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A SYSTEMATIC APPROACH TO THE QUALITY ASSESSMENT OF PRINTED PRODUCTS

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Abstract
Quality standards for the technological processes of the production of finished products are used in all countries of the world. Consumers of printing and packaging products are increasingly demanding ISO 9001 quality system certificates from manufacturing companies. It should be noted that international and national standards use different approaches to the standardization of processes and products, and the content of project management. To meet the demands of consumers, which are constantly increasing, quality management should be carried out based on a set of scientifically based principles, which can be divided into system-wide and special. The problem is relevant for modern Ukrainian enterprises, where, on the one hand, they need serious changes in the organizational structure, corporate culture, style and methods of project management; and on the other hand, compliance with the ratio of responsibility for quality between the management system and performers.
Evaluation of the quality of printed products at the current stage requires the application of the principles of a systematic approach, based on the principles of which it is possible to build a coherent, logically completed methodological system of quality indicators of a specific type of product. This will also make it possible to justify the problem of choosing certain methods and will give a normative and regulatory character to those indicators that are not reflected in the standards but are important for the practical use of products**.**
To create one or another model of the system, it is first necessary to carry out its verbal and informational description and tuple recording. The components of a verbal informational description usually reflect a description of the external environment, and the system's connections with it; identification of the relationship between factors, characteristics of the variability of factors; elementary composition of the system, and its parts; description of connections between elements of the system and subsystems; operation of the system, i.e. description of the process of functioning and development of the system. The tuple record of the system model of the quality

assessment takes into account the classification characteristics of products, the set of "inputs" and "outputs" of the system; a set of variable parameters and processes.

The goals of quality management at each stage of the technological process for each specific type of printed product can be individual. To cover the management of all stages of the life cycle of media or packaging products within the subsystems of the quality system, it is necessary to perform a full set of special (specific) quality management functions. The matrix method or elements of the ISO 9000 series system can be used to form these functions.

Keywords: *systematic approach, quality, printed products, standard.*

Introduction

Evaluation of the quality of printed products at the current stage requires the application of the principles of a systematic approach, which is oriented towards the study and knowledge of the entire set of complex hierarchical relationships between them. Such a methodological approach to the methods of evaluating the qualitative indicators of printed products and their classification makes it possible to identify ways of their systematization. Based on the principles of system analysis, it is possible to build a coherent, logically completed methodological system of quality indicators of a specific type of product. This will also make it possible to justify the problem of choosing certain methods and give a normative and regulatory character to those indicators that are not reflected in the standards but are important for the practical use of products. To create one or another model of the system, it is first necessary to carry out its verbal and informational description and tuple recording. The components of a verbal-informational description usually reflect a description of the external environment, the system's connections with it; identification of the relationship between factors, characteristics of the variability of factors; elementary composition of the system, its parts; description of connections between elements of the system and subsystems; operation of the system, i.e. description of the process of functioning and development of the system.

Ukrainian and foreign scientists obtained important results in the research of the problem of assessment and quality assurance of printed products: V. Senkivskyi (2012), I. Pikh (2017), A. Kudryashova (2022), G. Kipphan (2001), D. Sajek (2022), A. Windriya (2020) et al.

At the same time, the analysis of literary sources showed a lack of research aimed at identifying multiple factors and determining the importance of their influence on the implementation of the processes of forming, printing and finishing printed products, determining optimal alternative options for the implementation of these processes, and comprehensive prognostic assessment of quality.

Therefore, the research of the technology of predictive assessment of the quality of various types of printed products and packaging based on system analysis and fuzzy logic tools is an urgent task.

