

# Supplier selection based on complex indicator of finished products quality

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**Abstract.** In the article the authors consider possible directions of solving problems when selecting a supplier for deliveries of raw materials and materials of an industrial enterprise, possible difficulties are analyzed and ways of their solution are suggested. Various methods are considered to improve the efficiency of the supplier selection process based on the analysis of the paper bags supplier selection process for the needs of the construction company. In the article the calculation of generalized indicators and complex indicator, which should include single indicators, formed in groups that reflect different aspects of quality, is presented.

## 1. Introduction

The supplier selection is one of the processes, which optimization does not require large financial expenses but leads to significant results: to reduction in the purchase price to 40% and to reduction in the procurement budget to 10% [1, 2].

The experience shows that the most typical problems of the supplier selection process, which industrial enterprises and companies face, are the following:

- non-transparent procedures of supplier selection and, as a result, high procurement prices and low quality products;
- decision-making subjectivity due to the influence of the human factor when making decisions of the key issues in the supplier selection procedure;
- lack of the competitive environment due to the unchanged supplier lists, which the most are intermediaries.

There are methods to improve the efficiency of the supplier selection process [3, 4].

For example, to increase the transparency of the selection procedure, it is proposed to conduct procurement through the tender announcement, on the electronic trading platforms or by means of the proposals and prices request.

To increase decision-making objectivity, the following methods can be used: the personification and the definition of the boundaries of responsibility, the introduction of regulation describing the supplier selecting process and individual provisions for each procedure.

The expansion of the competitive environment can be achieved by forming database of the products potential suppliers by means of the procedure of their certification and verification of compliance with the requirement of economic security.

Regardless of the company's methodology of the supplier selection process, it is obvious that this procedure is significant, time-consuming and responsible. In addition, we should not forget that a



prerequisite of the supplier selection is to ensure high quality products. It is proposed to consider the approach to the supplier selection based on the complex quality of finished products.

As an example, it is considered the process of paper sacks supplier selection for the needs of a construction company.

The complex quality indicator has to include single indicators, formed in groups, reflecting different aspects of quality - technical, economic, consumer, etc.

Having studied and analyzed the indicators of product quality, as well as various lists of these indicators, the following system of generalized quality indicators of the paper, used for paper sacks, is proposed:

1. Organizational and economic indicators are the indicators, which are connected with improving of manufacture and work organization, responsibility of production quality, a policy of pricing.

This group of indicators is characterized by the following single quality indicators:

- product price,
- delivery of discounts,
- credit granting,
- manufacturer's reputation.

2. Technological indicators are the indicators that characterize the quality of finished paper according to the technological regulation.

As it is known, sack paper should have specific indicators, reflecting strength properties and porosity requirements in addition to traditional quality indicators. Therefore, this group of indicators is characterized by means of the following single quality indicators:

- weight of  $1\text{m}^2$ ,
- humidity,
- ultimate tensile strength,
- tensile indicator,
- tensile strain,
- tensile energy absorption,
- tensile energy absorption index,
- tear resistance index,
- surface absorbency of water,
- air resistance.

The weight of  $1\text{m}^2$  and the moisture of the finished paper are traditional indicators of the quality of any paper and they are determined by the requirements of the regulations. Ultimate tensile strength, tensile indicator, tensile strain, tensile energy absorption, tensile strength absorption index, tear resistance index are mechanical properties of paper, characterizing paper strength and its resistance to the deformation, that is very important for sack paper because it is used for storage and transportation of bulk materials (sand, cement, lime, etc.), including its utilization for construction industry purposes.

Surface absorbency of water - it is the property of paper to absorb liquid, air resistance (porosity) - it is the degree of filling the material volume with pores (air cells). The realization of the requirements for these indicators determines the quality of the process of filling paper sacks with bulk materials and their storage.

In addition to fulfilling the requirements of the regulation to the listed quality indicators of the documents, the absence of the defects (holes, cracks, folds, etc.) is a necessary condition.

