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EFFICIENCY OF USING A NEW FEED ADDITIVE IN FEEDING CHICKENS OF BROILERS

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Abstract

The paper set the task to study: the influence of feed additives on productive and slaughter indicators of poultry; to investigate the condition of the internal organs under the action of feed additives; calculate the economic efficiency of the enzyme preparation.

As a result of the experiment, an increase in live weight of poultry for 42 days of rearing by 371.8 g (*** P <0.001), which is 13.4%, and a decrease in feed consumption per 1 kg increase by 0.09 kg or 4, 9%. The experimental group receiving the enzyme preparation in addition to the main diet had a higher weight of half-gutted carcass by 347.3 g or 15.8% and the weight of gutted carcass by 282 g or 14.3% and slaughter yield by 0.6% .

The use of the enzyme preparation in the feed for broiler chickens is economically justified: an increase in revenue by 16.7%, profit from sales by 41.5% and the level of profitability by 7.7%.

Keywords: broiler chickens, new feed additive, internal organs, gains, feed conversion.

Actuality of theme. At present, poultry farming in Ukraine is one of the most intensive and dynamic branches of agricultural production, which has all the opportunities to overcome the economic difficulties in a short time.

The main goal of poultry farming in our country is to increase the production of dietary, high-calorie products - eggs and meat in order to provide people with physiologically necessary nutrition [7].

Interest in the poultry industry is due to technological and economic advantages: compared to low feed costs, short reproduction period, the ability to regulate product quality. The latter depends on many factors, in particular, on the technology of breeding and keeping poultry.

An important factor in the development of poultry farming is selection work aimed at improving productive and breeding qualities, as well as the creation of new breeds, lines, crosses of all species of poultry. Therefore, as a result, it is necessary to apply scientifically sound technologies for keeping and feeding birds [32].

During the selection of cross COB - 500 special attention is paid to the efficiency of feed conversion. In all countries of the world, cross has the lowest feed costs for the production of 1 kg of chicken meat, which at current feed prices make it profitable and profitable to breed it [40].

In the world practice of poultry development as additives to poultry diets add biologically active substances: vitamins, antioxidants, trace elements, antibiotics and others that increase the body's resistance, improve feed intake, increase the secretion of digestive glands, effectively affect metabolic processes, but not involved in the breakdown of feed nutrients. Among biologically active substances, enzymes are the most important. Moreover, from these stimulants enzyme preparations are fundamentally different in that they are directly represented by biocatalysts that affect the digestibility of feed nutrients.

Enzymes in nature are multifaceted, and all life manifestations are related to their functions. Under the influence of enzymes in the digestive tract of animals is the breakdown of nutrients of feed masses, which are converted into energy and structural materials necessary for growth and reproduction, production and other biological synthesis in the body of living beings [41].

Enzyme preparations improve the chemical composition of rations as well as the digestibility of feed nutrients, which in turn improves the productivity of poultry. Compensating for the insufficiency of the enzymatic system of the digestive tract of birds, stimulate the assimilation of nutrients. According to experimental studies, the use of enzyme preparations allows to purposefully influence the productivity and more efficient use of feed.

Analysis of recent research and publications. Fundamentals of physiology and feeding of broiler chickens. The productive qualities of poultry, the economic feasibility of poultry farming in general is determined by a set of biological characteristics of poultry as an object of agricultural production.

Features of poultry nutrition are based on the structure and functioning of the digestive system. Digestive organs begin with the beak, the shape depends on the living conditions of the bird. There are no teeth in the mouth of the bird, so the food does not undergo physical changes, and, slightly wet with saliva, enters the esophagus, through which the food enters the ox. In the wild, food can be delayed for up to 8 to 12 hours. From the ox through the esophagus, the food enters the glandular stomach, where it is moistened with digestive juices. Next is the muscular stomach, the inner surface of which is covered with a cuticle. In the muscular stomach there is a grinding of a forage by reduction of a muscular wall of a stomach and by means of small stones which the bird swallows in advance. The muscular stomach is emptied reflexively by opening of a pylorus, and the chyme falls out in a duodenum, and then and in a small bowel. Under the action of pepsin

and hydrochloric acid in the initial segment of the duodenum is a partial breakdown of proteins. Moving through the small intestine, chyme mixes with intestinal juice, which contains amylase, invertase, trypsin, lipase, as well as bile, which further breaks down the main nutrients of the feed [3].

The reaction of the gastrointestinal tract varies from acidic (pH - 2.2) - muscular stomach, to slightly alkaline - in the jejunum (pH - 7.0). In the cecum under the action of proteases produced by bacteria and enzyme residues is the breakdown of indigestible proteins. The rate of promotion of chyme by the bird's digestive tract depends primarily on the method of feeding, the composition of the diet and the particle size of its components. With the dry method of feeding complete ration of loose feed, feed masses pass through the digestive tract in chickens in 3 - 4 hours.

In addition to these features of digestion, it is very important that the bird does not have a large intestine, so it is not able to digest protein foods well. Therefore, the bird has two large caecum, designed to digest hard-to-digest protein foods.