Methodology and equipment

To create functional models of preprint, print, and post-print processes, the system and matrix analysis were used. The principles of the theory of hierarchical multi-level systems were used to isolate and formalize the relationship between factors influencing the quality of printed products and to create models of the priority influence of factors on the analyzed technological processes. To optimize the weight values of factors and synthesize models of their priority influence, methods of pairwise comparisons and multifactorial selection of alternatives based on the linear collapse of criteria, methods and tools of fuzzy logic were used. Fuzzy logic makes it possible to perform fuzzification, which consists of replacing the concepts of a clear set with the concepts of a fuzzy set, that is, comparing the set of values of its belonging functions. It is advisable to use this approach in the study of technological processes, the factors of which cannot be presented in numerical form. Accordingly, a comparison of term-sets of values of the analysed factors and belonging functions necessary for their formalization is carried out. Fuzzification provides a high level of correspondence of the model to the real state.

Analytical research and problem solutions

When developing a method of forecasting the quality of printed products with the use of fuzzy logic, several scientific and methodological principles are applied: the linguistic nature of the forecast (output) and input factors; linguistic knowledge; hierarchies of the knowledge base (figure 1) (S. Havenko, Hileta et al., 2019).

A hierarchical structure of the mathematical model was built based on the formalization of the influence factors given by fuzzy sets. Belonging functions were used to estimate and optimize the values of formalized linguistic factors. The study of the process of evaluating the quality of printed products consists not only in the ranking of factors. An important problem is the numerical expression of the degree of influence of a factor of a lower level on an element of a higher level associated with it, or the degree of dominance of a factor. It is called numerical or cardinal agreement according to the level of priority (Stetsenko, 2010; Tomashevskyi, 2005).

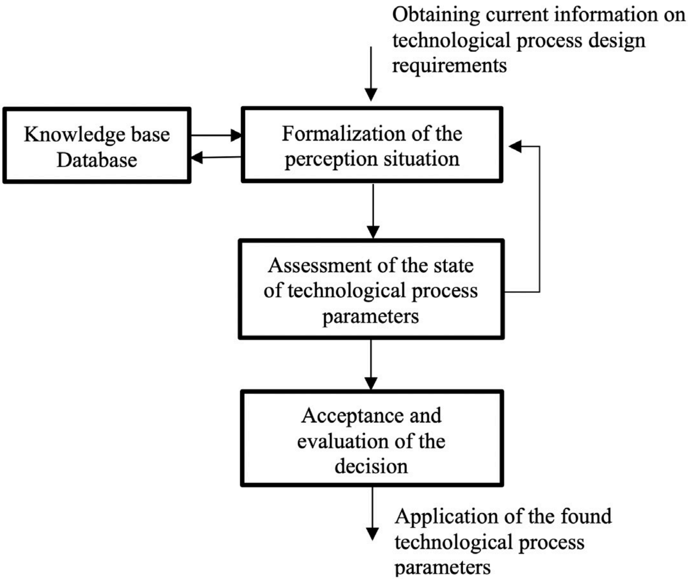

Fig 1. Structural diagram of the process of assessing the quality of perception

A set of determining factors affecting the process of design and production of printed products was identified as a result of the analysis of literary sources (S. Havenko, 2002; Havrysh & Tymchenko, 2014; M. Havenko, 2016) and expert survey.

Research results

It is important to build a quality model of the print production process. Let's consider the process of realization of the stages of the creation of printed products as a function Q= F (p_1 p_2 p_3), whose arguments are factors (linguistic variables) and p_1, p_2, p_3 – weights for factors. The value of this function will determine the predicted integral indicator of the quality of the implementation of the production process Q, expressed through partial indicators of the quality of linguistic variables, grouped according to their functional purpose.

$$Q = F\ (X\ Y\ Z\ T) \quad (1)$$

Argument X identifies an indicator that determines product quality: $Y = F_y (y_1, y_2, y_3)$, where y_1 is the linguistic variable "preprint"; y_2 is the linguistic variable "print"; y_3 is a linguistic variable "post-print". The Z argument identifies a total indicator that determines the quality of product processing. The T argument identifies a total indicator that determines the quality of the marketing data.

Let's design a fuzzy knowledge base and define an integral indicator of the quality of the product manufacturing process. To do this, let's establish the linguistic terms of the integral indicator. Let the integral indicator be the linguistic variable Q — "the quality of the implementation of product manufacturing processes", and the linguistic terms of this variable will be the terms "low", "medium", and "high".

