction

Using adequate techniques to analyse the problem allows on identify the source of their occurrence. It is important in view of the possibilities of making right actions, which will prevent this problem in the future (Siwec et al., 2019; Pacana et al., 2019a). Traditional quality management techniques are Ishikawa diagram and 5Why method, and using their in a sequential way allows identifying the root of the problem (Pacana et al., 2018). Ishikawa diagram, called the fishbone diagram or diagram of causes and effects, allows on analyze the problem and identify the potential causes of the problem (Pacana et al., 2019a). These causes are ordered according to selected categories, and basic Ishikawa categories are man, method, machine, material, management and environment. It is so-called

rule the 5M+E (Lira et al. 2017; Pacana et al., 2019b). The potential causes are often pointed during the brainstorm. After collecting potential causes, it is possible to choose among them the root causes of the problem (Jalal et al., 2019). Next, it is effective to use the 5Why method by which it is possible pointed to the root of the problem (Pacana et al., 2018; Pacana et al., 2019b).

The sequence of the Ishikawa diagram and 5Why method can be more effective. It is possible in a case when to this sequence will be implemented the method, which in a detailed and reliable manner (computationally) will analyze the relationships and dependencies between Ishikawa categories and also between the potential causes. One such method is the Fuzzy Analytic Hierarchy Process, i.e. FAHP. The FAHP method has applies to analyze of the decision problem in

which are many conflicting criteria (Ghunaim and Dichter, 2019; Chang et al., 2017; Ligus, 2017; Babak and Turan, 2012). FAHP is method adequate in case of problems, in which making decisions is burdened with uncertainty (Faran, et al., 2019; Mochammad, et al. 2018). In the FAHP method the fuzzy sets are using, which is important for the problem burdened with subjectivity (Bhanu and Amit, 2019; Kiani et al., 2019; Yulian et al., 2018; Ligus, 2017; Mir et al., 2016).

Therefore, it was considered that it is purposeful to implement the FAHP method in the process of analyzing and identify source cause, by using the Ishikawa diagram and 5Why method.

2. Aim and subject of the study

The aim of the study to implement the FAHP method in the sequence of traditional quality management techniques (Ishikawa diagram and 5Why method) and proposition new, not practiced yet the method to complex analysis of the problem and identify the root of its root cause. The implementation of this method was analyzed on the example of a problem with the unstretched foil on the furniture front.

The subject of the study was the furniture front, on which the problem with the unstretched foil was identified, which the example is shown in Figure 1.



Fig. 1. The unstretched foil on the furniture front

This problem occurred in a furniture manufacturing company located in Podkarpacie. In the enterprise relatively often the problem with the unstretched foil was identified. In the 2018 year (for about 9 months) the about 134 furniture fronts were identified, on which the problem with unstretched foil was identified. Because on problem influenced a large number of factors, and the source of its creation was not specified, this problem was thoroughly analyzed using a new, non-practiced sequence of methods.

3. Method

The method was the Ishikawa diagram, the FAHP method, and the 5Why method. To the process of analysis of the causes of the problem by integrated traditional quality management techniques, i.e. Ishikawa diagram, the FAHP method was implemented.

In the first step of solving the problem with unstretched foil on the furniture front, the Ishikawa diagram was made. To the

basic categories of the Ishikawa (5M+E, i. e. man, method, machine, material, management and environment) the potential causes were pointed.

In the second step, according to the fuzzy Saalty scale (Table 1), relevance was fixed of the Ishikawa categories was made and the weight of each category according to the FAHP method was calculated.

Table 1. Fuzzy Saalty scale

description	fuzzy number	triangular fuzzy scale	inverse of the fuzzy triangular scale
equally important	1	(1, 1, 1)	(1, 1, 1)
slightly more important	3	(1, 3, 5)	(1/5, 1/3, 1)
more important	5	(3, 5, 7)	(1/7, 1/5, 1/3)
much more important	7	(5, 7, 9)	(1/9, 1/7, 1/5)
absolutely more important	9	(7, 9, 9)	(1/9, 1/9, 1/7)

The aim of using the FAHP method was an indication, which of a category has the most important influence on the problem, what generated indication the right area of next analyses of the problem (criterium and causes). The rating of the relevance of the categories was made in a subjective way, basic on the analysis of the potential causes noted to the categories and their influence on the problem occurrence.

