Agronomy Research **15**(1), 155–161, 2017

The use of TOPSIS method in the manufacturing process of clutch plate of agricultural machinery

T. Holota[1,*], M. Holienčinová[2], M. Kotus[3] and J. Chrastina[1]

[1]Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of building equipment and technology safety, Tr. A. Hlinku 2, SK 949 76 Nitra, Slovakia
[2]Slovak University of Agriculture in Nitra, Faculty of Economics and Management, Department of Marketing and Trade, Tr. A. Hlinku 2, SK 949 76 Nitra, Slovakia
[3]Slovak University of Agriculture in Nitra, Faculty of Engineering, Department of Quality and Engineering Technologies, Tr. A. Hlinku 2, SK 949 76 Nitra, Slovakia
[*]Correspondence: tomas.holota@gmail.com

Abstract. Rating and determination of factors of importance affecting the pressing process of clutch plates is, in most organizations, an individual and subjective decision of individual employees.

The paper describes the process of relevant material selection for the organization. This process is designed with the aim to use the exact methods in order to replace subjective material selection by objective process. The most appropriate method appears the multi-criteria statistical analysis TOPSIS.

TOPSIS method has been widely applied in many areas with good results as the choice of marketing strategy, optimization of mechatronic systems, safety management, business competitions, management of crisis situations, assessment of trends, planning and many others. This is the first time when TOPSIS method was used in the selection of the most important causes affecting the pressing process of clutch plates.

The aim of this paper is to carry out the multi-criteria statistical analysis TOPSIS which evaluates and determines the order of importance of various factors affecting the pressing process of clutch plate which is a component part of agricultural machinery. On the basis of performed method we can prevent from subjective evaluation and make rational decisions based on the statistical analysis.

Key words: TOPSIS, Multi-criteria Analysis, Statistical Method, Process, Pressing.

INTRODUCTION

Successful searching and determining the factors affecting the process is the main prerequisite for successful improvement of the process whose result is an effective and efficient convert of inputs to outputs. When evaluating factors affecting the process there are two possible ways – subjective way of evaluation and the objective one. Subjective evaluation is affected by individuals and by subjective decision of individual employees.

During the objective evaluation there are used the one-criterion and the multi-criteria statistical methods ensuring the impartiality and objectivity of the final factors evaluation (Kowalski et al., 2009).

Method TOPSIS (Technique for the Order of Preference by Similarity to Ideal Solution) belongs to multi-criteria statistical methods.

In another words, the multi-criteria technique is based on obtaining the alternative that approaches the most ideal alternative. For this purpose is considered the positive ideal alternative and the negative one. It is a technique for order the preference by similarity to ideal solution (Nagyová et al., 2014).

Many multi-criteria analyses are based on the additive concept together with the assumption of independence, however, not all individual criteria are independent (Mateo, 2012; Lestyánszka et al., 2013).

Development of this method by Hwang and Yoon is dated back to 1995. At the beginning, the alternatives were sorted according to their distance from ideal (positive) and inappropriate (negative) solution, it means the best alternative is also the shortest distance from the ideal solution and inappropriate solution with the longest distance from the ideal solution. The ideal solution is identified as the variant with a hypothetical alternative that has the best values for all considered criteria, while inappropriate variant is identified as the hypothetical alternative which has the worst values of the criteria (Sarraf et al., 2013).

It is a method of countervailing aggregation, which compares the complex of alternatives by identification of weights for each criterion, standardized score for each criterion and calculating geometric distances between each alternative and the ideal variant according to the best score for each criterion (Hwang & Yoon, 1995; Cheung & Suen, 2002; Ťavodová, 2006)

The aim of this paper is to evaluate and determine the order of importance of each factor affecting the pressing process of clutch plates, which are a part of agricultural machinery by applying the multi-criteria TOPSIS method. On the basis of performed method, we can prevent from subjective evaluation and make rational decisions based on statistical analysis.

MATERIALS AND METHODS

Before applying the multi-criterial statistical method TOPSIS it is necessary to identify each factor. For identifying each factor is possible to use various tools, for example the brainstorming.

