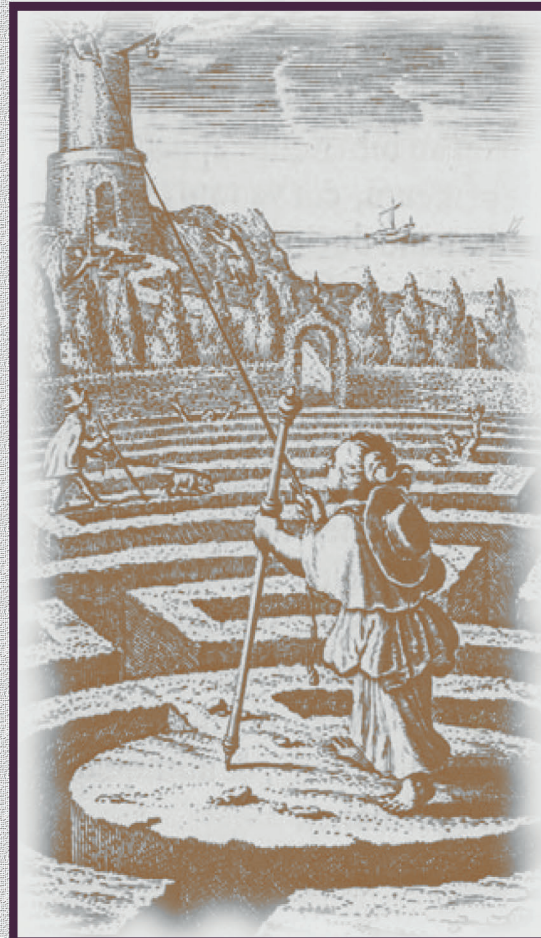# SCIENTIFIC ENQUIRY IN THE CONTEMPORARY WORLD: THEORETICAL BASICS AND INNOVATIVE APPROACH

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7th edition

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Science editor: E. Murzina

CATEGORICAL-FUNCTORIAL ANALYSIS OF BAKERY PRODUCTION

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Abstract

Knowledge characterization issues based on mathematical theory of categories and functors are studied. Categorical-functorial analysis of bakery production functioning as intelligent control object is conducted. The categories analysis results that characterize the quality of raw materials, part finished and finished bakery production items are presented. The conclusions below about the prospects of this approach implementation are shown.

Keywords: Bakery production, products quality, categorical-functorial analysis, intelligent control.

Bakery production has all attributes of complex organizational and technical systems, such as the availability of complex technological processes with various physicochemical types, high uncertainty level including multiple objects' activity, nonlinearity, multi-factorality, non-stationarity. Improving processes' efficiency and quality requires modern methods and control systems using, fundamentally new systems design approaches based on modern information technologies and net-centric automation approach concept.

The main criteria in bread production control are effectiveness, production loss and product grade. If the estimation of first two criteria is accomplished with clear positions, then determination of product grade due to its uncertainty requires using various methods and models. Significant interest entail intelligent technologies implementation, including knowledge base with production rules using such constructed on estimated semantic principles. The process that is badly formalized in informatics science is formation of semantic sense. Categories and functors are recently used as a high-potential apparatus for more pure formalization of complex and dynamic systems, which include the control systems of bakery production [1]. This apparatus gives an establishment of estimated semantic ratios to construct knowledge bases with intelligent control systems of complex technological objects' control. In every controlled object while its description, the key terms that meet basic concepts and phenomena called categories are pointed out.

K=<S, M> category is a set of S elements (components, characteristics, parameters, properties and other system parameters) called category objects and a set of morphisms transformations M – a special type of

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transformations that allow to describe (define) equivalence, invariance and other characteristics.

Functor is an analogue to semantic procedure that characterizes transformation among categories that leads to instructive information. Functor is estimated with a pair of images that contain morphisms composition and content data identity while objects and morphisms transformations.

Strict categories and functors of mathematical apparatus base makes it possible to explore semantic sense mathematically well-defined (by constructing semantic networks, frames analysis, production rules, etc.) that is necessary criterion for knowledge formalization, knowledge bases and decision support for intellectual system development. Categorical-functorial approach in knowledge formalization issue gives a possibility to formalize tentative used terms, which greatly improves bakery production' technological processes efficiency.

The analysis of bakery technological complex as control object using categorical-functorial approach gives a possibility to exclude quality, productivity and loss categories characterized by objects and operations. The connection among various categories is carried out by functor that render possible, for example, for quality category to identify properties including various quality parameters information content due to functor transformations by determining functors' structure and parameters (connections among definite quality parameters) [2].