Therefore, pulp and paper industry enterprises utilize automated control systems of technological processes, which are often supplemented with the defects existence control systems on the paper web. The implementation of operational control and diagnostics systems makes it possible to improve the quality of the finished products [5, 6]

3. Consumer indicators are the indicators characterizing information expressiveness, rationality of the form, composition integrity, perfection of industrial realization, stability of marketable condition.

This group of indicators is characterized by the following single quality indicators:

- the presence of the required constructive parameters in the list,

- the possibility of color image application,
- the imprint brightness,
- the marketable condition.

4. Ecological indicators are the indicators that characterize the level of product harmful effects on the environment, appearing when product's exploitation or consumption (for example, the specific concentration of harmful substances released in the environment during its exploitation or storage, etc.).

It is proposed to include the aspects mentioned below to this group of indicators:

- the degree of rinsing,
- the absence of chlorine-containing substances or elemental chlorine,
- the availability of certificates for paper,
- the availability of certificates for glue,
- the availability of certificates for dye,
- the availability of certificates for printing ink,
- the usage of 100% sulphate pulp.

The usage of 100% sulphate pulp provides higher paper-forming properties: fibers are more flexible and they have better mechanical properties. The paper made from that pulp is denser, more heat-resistant and it has a lower tendency to deformation.

It is important to imagine the sequence of calculation of the complex quality index in the algorithm form (Figure 1).

The assignment of the weight coefficient  $K_j$  to each generalized quality indicator of paper sacks is carried out based on the analysis taking into account expert estimations, with different weight coefficients, ranging from 0 to 1 with an interval of 0.05.

From the point of view of assessing the quality of paper sacks, it is obvious that the key indicator is the technological indicator and its weight coefficient is assumed equal to 1.00. The second significant quality indicator is the ecological indicator of the quality of paper sacks (its coefficient of weight is 0.90). The third significant quality indicator is the consumer indicator (its coefficient of weight is 0.80). The last indicator that determines the quality of paper sacks, is the organizational and economic indicator (its weight is 0.70). Having analyzed the importance (weight) of single quality indicators, their ranks are determined. In this case, rank 1 is assigned to the most important indicator, rank 2 - is the next important one after the first one, etc. The weight coefficient  $m_j$  for each single indicator is defined as following: for the index having rank 1, the weight factor is defined equal to 1, for the index with a rank 2, the weight coefficient is defined as the weight fraction of the first indicator, and so on.