Procedure for brainstorming application:

1. Determining the appropriate place for meeting of larger group of people and determine the date of meeting.
2. Informing the representatives of each involved department in organization (Department of quality, design, manufacturing, marketing, purchasing, sales, tools and warehouse) about the meeting.
3. Selecting the responsible person (moderator) for brainstorming leadership.
4. Keeping the principles and rules of brainstorming.
5. Writing down and process all ideas and comments in the usable form due to creation of Ishikawa diagram in which they will be sorted according to individual causes and consequences resulting from the needs of diagram.
6. Displaying the results of brainstorming into the mind map.

Procedure for TOPSIS method application

Selection of plate was realized on the basis of multi-criterial method TOPSIS by applying the following procedure:

1. Converting minimum criteria to maximum criteria.
2. Constructing normalized criteria matrix $R = (r_{ij})$, where $i = 1, 2....m$ (m – number of variants) and $j = 1, 2....r$ (r – number of criteria).

$$r_{ij} = \frac{g_{ij}}{\sqrt{\sum_{i=1}^{m} g_{ij}^2}} \tag{1}$$

where: g_{ij} – the value of i – th row (variants) and j – th column (criteria).

3. Calculating the weighted criteria matrix $W = (w_{ij})$ that each column of matrix R is multiplied by weighted vector (v_j) of corresponding criterion ($w_{ij} = v_j \times r_{ij}$).
4. Determining the distance of ideal variant (d_i^+) and distance of basal variant (d_i^-), by using individual parameters (elements) of matrix W and the equation:

$$d_i^+ = \sqrt{\sum_{j=1}^{r} (w_{ij} - H_j)^2} \tag{2}$$

$$d_i^- = \sqrt{\sum_{j=1}^{r} (w_{ij} - D_j)^2} \tag{3}$$

where: H_j – max w_{ij}; D_j – max w_{ij}.

5. Subsequently counting up relative distance indicators of variants from basal variant.

$$c_i = \frac{d_i^-}{d_i^+ + d_i^-} \tag{4}$$

6. As the last point- arranging the variants according to resulting values in descending order.

RESULTS AND DISCUSSION

Brainstorming method preceded to TOPSIS method performed in order to identify areas which can affect the non-conformities the most and joined issues like claims and financial unprofitability of pressing process of clutch plates.

We invited representatives of all stakeholders (departments) in organization to the brainstorming realization: project department, production department, design department, tool room, warehouse, technology department, quality department, purchasing department, marketing department and sales department.

After explaining the issues and determining the aim of brainstorming and its rules, we recorded all ideas and good points of each participant. Recorded ideas and thoughts were plotted in the graphical form by using the mind map (Fig. 1).

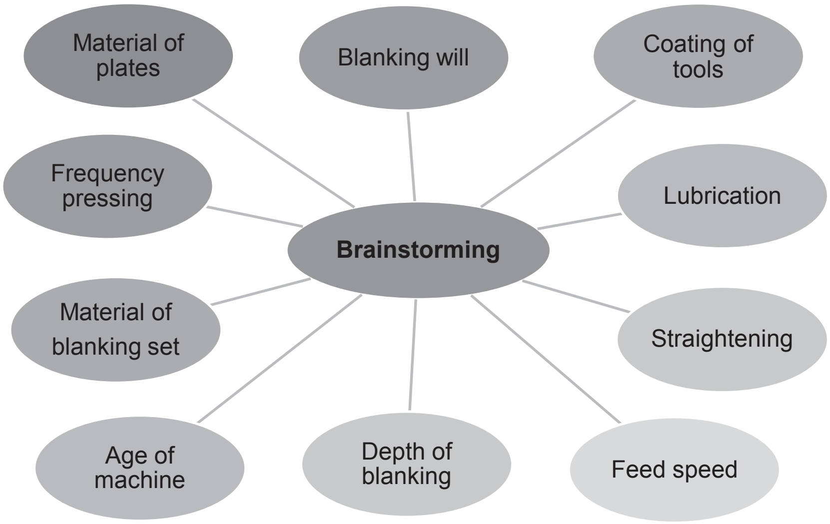

Figure 1. Mind Map from the Brainstorming Group.