At the next level, we refer the terms "low", "medium", "high" to the following linguistic variables:

C — "quality of preprint processes",

V — "quality of print processes"

G — "quality of post-print processes."

The fuzzy knowledge base, according to the multi-level model of fuzzy logic derivation, which reflects the hierarchy of linguistic variables, will have the form:

IF (C= low) I (C= medium) I (C= high)
I (V= low) I (V= medium) I (V= high)
I (G= low) I (G= medium) I (G= high),
THEN (Q= low) I (Q= medium) I (Q= high).

Based on the established conditions, let's build a matrix of knowledge (Table 1).

Table 1. Knowledge matrix for the linguistic variable Q

Quality of products output data (preprint)	Quality of print processes	Quality of post-print processes	Quality of the set of production processes
C	V	G	
low	medium	low	low
medium	low	low	low
medium	medium	low	medium
high	medium	medium	medium
high	high	high	high
high	medium	high	high

The knowledge matrix for the linguistic variable Q will correspond to fuzzy logic equations. Belonging functions will have the form:

for the term «low»
$\mu_{low}(Q)= \mu_{low}(C)\wedge\mu_{medium}(V)\vee\mu_{low}(G)\wedge\mu_{medium}(C)\vee\mu_{low}(V)\wedge\mu_{low}(G)$

for the term "medium"
$\mu_{medium}(Q)=\mu_{medium}(C)\wedge\mu_{medium}(V)\wedge\mu_{low}(G)\vee\mu_{low}(C)\wedge\mu_{medium}(V)\wedge\mu_{medium}(G)$

for the term "high"
$\mu_{high}(Q)=\mu_{high}(C)\wedge\mu_{high}(V)\wedge\mu_{high}(G)\vee\mu_{high}(C)\wedge\mu_{medium}(V)\wedge\mu_{high}(G)$

The generalized version of the logical statement for the linguistic variable "preprint quality" will have the form: IF (C_1) = (small, medium, high), (C_2) = (simple, complicated, complex), (C_3) = (small, medium, high), THEN (C) = (low, medium, high). The general fuzzy set of the linguistic variable Q for the analysed belonging functions concerning the fuzzy terms "low", "medium", and "high" and the corresponding values of the variable Q will have the form:

$$Q(C,V,G) = \{\mu_{low}(Q)/k_1,\ \mu_{medium}(Q)/k_2,\ \mu_{high}(Q)/k_3\} \quad (2)$$

where k_1, k_2, k_3 — quantitative values of the variable Q concerning the analysed terms. The next stage of research is defuzzification. To implement this stage, we build a table based on term-sets with normalized values of belonging functions at three points of division of the universal set of values D of each linguistic variable.

Table 1. Term-set belonging functions

	K (g_1)(preprint)			K (g_2)(print),			K (g_3)(postprint)		
D_1 (conventional units)	1	2	3	1	2	3	1	2	3
$\mu_{low}(d_1)$	0.11	0.25	1	0.17	0.2	1	0.11	0.14	1
$\mu_{medium}(d_2)$	1	0.14	1	1	0.11	1	1	0.12	1
$\mu_{high}(d_3)$	1	0.17	0.11	1	0.2	0.11	1	0.2	0.13

Let's substitute the values of the terms "low", "medium", "high" from Table 2 into fuzzy logic equations for the linguistic variable C:

for the term “low”

$\mu_{low}(C)=12 \wedge 0.17 \wedge 0.25 \vee 0.17 \wedge 0.25=0.17$

— for the term “medium”

$\mu_{medium}(C)=0.12 \wedge 0.14 \wedge 0.25 \vee 0.12 \wedge 0.14 \wedge 0.11=0.12$

— for the term “high”