For the means of automatic control system categorical-functorial analysis' design for bakery production will define the target categories of improving baking products quality on various control levels in company's organizational and technological structure.

The compatibility among input attributes and relevant data structures using information modeling can be set. Thus, improving the quality system make it possible to provide supporting information (input, temporary, output) in automatic mode according to definite bakery process state in the required time.

There are still no constructive means in defining these processes' dynamics and solving the complex of choice issues at this branch. An up-to-date target of structural-functional synthesis for inference chains in intelligent control systems can be assigned by choosing this choice issues' type. Applied control theories and relevant models' classes (categories) designed to date which can be primarily attributed: system dynamics models, logic-dynamic systems, Petri nets, dynamic models of complex operations gives a possibility to formally describing and solving only a limited range of analysis, monitoring and bakery production control targets.

The functors transformation process for dough stage (figure 1) and proofing stage (figure 2) is carried out.
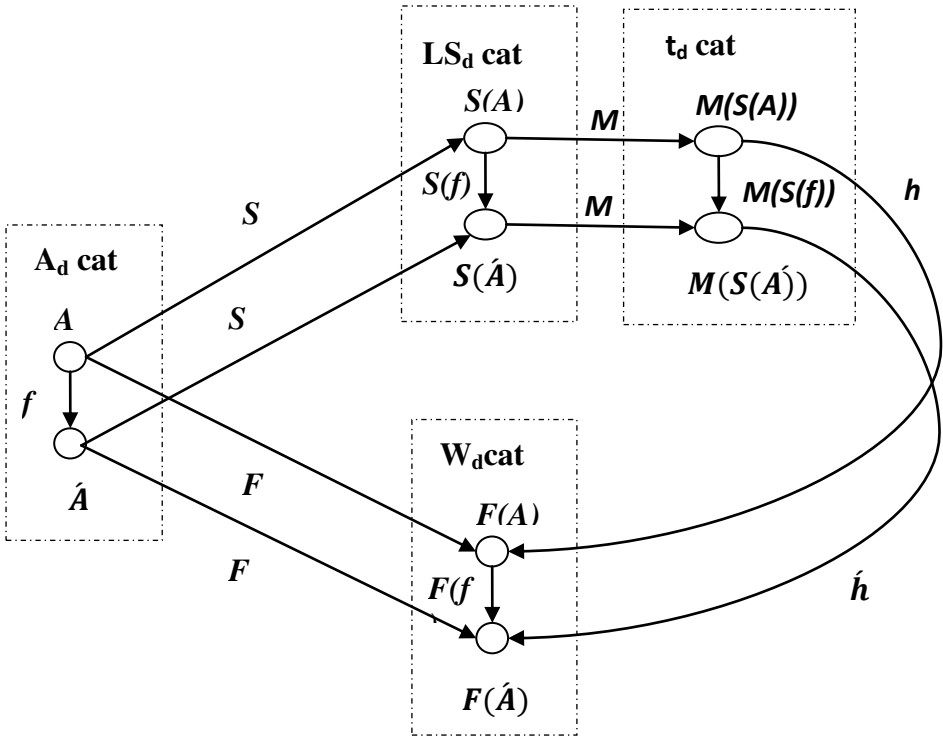
Figure 1. Transformation functors' procedure from A_d category for preparation of raw materials

where A_d cat – "Titrated dough acidity" category;
LS_d cat – "Dough lifting strength" category;
t_d cat – "Dough temperature" category;
W_d cat – "Dough humidity" category.

S, F – functors corresponding to A and Á objects and f morphism, A_d category, and put in correspondence this categories elements with LS_d category and t_d category elements respectively.

S(A), S(Á), S(f) – codomains: LS_d category objects and morphisms

F(A), F(Á), F(f) codomains: $W_т$ category objects and morphisms;

M – functors corresponding to S(A), S(Á) objects and S(f) morphism, LS_d category, and put in correspondence this categories elements with t_d category elements;

M(S(A)), M(S(Á)), M(S(f)) – codomains: t_d category objects and morphisms.