According to the FAHP method, the clear weights from fuzzy comparison matrices were calculated (1-3) (Ligus, 2017; Mir et al., 2016; Radionovs et al., 2016):

$$S_i = \sum_{j=1}^m M_{gi}^j \otimes [\sum_{j=1}^m \sum_{j=1}^m M_{gi}^j], \quad (1)$$

where,

$$\sum_{j=1}^m M_{gi}^j = (\sum_{j=1}^m l_j, \sum_{j=1}^m m_j, \sum_{j=1}^m u_j), \quad (2)$$

and

$$[\sum_{i=1}^n \sum_{i=1}^n M_{gi}^j]^{-1} = \left(\frac{1}{\sum_{j=1}^m u_j}, \frac{1}{\sum_{j=1}^m m_j}, \frac{1}{\sum_{j=1}^m l_j} \right) \quad (3)$$

Next, the weights of the fuzzy values were calculated, where the diffuse value comparison method was used (u, m, l) for each of the Ishikawa categories (5M+E) (4) (Ligus, 2017; Radionovs et al., 2016):

$$V(M_1 \geq M_2) = hgt(M_1 \cap M_2) = \begin{cases} 1, & \text{if } m_1 \geq m_2 \\ 0, & \text{if } l_2 \geq u_1 \\ \frac{l_2 - u_1}{(m_2 - u_1) - (m_2 - l_2)}, & \text{others.} \end{cases} \quad (4)$$

Then, the comparison was made of the minimum value being the overall result for each Ishikawa diagram criterion analyzed (5) (Chang et al., 2017; Ligus, 2017):

$$V(M \geq M_1, M_2, \dots, M_k) = \min V(M \geq M_i), i = 1, 2, \dots, k \quad (5)$$

The obtained values were normalized, in which the obtained minimum values were divided by the sum of these minimum

values for the analyzed category. The sum of normalized values for a given category should be equal to 1. In the last stage, the results were analyzed and the Ishikawa categories were selected, which were used in the next analysis in order to identify the main source of the problem.

In the third step, to precisely identified (numerical) which of potential causes were the main cause of the problem, the relevance of the potential causes was fixed. In this step, also was used the FAHP method and the mathematical formulas (1-5). After identifying the main causes of the problem (with the lowest weight) the next analysis with the 5Why method was made, in order to identify the root of the problem.

After analyzing the problem (unstretched foil) by the 5Why method, to the identified the main causes the “Why?” ques-

tions were asked. According to the 5Why method, the questions were asked to until the moment receive an answer that was also the root cause of the problem.

3. Results

The Ishikawa diagram which was made to the problem with unstretched foil on the furniture front is shown in Figure 2. Next, the Ishikawa categories including the potential causes were analyzed. In order to identify the category or categories Ishikawa which has the most important influence on the problem, the relevance of categories Ishikawa was rated, which is shown in Table 2. The results from FAHP method is shown in Table 3.