$\mu_{high}(C)=0.2 \wedge 0.25 \wedge 0.2 \vee 0.12 \wedge 0.14 \wedge 0.2=0.2$

Let’s substitute the values of the terms “low”, “medium”, “high” from Table 2 into fuzzy logic equations for the linguistic variable V:

— for the term “low”

$\mu_{low}(V)=0.2 \wedge 0.17 \vee 0.11 \wedge 0.17=0.17$

— for the term “medium”

$\mu_{medium}(V)=0.2 \wedge 0.14 \vee 0.11 \wedge 0.14 \wedge 0.14=0.14$

— for the term “high”

$\mu_{high}(V)=0.2 \wedge 0.25 \vee 0.11 \wedge 0.25=0.2$

Let’s substitute the values of the terms “low”, “medium”, “high” from Table 2 into fuzzy logic equations for the linguistic variable G:

— for the term “low”

$\mu_{low}(G)=0.17 \wedge 0.14 \vee 0.17 \wedge 0.2=0.17$

— for the term “medium”

$\mu_{medium}(G)=0.14 \wedge 0.14 \vee 0.14 \wedge 0.2=0.14$

— for the term “high”

μ_{high} (G)=0.14 ∧ 0.12 ∨0.25 ∧0.12=0.12

For the highest level Q, the final values of the belonging functions will have the form:

— for the term "low"

μ_{low} (Q)=0.17 ∧0.14 ∧0.17 ∨0.12 ∧0.17∧0.17=0.14

— for the term "medium"

μ_{medium} (Q) =0.12 ∧ 0.14∧ 0.17∨0.2∧0.14 ∧ 0.14=0.14

— for the term "high"

μ_{high} (Q)=0.2 ∧ 0.2∧ 0.12 ∨0.2 ∧0.24∧0.12=0.12

To determine the numerical value of the evaluation of the quality of the implementation of the printed product manufacturing process, let's perform the defuzzification of the fuzzy set according to the principle of the centre of gravity:

$$Q = \sum_{i=1}^{M} [Q + (i-1) \cdot (\Omega - \Omega)/m - 1]_{\mu_i} \cdot (Q) \cdot / \cdot \sum_{i=1}^{m} (Q) \quad (3)$$

where Q_{min} – the minimum value of the quality indicator; Q_{max} is the maximum value of the quality indicator; and m is the number of fuzzy terms.

As a result of the calculation, we will obtain the quantitative value ($Q_{predicted}$=48.56%) of the integral quality indicator of the printed product manufacturing process, provided that: m=3; μ_1(Q)=μ_{low}(Q); μ_{2low}(Q)=μ_{medium}(Q); μ_3(Q)=μ_{high}(Q): conditional limits for the variable Q^Q=1%; Q=100%. For the fuzzy estimation terms Q, let's perform the calculation at three interval points: 1%, 50%, 100%.

Taking into account the formed set of research stages, the model of predictive assessment of the quality of production processes of printed products will include 8 stages: preprint, print and post-print technological processes; simulation of functions; synthesis of factors models; optimization of models; selection of alternative options for ensuring the quality of printed products; synthesis of models of fuzzy logic derivation; formation of integral indicators of the quality of printed products.

Thus, a structural-functional model of information technology for predictive assessment of the quality of technological processes at the stages of preprint, print and post-print has been developed, which considers the stages of research and enables a priori assurance of the quality of printed products.

Conclusions

1. As a result of the conducted theoretical and experimental studies, universal term sets of values and their corresponding linguistic terms were formed for linguistic variables (factors) of the processes of forming and obtaining high-quality printed products at the preprint, print and post-print stages.
2. By calculating the matrices of pairwise comparisons for each linguistic variable and its corresponding term-set of values, the values of the belonging functions of linguistic variables of the analyzed technological processes were obtained.
3. The value of the evaluation of the quality of the processes implementation of formation and production of printed products was obtained by defuzzification of fuzzy sets according to the principle of the center of gravity. The integral quality indicator of the quality formation process is 48.56%, and the integral quality indicator of the quality assurance process is 51.44% with maximum values of 100%.

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