According to VI Besulin [5], in poultry compared to mammals, better absorbed nutrients. Thus, in poultry the highest coefficient of feed digestibility - 85 - 90% against 75 - 80 - in pigs and 65 - 70% - in cattle.

In the body of birds compared to the body of mammals are more intense metabolic processes. This is confirmed by data on energy expenditure for maintenance foods needed by the body to ensure its viability. Poultry omnivorousness is an important biological feature that allows the use of various feed ingredients in feeding, mainly concentrated feeds, biologically active substances that ensure intensive growth and development, maintenance of normal immunological status, body resistance, high productivity.

Feeding is an integral part of the technology of poultry production. In the structure of the cost of poultry meat, feed costs are 60 - 70%. The realization of the genetic potential of poultry of different species and areas of productivity is possible only against the background of full feeding, ie meeting its needs for energy, nutrients and biologically active substances. This is achieved by organizing normalized feeding depending on the species, breed, cross, age, physiological condition, sexual characteristics and methods of maintenance [6, 7].

Normalized feeding - feeding of poultry according to scientifically substantiated norms of metabolic energy and complex of nutrients and biologically active substances. When organizing normalized feeding, it is necessary to take into account the peculiarities of metabolism in different species and age groups of birds.

The bird is characterized by intensive metabolism, and therefore high compared to other animals, body temperature (41 - 420 C) and three times higher oxygen demand per 1 kg of live weight. It is characterized by high conversion of metabolic energy and feed protein into products and limited endogenous synthesis of vitamins, so the need for them is provided by guaranteed supplements. The bird does not have sweat glands, which play an important role in thermoregulatory processes, so the violation of the optimal temperature parameters of the bird leads to unnecessary costs for the regulation of heat generation and heat transfer. The bird has limited internal reserves of nutrients and energy, so the effects of poor feeding are detected quickly and are accompanied by a decrease in productivity, reproductive capacity and overall resistance of the organism [12].

The modern system of normalized feeding is based on a comprehensive assessment of the nutritional value of feed and the norms of the bird's need for metabolic energy, nutrients and biologically active substances. Estimation of feed nutrition is determined by the content of metabolic energy, crude protein, essential amino acids, crude fiber, minerals and vitamins. At the same time eating of forage, digestibility and assimilation of nutrients is considered. During the development of feeding norms, the factorial method of individual needs of different species of birds in energy and nutrients is used, ie certain indicators of costs for the maintenance of vital functions, product formation are determined.

Need - the amount of metabolic energy, nutrients and biologically active substances per day, necessary to ensure the normal course of vital functions and synthesis of products in strictly controlled conditions of poultry. The feed rate is the average amount of a certain amount of metabolic energy and nutrients and biologically active substances, the need for daily coverage of livestock costs, ensuring a certain level of productivity with efficient use of feed, taking into account possible losses in economic conditions. It will exceed the need of poultry in some indicators by 10 - 30%, as it takes into account the technological conditions of production (temperature fluctuations, feed quality, stress factors, etc.). Scientific studies show that the indicators by which the rationing of poultry (metabolic energy, crude protein, etc.) are in some dependence and change accordingly under the influence of various factors: the level of productivity, physiological condition, housing conditions. This makes it possible to apply the rationing of the content in 100 grams of complete feed metabolic energy and a complex of nutrients in optimal proportions [7].

Unlike young hens of broiler hens, broilers have extremely high growth energy, especially in the first period of life, and are prone to obesity in the next. It is established that high productivity of broilers is possible under the conditions of achievement by them of the potential weight conditions from the first days of life. Therefore, it is important to start feeding the young immediately after its receipt for cultivation, no later than 12 - 13 hours from the moment of their removal. As a highly productive organism, broilers are more sensitive to various deviations in feed, this is reflected in the deterioration of their health, reduced weight gain [19,39].

The system of normalized feeding is aimed at the rational use of feed, as well as reducing the cost of feed per unit of output and reducing its cost. In the conditions of industrial production of poultry products, as evidenced by domestic and international experience, the most effective is the dry method of feeding poultry with complete feed, which fully meets its need for metabolic energy and nutrients and biologically active substances.

In terms of production, lack of energy in the diet is the cause of reduced poultry productivity. When feeding poultry, a sufficient concentration of metabolic energy in the feed is not only an important factor in energy nutrition, but also the normalization of other nutrients and biologically active substances. The fact is that the caloric content of feed depends on its consumption, and this causes the entry into the body of poultry protein, amino acids, vitamins, minerals. Metabolic energy is an indicator that indicates the nutritional value of feed and characterizes the energy available to birds of chemical bonds of proteins, fats and carbohydrates. Nowadays, the composition of feed mixtures for poultry mainly include wheat, barley, sunflower meal [41].

In the process of digestion, some of the gross energy of feed is excreted with indigestible residues in the feces, and the second - remains in the body. This is the digestible energy of nutrients, which is 80 - 85% of the gross energy of feed. Exchange energy is 72 - 75% of gross. It is the content of metabolic energy that determines the energy nutrition of poultry feed. Metabolic energy provides the body with the most important physiological processes: growth, development, egg formation, normal functioning of all systems.