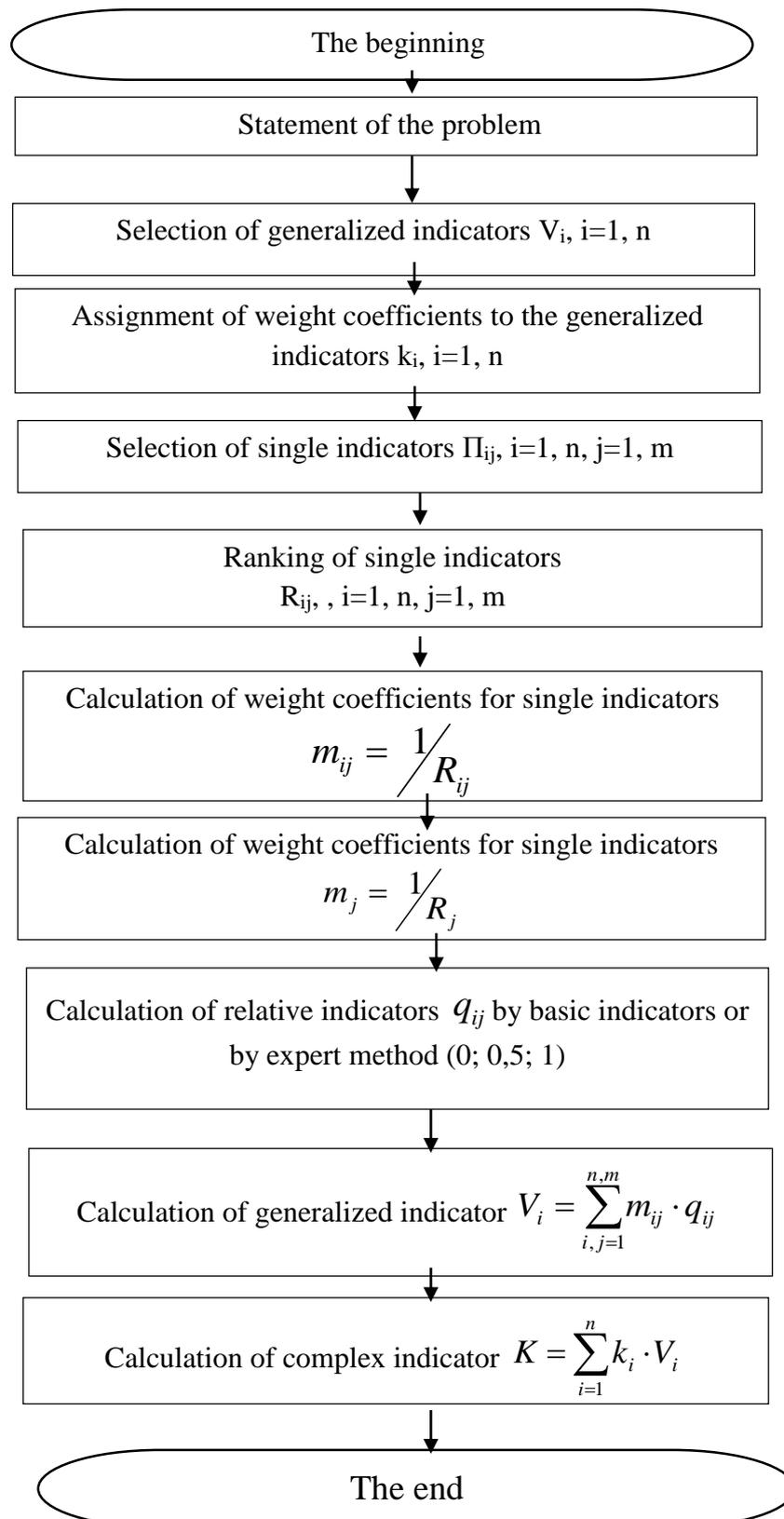


Figure 1. Calculation algorithm of complex indicator

## 2. Experimental section

The data obtained are presented in Table 1.

Table 1. Determination of the weight coefficients of quality indicators of paper sacks

Generalized quality indicator, $V_j$	Weight coefficient for generalized indicator, $k_j$	Single indicator, $\Pi_{ij}$	Rank, $R_{ij}$	Weight coefficient for single indicator, $m_{ij}$
Technological	1.00			
		Surface absorbency of water	1	1
		Air resistance	2	0.5
		Ultimate tensile strength	3	0.33
		Tensile indicator	4	0.25
		Tensile strain	5	0.2
		Tensile energy absorption	6	0.17
		Tensile energy absorption index	7	0.14
		Tear resistance index	8	0.13
		Weight of $1\text{m}^2$	9	0.11
		Humidity	10	0.1
Ecological	0.9			
		Usage of 100% sulphate pulp	1	1
		Degree of rinsing	2	0.5
		Absence of chlorine-containing substances or elemental chlorine	3	0.33
		Availability of certificates for paper	4	0.25
		Availability of certificates for glue	5	0.2
		Availability of certificates for dye	6	0.17
		Availability of certificates for printing ink	7	0.14
Consumer	0.8			
		Marketable condition	1	1
		Presence of the required constructive parameters in the list	2	0.5
		Possibility of color image application	3	0.33
		Imprint brightness	4	0.25
Organizational and economic	0.7			
		Price	1	1
		Reputation	2	0.5
		Allowing discount	3	0.33
		Allowing credit	4	0.25

The calculation of relative indicators for a group of technological indicators and for a single indicator - "Price" was made taking into account the basic quality indicators of sack paper SKS 70g /m<sup>2</sup>, (STO 51321438-002 - 2010).