h, ĥ – morphisms that connect objects M(S(A)), M(S(Á)) to F(A), F(Á) respectively. Functors morphisms condition for h, ĥ will be fulfilled with

$$\acute{h} \oplus M(S(f)) = F(f) \oplus h$$
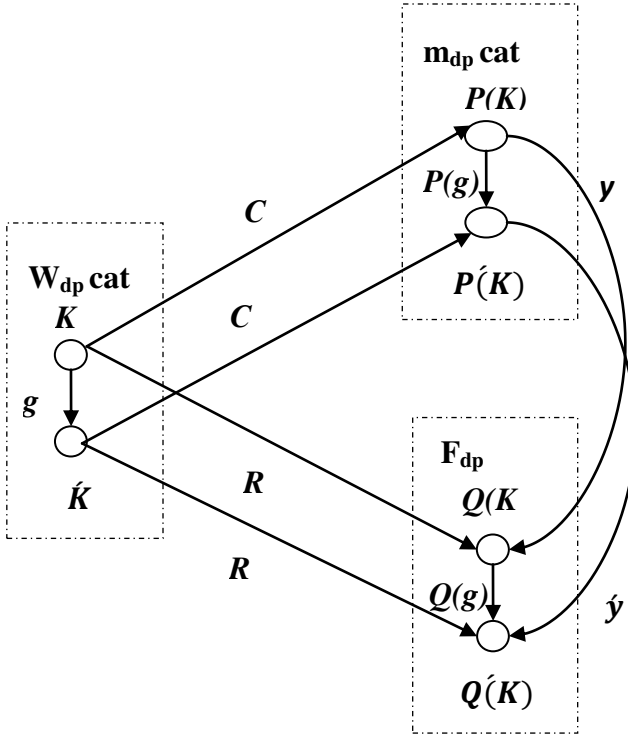

Figure 2. Transformation functors' procedure from F_{dp}
category for preparation of raw materials

where F_{dp} cat – "Dough piece molding ability" category;
W_{dp} cat **–** "Dough piece humidity" category;
m_{dp} cat – "Dough piece mass" category;

C, R – functors corresponding to objects K and $\acute{K}$ and g morphism, W_{dp} category, and put in correspondence this categories elements with m_{dp} category and F_{dp} category elements respectively.

P(K), P($\acute{K}$), P(g) – codomains: m_{dp} category objects and morphisms;
Q(K), Q($\acute{K}$), Q(g) – codomains: F_{dp} category objects and morphisms;
y, $\acute{y}$ – morphisms that connect objects P(K), P($\acute{K}$) to Q(K),Q($\acute{K}$) respectively. Functors morphisms condition for y, $\acute{y}$ will be fulfilled with

For computer interpretation, knowledge and data processing on the domain (objects, processes, phenomena, its structure and connections) it need to be formalized and presented in a certain formalized form. In traditional mathematical model implementing method with its data and modelling algorithm is constructed (modeling software), so data procedurally depends on processing method (algorithm). In intelligent systems object's

area data are given as a declarative (descriptive) model of database and appropriate rules of withdrawal that are independent from processing procedures. Special models of knowledge presenting in form of production rules will be used. Database contains general fixed laws, rules describing various bakery production environment issues. The withdrawal procedures allow under the general rules to bring solutions to a given specific bakery production operation that is described with some initial data. The inference chain is constructed with approaching the decision as the output data at every step and new outputted data before this step. Specific forms of deductive inference organizing depend on knowledge form for presenting in database (which language is used in knowledge presentation).

Conclusion

Categorical-functorial approach render possible to reduce the proportion of quality parameters subjective estimation by using algorithmically filled procedures in verbal form. The possibility emerges to calculate system quantitative characteristics (including quality parameters), to indicate the optimal system states due to it, when using categories and functors theory. In categorical-functorial system description the focus is shifting from the "frozen" object state to its various characteristics and transformation forms. The key point in such description is putting to that category all (valid by structure) means of object's changing along with structured objects. This render possible to replace the set-theoretical object presentation as a "frozen" structure with its processes' real presentation. Connecting among various categories was carried out on the functors basis that allowed, for example, for quality category to identify the properties of various quality parameters due to functoral transformations by determining functors' structure and parameters (connections among certain quality parameters). Category presents itself as a combination of two classes: objects class and morphisms class. Morphisms as ratio characteristics among categories were formulated in verbal form and implemented in data base in form of production rules. Categorical-functorial analysis was conducted for such quality categories as physicochemical properties of raw materials (flour, leaven), part finished (sponge dough, sourdough, dough) and finished bakery production items.

Categorical-functorial analysis render possible to examine structural object characteristics in dynamics that occur in situational connection that is necessary for management scenarios creation and makes it possible to structure parameters and its connections.

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For notes

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