SYSTEM APPROACH IN CRUMB BRIQUETTE TECHNOLOGY
СИСТЕМНИЙ ПІДХІД У ТЕХНОЛОГІЇ СУХАРНИХ БРИКЕТІВ

c.t.s., as.prof. Makhynko V.M. / к.т.н., доц. Махинько В.М.
ORCID: 0000-0003-2039-5137

c.t.s., as.prof. Sharan A.V. / к.т.н., доц. Шаран А.В.

c.t.s., as.prof. Sharan L.O. / к.т.н., доц. Шаран Л.О.

National University of Food Technologies, Ukraine, Kyiv, Volodymyrska str. 68, 01601
Національний університет харчових технологій, Київ, вул. Володимирська 68, 01601

Abstract. Classic bakery products are made under traditional technologies, the scientific basis of which is studied rather thoroughly. Development of new products and technologies requires application of system approach. This work considers possibility to apply the main provisions of system analysis to the crumb briquette technology. It also provides functional flowsheet of briquette production and distinguishes the main and the central subsystems. Based on the briquette formation stage example, the work shows rules for drawing up of parametric diagram and highlights its input and output factors. Application of the above approach will ensure efficient improvement of technological parameters and selection of optimal ration of recipe components.

Key words: crumb briquettes, technology, system analysis, functional diagram, parametric scheme.

Introduction.

Bread baking industry produces a wide range of bakery products. Despite differences in appearance, weight and receipts, most of these products are made under traditional technologies. The scientific bases of bakery were examined in a sufficient level of detail. They are studied in a considerable number of professional articles and scientific works [1, 2, 3]. However, manufacture of non-traditional
products requires additional research to determine optimal parameters of the process and the composition of the recipes.

**Problem Statement.**

Crumb briquettes is a promising type of bread products made by pressing bread crumbs with various target additives. The absence of fermentation stage allows to considerably diversify the recipes by selecting component proportions in accordance with the objectives (increase of nutrition value, decrease of caloric value, addition of health-improving features, etc.). However, crumb briquette production technology is not sufficiently developed which complicates its possible improvement or optimization. To find the best parameters of technological process or the best proportion of recipe components, we mainly used the following single-factor experiment: we were successively changing only one parameter or dosage of a certain type of raw material [4, 5]. In the experiment, we did not consider relation between individual parameters of the system and mutual influence of raw material components of the recipe. Determination of optimal proportion of various types of raw materials and selection of the best parameters of the technological process requires systematic analysis of the chosen technology.

**Purpose of the Study.**

The purpose of the study is to consider technological flowchart of crumb briquette production from the point of view of the system analysis for its possible mathematical modeling and optimization.

**Presentation of the Basic Material.**

Like most of food industry’s technological lines, the crumb briquette production technology may be referred to complex systems. Such systems have a large number of influencing factors and complex relations between quality indicators of raw materials, technological process parameters and consumer properties of finished products. Most of the above dependencies are nonlinear, therefore their study requires use of system analysis tools [6, 7, 8].

According to the main provision of this analysis, any large system can be represented as a set of simpler systems (subsystems) connected by functional
relations. The system under study can be represented as a functional flowsheet which
specifies succession of technological processes and shows the most important
relations between them. Functional diagram of the crumb briquette production
technology is shown in figure 1.

Figure 1. Functional Flowsheet of the Crumb Briquette Production Technology

Since the main objective of the technological system is to ensure high quality of
the final products, the subsystems are designated bottom-up. The technological
flowsheet of crumb briquette production has five subsystems:

- subsystem E – preparation of raw materials (crumb, powdery, viscous or
  liquid additives or additional raw materials);
- subsystem D – preparation of mixture (mixing of components, granulation,
  fractionation, etc.);
- subsystem C – formation of briquettes (filling of molds, pressing, holding
  under pressure, removal of briquettes);
- subsystem B – processing of briquettes (surface cleaning, visual quality
  control);
➢ subsystem A – storage and packing (ensuring necessary storage conditions, individual or group packing of finished briquettes).