The complex indicator of the quality of paper sacks is estimated by the following equation:

$$K = \sum K_i * V_i.$$

In the equation  $K_i$  is the weight parameter of the  $i$ -th generalized quality indicator, which is included in the complex quality indicator;  $V_i$  - generalized quality indicator.

## 3. Results section

The values obtained are presented in Table 2 - Calculation of the generalized indicators and the complex indicator.

Calculations were made in three options:

- The best quality and customer's satisfaction (option 1);
- Good quality, slight deviations from customer's requirements (option 2);

- Full discrepancy from the customer's requirements, the conformity just in the technological indicators (option 3).

**Table 2.** Calculation of the generalized indicators and the complex indicator

Generalized quality indicator, $V_i$	Weight coefficient, $k_i$	Single indicator, $\Pi_{ij}$	Rank, $R_{ij}$	Weight coefficient, $m_{ij}$	Relative quality indicator, $q_{ij}$		
					Option1	Option 2	Option 3
1.Technological	1.00						
		Surface absorbency of water	1	1	1.06	1.03	1.00
		Air resistance	2	0.5	1.15	1.05	1.00
		Ultimate tensile strength	3	0.33	1.31	1.27	1.1
		Tensile indicator	4	0.25	1.26	1.26	1.26
		Tensile strain	5	0.2	1.1	1.1	1.1
		Tensile energy absorption	6	0.17	1.3	1.3	1.3
		Tensile energy absorption index	7	0.14	1.23	1.23	1.23
		Tear resistance index	8	0.13	1.08	1.08	1.08
		Weight of 1m <sup>2</sup>	9	0.11	1	1	1
		Humidity	10	0.1	1	0.9	0.8
		$V1 = \sum m_{ij} * q_{ij}$			3.35	3.25	3.12
2.Ecological	0.9						
		Usage of 100% sulphate pulp	1	1	1	1	0
		Degree of rinsing	2	0.5	1	0.5	0
		Absence of chlorine-containing substances or elemental chlorine	3	0.33	1	1	0
		Availability of certificates for paper	4	0.25	1	1	0
		Availability of certificates for glue	5	0.2	1	0	0

	Availability of certificates for dye	6	0.17	1	1	0
	Availability of certificates for printing ink	7	0.14	1	0	0
	$V2 = \sum m_{ij} * q_{ij}$			2.59	2.0	0
3. Consumer	0.8					
	Marketable condition	1	1	1	1	0
	Presence of the required constructive parameters in the list	2	0.5	1	1	0
	Possibility of color image application	3	0.33	1	0.5	0
	Imprint brightness	4	0.25	1	0.5	0
	$V3 = \sum m_{ij} * q_{ij}$			2.08	1.8	0
4. Organizational and economic	0.7					
	Price	1	1	1.03	1.03	0
	Reputation	2	0.5	1	1	0
	Allowing discount		0.33	1	0	0
	Allowing credit		0.25	1	0	0
	$V4 = \sum m_{ij} * q_{ij}$			2,11	2.03	0
	$K = \sum k_i * V_i$			8.822	7.911	3.12

#### 4. Summary

The method represented above is very detailed for the analysis of product quality, it is possible to assign various weights for quality indicators, that allows to determine the significance of each indicator. In addition, using this method, there is an opportunity to assign not only 0 or 1 values to single indicators, but also an average of 0.5, that is crucial for some indicators. The usage of ranking method provided a possibility to divide the indicators into groups according to their significance.

Having obtained the values of the complex quality indicators of sack paper for three variants, it is possible to say that using this method gives a wide range of complex indicator values for "good" and "bad" supplier. Therefore, the proposed methodology allows to analyze accurately and in details the product quality and to choose the best supplier, taking into consideration the presented justification and established criteria for the needs of the construction company.

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