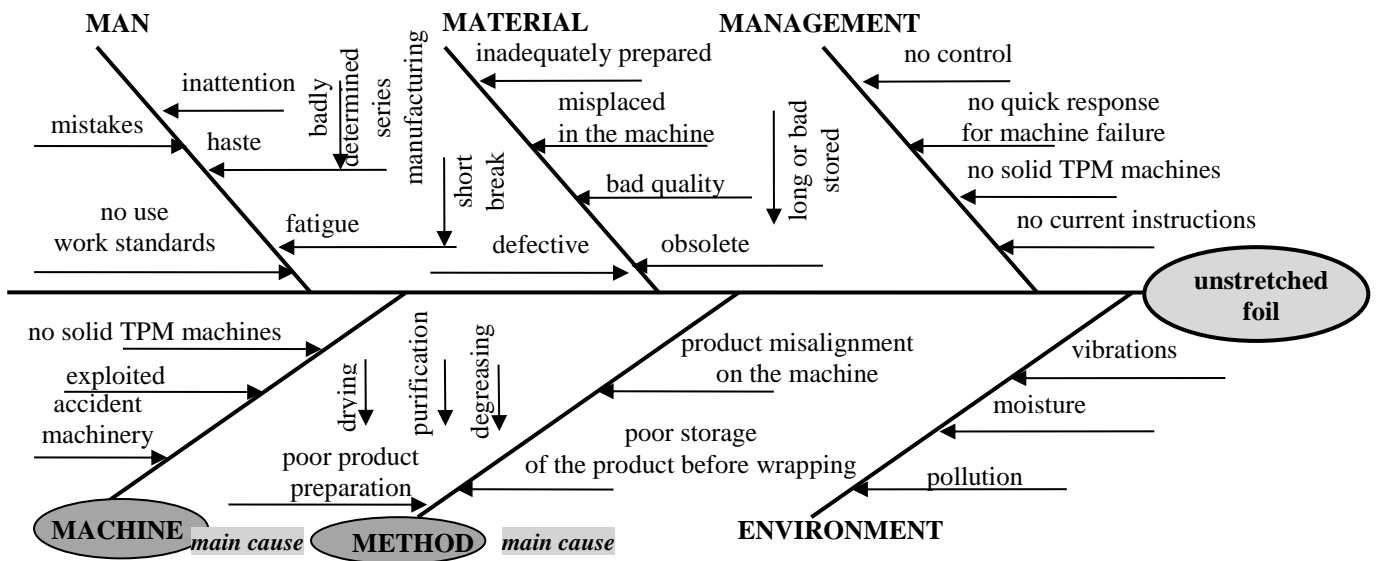


Fig. 2. Ishikawa diagram for the problem with unstretched foil on the furniture front

Table 2. The relevance of Ishikawa categories with taking into account eventually influence of the potential causes on the problem of the unstretched foil on the furniture front

Ishikawa categories	man	material	management	machine	method	environment
man	(1, 1, 1)	(1/9, 1/7, 1/5)	(1/9, 1/7, 1/5)	(1/9, 1/7, 1/5)	(1/9, 1/7, 1/5)	(1, 3, 5)
material	(5, 7, 9)	(1, 1, 1)	(1, 3, 5)	(1/7, 1/5, 1/3)	(1/7, 1/5, 1/3)	(5, 7, 9)
management	(5, 7, 9)	(1/5, 1/3, 1)	(1, 1, 1)	(1/9, 1/7, 1/5)	(1/7, 1/5, 1/3)	(3, 5, 7)
machine	(5, 7, 9)	(1, 3, 5)	(5, 7, 9)	(1, 1, 1)	(1/5, 1/3, 1)	(5, 7, 9)
method	(5, 7, 9)	(3, 5, 7)	(3, 5, 7)	(1, 3, 5)	(1, 1, 1)	(5, 7, 9)
environment	(1/5, 1/3, 1)	(1/9, 1/7, 1/5)	(1/7, 1/5, 1/3)	(1/9, 1/7, 1/5)	(1/9, 1/7, 1/5)	(1, 1, 1)
Value normalized	0.345	0.138	0.207	0	0	0.310
Ranking	4	2	3	1	1	5