The aim of brainstorming was to find factors affecting causes as well as increasing lifetime of press tool, what will lead to the overall effectiveness and efficiency of pressing process of clutch plate.

As could be seen in Table 1, there are the individual factors of brainstorming and the evaluation range of individual factors. Selected four-step range described the dependence of each factor affecting the improvement of pressing process of clutch plates used in agricultural machinery. Professionally qualified members (Deputy of project, production, design, technology, quality department and tool room) were invited to brainstorming meeting and participated in ratings.

To each factor was assigned the degree of dependence by each deputy. Finally were allocated values recorded into Table 1.

Table 1. Brainstorming Factors with the Degree of Dependency

Factors from brainstorming	Non-dependence	Weak dependence	Medium dependence	Strong dependence
Material of plates	1	1	0	4
Blanking will	3	1	2	0
Coating of tools	3	1	0	2
Lubrication	1	1	1	3
Straightening	1	3	2	0
Feed speed	3	2	0	1
Depth of blanking	4	1	1	0
Age of machine	1	3	1	1
Material of blanking set	0	1	0	5
Frequency pressing	4	1	1	0

Individual criteria were transformed by our own marking system:

- Non-dependence = Criterion 1 (C1)
- Weak dependence = Criterion 2 (C2)
- Medium dependence = Criterion 3 (C3)
- Strong dependence = Criterion 4 (C4)

The brainstorming factors were transformed into variants 1–10, succession of factors remained unchanged for better identification after the statistical methods evaluation.

We created a decision matrix with standard values of weights for each criterion with a cumulative sum of weights equal to 1.00 (Table 2). Standard values of weights were set on the basis of Metfessel's allocation, when 100–point scale was allocated among the criteria.

Table 2. Decision Matrix with Values Weight

	C_1	C_2	C_3	C_4
Weight	0.05	0.15	0.3	0.5
Variant 1	0.0063	0.0279	0	0.2673
Variant 2	0.0189	0.0279	0.1732	0
Variant 3	0.0189	0.0279	0	0.1336
Variant 4	0.0063	0.0279	0.0866	0.2004
Variant 5	0.0063	0.0836	0.1732	0
Variant 6	0.0189	0.0557	0	0.0668
Variant 7	0.0252	0.0279	0.0866	0
Variant 8	0.0063	0.0836	0.0866	0.0668
Variant 9	0.0000	0.0279	0	0.3341
Variant 10	0.0252	0.0279	0.0866	0

We calculated a relative distance indicator of individual variants from basal variant (Table 1). Values of these parameters vary between 0 and 1, where 0 represents the basal variant and 1 is the most ideal variant. We sequenced all variants according to calculated values of indicators into Table 3.

Table 3. Arrangement of Factors on the Basis of TOPSIS Method

Rank	Marking of factor	Value
1.	**Material of blanking set**	**0.7546**
2.	**Lubrication**	**0.7182**
3.	**Material of plates**	**0.6507**
4.	Coating of tools	0.4171
5.	Age of machine	0.3819
6.	Straightening	0.3429
7.	Blanking will	0.2621
8.	Feed speed	0.2427
9.	Depth of blanking	0.1905
10.	Frequency pressing	0.1056

On the basis of TOPSIS method results were determined the most relevant factors (those which reached the values of 0.5 and above): material of blanking sets, lubrication and material of plate.

Material selection is an extremely important decision-making process that affects mainly purchasing department of each company (Lukoszová, 2004).

The greater purchasing opportunities, the more suppliers, the more ways to meet the needs of the company but also the more serious and difficult is this decision. Decision-making process is not a simple process. This process must be understood in a broader sense, as a process that precedes:

- identifying the decision problem;
- assessing of situation;
- decision-making criteria in materials selection;
- selecting the methods (Nenadál, 2006).