By presenting the system as a set of interconnected simple processes, we can reasonably select optimization object, the factors that influence this object and the indicators that show selected subsystem’s performance. It is reasonable to start system improvement from optimization of parameters of the central subsystem, that is the subsystem which has the most influence on quality of the final product. Subsystem C (formation) is the central subsystem of the crump briquette technology. It is recommended to draw up parametric diagram to illustrate all factors that influence the system and define its work. The diagram is represented as a black box with four groups of factors (figure 2):

X – input leading factors, that is the factors which substantially influence the process and may be purposefully changed by the researcher for systematic effect on the subsystem;

Z – input disturbing factors which influence the subsystem under study, but cannot be changed at this technological stage (their influence should only be taken into account);

Y – output controlled factors which define subsystem operation and substantially, sensitively and expectedly change under influence of the input leading factors;

U – condition parameters which define the object selected, but do not change at this stage or change insubstantially.

![Figure 2. General Parametric Diagram](image-url)
Let us draw up parametric diagram of the central subsystem C (figure 3).

![Image of a parametric diagram](image)

**Figure 3. Parametric Diagram of the Crump Briquette Pressing Subsystem**

At this stage, the input leading factors include – mass of the material used to make one briquette $G_m$, pressing capacity $V_p$, working pressure $P_p$ and duration of holding under pressure $\tau_p$. Physical and chemical indicators of the mixture (viscosity $V_m$, adhesiveness $A_m$, compression $C_m$), temperature $T_m$, moisture $M_m$, granulation $G_m$ and its uniformity, and plug diameter $D_p$ may be referred to the disturbing factors. Then the output controlled parameters will be briquette strength $S_b$, duration of its soaking $\tau_s$, density and dimensions $D_b$. Condition parameters are organoleptic parameters of briquette $O_b$, its compression factor $C_b$ and buoyant force $F_b$.

The parametric scheme above may become the basis for the selected subsystem’s optimization. For this purpose, we should select one of the indicators among the output controlled factors which will be sensitively change under influence of input factors while defining efficiency of changes made by the researcher. The best factor to select is usually the one that is easy to measure and is directly connected with the intended purpose of the subsystem under study. At the crump briquette pressing stage, strength of the products obtained may be such indicator. Then the target function of the subsystem selected may be represented as dependence between the selected optimization criterion and the input leading factors:

$$Y_{opt} = f(x_i)$$

**Summarize and Conclusions.**

This work considers the prospects of application of the main provisions of system analysis to crump briquette technology improvement. Drawing up of the
A functional flowchart allowed to distinguish the main subsystems and to select the central one among them – the briquette formation stage. The pressing process parametric scheme was the basis for distinguishing the leading factors \(G_m, V_p, P_p, \tau_p\) and the central subsystem’s \(S_b, \tau_s, D_b\) performance indicators. Strength of finished briquettes was selected as the optimality criterion, and target function of the pressing process was drawn up, which will allow to efficiently optimize the crump briquette formation stage:

\[ S_b = f(G_m, V_p, P_p) \]

References:

Анотація.

Класичні хлібобулочні вироби виготовляються за традиційними технологіями, наукові основи яких вивчено досить групою. Розроблення нових виробів і технологій вимагає використання системного підходу. Розглянуту можливість застосування основних положень системного аналізу у технології сухарних брикетів. Наведено функціональну схему їх виробництва, виділено основні та центральні підсистеми. На прикладі стадії формування брикетів показано правила складання параметричної схеми з виділенням вхідних та вихідних факторів. Застосування запропонованого підходу забезпечить ефективне удосконалення технологічних параметрів та вибір оптимального співвідношення рецептурних компонентів.

Ключові слова: сухарні брикети, технологія, системний аналіз, функціональна схема, параметрична схема.

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