Table 3. Results from the FAHP method and relevance the Ishikawa categories

Results				Relevance							
Categories and symbol	l1	m1	u1								
Man (M1)	0.1725	0.3261	0.6434	V(M1≥M2)	1	V(M2≥M5)	1	V(M4≥M2)	0.8	V(M5≥M6)	0
Material (M2)	0.0441	0.1069	0.2438	V(M1≥M3)	1	V(M2≥M6)	0.4	V(M4≥M3)	0.4	V(M6≥M1)	0.9
Management (M3)	0.0834	0.1817	0.3815	V(M1≥M4)	1	V(M3≥M1)	0.6	V(M4≥M5)	1	V(M6≥M2)	1
Machine (M4)	0.0364	0.0737	0.1513	V(M1≥M5)	1	V(M3≥M2)	1	V(M4≥M6)	0.1	V(M6≥M3)	1
Method (M5)	0.0139	0.0447	0.1197	V(M1≥M6)	1	V(M3≥M4)	1	V(M5≥M1)	0	V(M6≥M4)	1
Environment (M6)	0.1302	0.2668	0.5418	V(M2≥M1)	2.4	V(M3≥M5)	1	V(M5≥M2)	0.5	V(M6≥M5)	1
Vector: [1; 0.4; 0.6; 0; 0; 0.9]				V(M2≥M3)	1.1	V(M3≥M6)	0.7	V(M5≥M3)	0.2	Sum	2.9
				V(M2≥M4)	1	V(M4≥M1)	0	V(M5≥M4)	0.7		

After analyze using the FAHP method, it was concluded that the course of the problem with unstretched foil on the furniture fronts is among categories like machine and method. These categories were again analyzed using the FAHP method. The

relationships between potential causes were assessed, which are indicated in the Ishikawa diagram for selected categories (Table 4). Then they were analyzed according to the FAHP method (Table 5).

Table 4. The relevance of potential causes for selected Ishikawa categories with taking into account eventually influence of the problem of the unstretched foil on the furniture front

Machine and method	no TPM machine	exploited	accident machinery	wrong preparation product	bad product storage	product misalignment on the machine
no TPM machine (M1)	(1, 1, 1)	(1/9, 1/7, 1/5)	(1/9, 1/7, 1/5)	(1/7, 1/5, 1/3)	(1/9, 1/7, 1/5)	(1/5, 1/3, 1)
exploited (M2)	(5, 7, 9)	(1, 1, 1)	(1/9, 1/9, 1/7)	(1/5, 1/3, 1)	(3, 5, 7)	(5, 7, 9)
accident machinery (M3)	(5, 7, 9)	(7, 9, 9)	(1, 1, 1)	(1, 1, 1)	(5, 7, 9)	(1, 1, 1)
wrong preparation product (M4)	(3, 5, 7)	(1, 3, 5)	(1, 1, 1)	(1, 1, 1)	(5, 7, 9)	(3, 5, 7)
bad product storage (M5)	(5, 7, 9)	(1/7, 1/5, 1/3)	(1/9, 1/7, 1/5)	(1/9, 1/7, 1/5)	(1, 1, 1)	(1/9, 1/7, 1/5)
product misalignment on the machine (M6)	(1, 3, 5)	(1/9, 1/7, 1/5)	(1, 1, 1)	(1/7, 1/5, 1/3)	(5, 7, 9)	(1, 1, 1)
Value normalized	0.9	0	0	0	0	0.8
Ranking	3	1				2

Table 5. Results from the FAHP method and relevance the potential causes of the problem

Results				Relevance							
Symbol of cause	l1	m1	u1								
M1	0.1702	0.3283	0.6181	V(M1≥M2)	1	V(M2≥M5)	0.1	V(M4≥M2)	0	V(M5≥M6)	1
M2	0.0797	0.1476	0.2431	V(M1≥M3)	1	V(M2≥M6)	0	V(M4≥M3)	0	V(M6≥M1)	0.2
M3	0.0284	0.0372	0.0547	V(M1≥M4)	1	V(M3≥M1)	0	V(M4≥M5)	0	V(M6≥M2)	1
M4	0.0221	0.0315	0.0597	V(M1≥M5)	1	V(M3≥M2)	0	V(M4≥M6)	0	V(M6≥M3)	1
M5	0.1626	0.2970	0.5439	V(M1≥M6)	1	V(M3≥M4)	1	V(M5≥M1)	0	V(M6≥M4)	1
M6	0.0877	0.1584	0.2967	V(M2≥M1)	0.2	V(M3≥M5)	0	V(M5≥M2)	1	V(M6≥M5)	0.1
Vector: [1; 0; 0; 0; 0; 0.1]				V(M2≥M3)	1	V(M3≥M6)	0	V(M5≥M3)	1	Sum	1.1
				V(M2≥M4)	1	V(M4≥M1)	0	V(M5≥M4)	1		

After made calculate according to the FAHP method and subjective assessments, which have been granted to the potential causes of the problem, the main causes were selected. For the machine' category it were:

- exploited machine,
- accident machinery,

and for the method' category it were:

- wrong preparation product,
- bad storage of the product before wrapping.