The most significant advantage of TOPSIS method is that customers can determine their own criteria, which by relevance assign the weight and on that basis is calculated the best variant of solution (Čupić & Suknović, 2003).

CONCLUSION

There are several methods of multicriteria decision that have the same objective. The objective is to consider several variants of solution of the problem according to selected criteria and determination of their order.

The individual methods differ mainly according to determined weight of individual criteria (Garcia-Cascales & Lamata, 2011).

Displayed diversity of input data us points to the wide possibilities of variability of the result process (Nagyová et al., 2013). The right choice of importance of individual factors affect the effectiveness and efficiency of manufacturing process as well as the quality and lifetime of press tool.

After determining the factors affecting the pressing process of clutch plates with using brainstorming, we proceeded to multi-criteria statistical method TOPSIS. On the basis of values taking into account the criteria and the weights we obtained the final order of the factors affecting the pressing process. As the most important factors we determined following: material of blanking sets, lubrication and material of plate with regard to achieve a higher value as determined i.e. 0.5.

Analysis result by TOPSIS method led to the identification of three most important factors influencing the manufacturing process. During monitoring and control of these factors is possible to reduce the subjective assessment of the process and also to increase the objectivity of decision making.

In this paper there was evaluated one of the possibilities for effective and objective evaluation of manufacturing process. TOPSIS method can be applied also in the other manufacturing processes within the particular organization.

REFERENCES

Cheung, S.O. & Suen, H.C.H. 2002. A multi-attribute utility model for dispute resolution strategy selection. *Construction Management and Economics* **20**(7), 557–568.

Čupić, M. & Suknović, M. 2003. *Multicriteria decision making: formal access*. Faculty of Organization Science, Belgrade, 274 pp.

Garcia-Cascales, M.S. & Lamata, M.T. 2011. Multi-criteria analysis for a maintenance management problem in an engine factory: rational choice. *Journal of Intelligent Manufacturing* **22**(5), 779–788.

Hwang, Ch. & Yoon, K. 1995. *Multiple Attribute Decision Making: Methods and Applications A State-of-the-Art Survey*. 2nd edition. Springer Berlin Heidelberg, Berlin, 259 pp.

Kowalski, K., Stagl, S., Madlener, R. & Omann, I. 2009. Sustainable energy futures: Methodological challenges in combining scenarios and participatory multi-criteria analysis. *European Journal of Operational Research* **197**(3), 1063–1074.

Lestyánszka, Š.K., Ulewcz, R., Bajor, P. & Ingaldi, M. 2013. Using the statistical inspection in quality management by static tensile test of a material. *Fórum Manažéra* **2**, 34–36.

Lukoszová, X. 2004. Management of purchase. Computer Press, Brno, 182 pp. (in Czech).

Mateo, J.R.S.C. 2012. *Multi Criteria Analysis in the Renewable Energy Industry*. Springer-Verlag, London, 106 pp.

Nagyová, Ľ., Kádeková, Z. & Horská, E. 2013. Sustainability marketing in Slovak agribusiness practice. In Business management – practice and theory in the 21st century: *proceedings of scientific papers. International scientific conference June 6–7, 2013.* Slovak University of Agriculture, Nitra, SR, pp. 730–736.

Nagyová, Ľ., Košičiarova, I. & Kádeková, Z. 2014. Quality Brand: Guarantee of food quality on national level EU countries. 1st edition. Nitra: Slovenská poľnohospodárska univerzita.

Nenadál, J. 2006. *Management partnerství s dodavateli.* Management Press, Praha, 323 pp. (in Slovak).

Sarraf, A.Z., Mohaghar, A. & Bazargani, H. 2013. Developing TOPSIS method using statistical normalization for selecting knowledge management strategies. *Journal of Industrial Engineering and Management* **6**(4), 860–875.

Ťavodová, M. 2006. Utilisation of selected methods of quality improvement in assessing causes of products complaint. *Acta facultatis technicae* **10**(1), 5–12 (in Slovak).