In order to identify the root of the problem, the main causes which were selected were using in the next analysis by the 5Why method (Figure 3). It was concluded that the root cause of the problem was a lack of the new machine and failure to comply with labor standards.

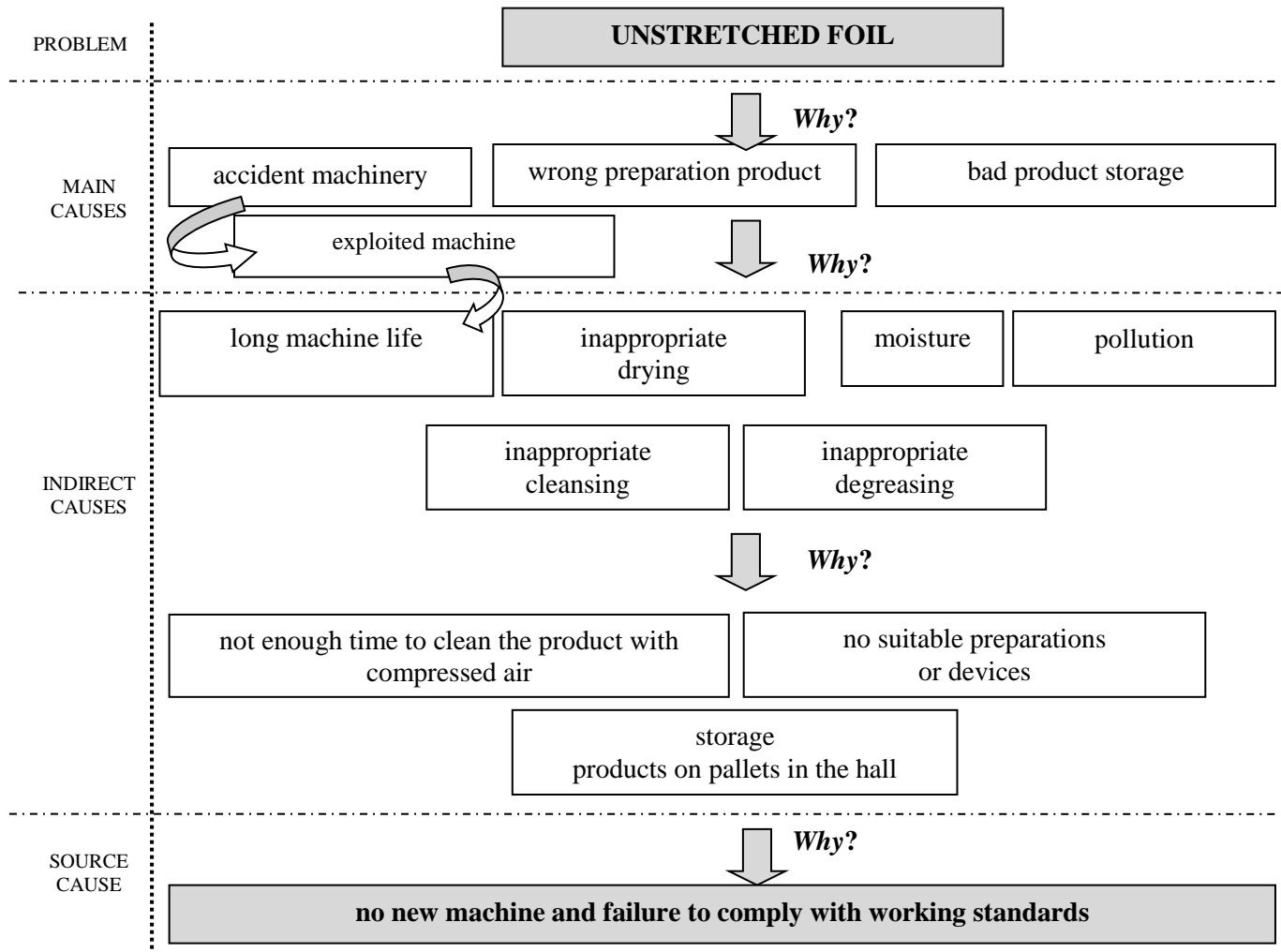


Fig. 3. The 5Why method for the problem with unstretched foil on the furniture front

4. Summary

Making a decision about the cause of the problem is sometimes a complex and troublesome process. Using traditional quality management techniques, i. e.: Ishikawa diagram and 5Why method, to identify the potential, main and in the end the source cause of the problem is not effective for a large number of the causes of the problem. In addition, these techniques do not take into account subjectivity and the risk of inaccurate interpretation of the causes. In order to improving the

process of identification the root of the problem, it was considered that

In order to improve the process of identifying the source of the problem, it was concluded that will be useful to practice a method that will reliably (numerically) indicate the area of causes that have the greatest impact on the emergence of the problem. The aim of the study to implement the FAHP method in the sequence of traditional quality management techniques (Ishikawa diagram and 5Why method) and proposition new, not practiced yet the method to complex analysis of the problem and identify the root of its root cause. The effectiveness

of this method was analyzed on the example of a problem with the unstretched foil on the furniture front.

In the first step, the Ishikawa diagram was made for the problem with unstretched foil on the furniture front. Using the FAHP method in the first the Ishikawa category (man, method, machine, material, management and environment) were analyzed, and next the potential causes of the problem. It was pointed out that the most significant impact on the emergence of the analyzed problem have potential causes indicated for the machine and method categories. From these causes the main causes were selected, i. e.: exploited machine, accident machinery, wrong preparation product, bad storage of the product before wrapping. Next, the 5Why method was used, in order to identify the root of the problem, which was a lack of the new machine and failure to comply with labor standards.

It is important to mention that the categories and reasons were identified by means of the FAHP method analysis process, and the selection of categories and reasons was supported by a reliable assessment (methodically and numerically). Additionally, the subjectivity of assessments granted for the analyzed factors was taken into account.

It was shown, that it is possible to implement the FAHP method in a sequence of traditional quality management techniques (Ishikawa diagram and 5Why method) to identify the root of the problem. This new method can be used to analyze other problems, on which influence subjectivism, a large number of different causes and the root of the problem is not known.

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通过在选定的质量管理技术中使用实施的FAHP方法确定问题的根源

關鍵詞

石川图
财务会计准则
5为什么
不兼容
质量管理

摘要

为了确定问题的根源而对问题进行复杂的分析，这是一个充满不确定性风险的过程。在质量分析的情况下会出现这种风险，在这种情况下，可靠的信息（编号）不会确认选择和决策的依据。在质量分析的情况下会出现这种风险，在这种情况下，可靠的信息（编号）不会确认选择和决策的依据。但是这些技术不包括不确定性的风险，因此应考虑适当方法，扩大其顺序。认为证明该方法是模糊层次分析法（FAHP）是有益的。研究的目的是按照传统的质量管理技术（石川图和5Why方法）的顺序实施FAHP方法，并提出新的，尚未实践的方法来对问题进行复杂分析并找出其根本原因。该研究的主题是家具正面，在该家具正面发现了不兼容现象（缩短了箔纸）。通过使用Ishikawa图和FAHP方法以综合的方式从分配箔不足的潜在原因的类别中，以精确的（数字）方式定义了最重要的类别（方法和机器）。接下来，使用相同的工具，分析潜在原因之间的关系，并选择问题的主要原因。然后，使用5Why方法定义了问题的根源（缺少新机器并且不符合劳动标准）。所获得的结果可能会因主观性而有所不同，但是，该方法本身被证明是有效的，可用于解决其他类型的问题。