The unit of measurement of the energy value of feed in accordance with the International System of Units (SI) is the joule (J). According to this system, one calorie corresponds to 4.1868 J. However, the metabolic energy in modern feeding norms is expressed not only in kilojoules (kJ) and mega joules (MJ), but also in kilocalories (kcal).

When feeding highly productive poultry in the diet it is necessary to adhere to the optimal ratio of metabolic energy and protein.

The energy-protein ratio is the amount of metabolic energy in 1 kg of feed per 1% of protein [12].

Under conditions when the food contains insufficient metabolic energy, the protein in the body is spent on energy needs. And this leads to lower productivity and increased feed costs per unit of output. Excess metabolic energy reduces feed consumption and nutrient efficiency and promotes intense fat deposition in the body of the bird.

The rationing of protein nutrition is carried out on crude protein. The composition of crude protein includes proteins and non-protein nitrogenous compounds - amides. Feed protein in poultry is converted into protein in meat, eggs and feathers.

Protein completeness of poultry feeding is achieved not only due to crude protein, but first of all, the content of essential amino acids in the diet. The following amino acids have a significant effect on protein synthesis in the body: lysine, methionine, cystine, tryptophan, arginine, histidine, leucine, isoleucine, threonine, phenylalanine, valine. However, lysine, methionine and cystine deficiency are most common in poultry feeding. In compound feeds, methionine is calculated together with cystine. In the body of birds from methionine cystine is formed [10].

Not only the lack but also the excess and imbalance of amino acids in the diet has a negative effect on the productivity of poultry and the efficiency of production.

In order to properly balance the feed for amino acids, it is necessary to calculate the index of amino acid balance. In the absence of amino acids in the diet, first of all, the first limiting amino acid is introduced into the feed to the norm, then - the second, third.

The enrichment of compound feeds with amino acids of chemical synthesis is effective: DL-methionine, L-lysine, monochlorohydrate, feed lysine concentrate, etc.

In the feeding of poultry normalize crude fiber, which includes cellulose, hemicellulose, lignin and other compounds. Fiber is necessary for normal digestion, as it forms a certain amount of chyme in the intestine, increases its peristalsis, activates the release of digestive enzymes, which has a positive effect on the digestibility of nutrients. But there are no enzymes in the body that break down fiber. This occurs mainly in the blind processes of the intestine under the influence of enzymes of microorganisms [12].

Animal and vegetable fats are used in poultry feeding. Their desired ratio in the feed is 1: 1. The norms of fat intake in compound feeds according to the recommendations of the Institute of Poultry UAAS are for young animals raised for meat (%): broiler chickens 1 - 4 weeks of age - 3 - 5, older - 5 - 8.

In feeding birds normalize such macro - elements as calcium, phosphorus and sodium.

Calcium is involved in the processes of skeleton formation, egg shells, blood clotting, enzyme activation, transmission of nervous system excitation and stabilization of cell membrane permeability. Phosphorus is central to the metabolism and energy of the bird. Phosphorus deficiency can cause loss of appetite, which negatively affects the productivity of poultry. Excess phosphorus reduces the absorption of calcium and causes excessive deposition in the kidneys, inhibits the growth of young animals, impairs the quality of egg shells. Sodium is an integral part of buffer systems that maintain acid-base balance in the body, regulates water metabolism, optimizes the environment for the action of enzymes. Sodium is a calcium antagonist, it increases the permeability of cell membranes. Sodium deficiency is usually observed in feeds (rations) with low feed content of animal origin [15].

Trace elements (manganese, zinc, iodine, copper, cobalt, iron, selenium, etc.) are indispensable factors in poultry nutrition. As part of many biologically active compounds - enzymes, hormones, vitamins, they affect the metabolism and energy in the body of the bird, and hence its productivity, reproductive qualities and natural resistance. Trace elements are normalized to 1 ton of feed. Their content in the components of feed is not taken into account. In the enrichment of feed with trace elements, it is important in the form of which chemical compounds they are used [43].

Standardization of vitamins. Vitamins are biologically active compounds that are not a source of energy or a plastic material, but are necessary for the normal course of metabolic processes in the body of the bird. The complete absence of vitamins in feeding causes beriberi with profound spread of metabolism, which leads to serious diseases and death of birds. In case of

insufficient supply of vitamins to birds, hypovitaminosis occurs, and in excess - hypervitaminosis.

In modern poultry farming, two types of poultry feeding are mainly used: dry and combined.

Broiler chickens, in contrast to other species of poultry, have a high growth rate, so from the first days they need to be fed complete feed, balanced in all nutrients [12].

Compound feeds are feed mixtures of plant, animal, mineral and biologically active feeds. They are made according to appropriate scientifically based recipes that provide the necessary combination of ingredients, efficient use of nutrients and high productivity of poultry with minimal feed costs per unit of output.

The first 5 - 7 days the chickens are fed pre-start feed, which includes only good quality feed that contains easily soluble nutrients that are easily absorbed by the body. Approximate variant of pre-start compound feed,%: corn - 50, wheat - 24, soybean meal - 14, milk powder - 12.

Complete feeds should be enriched with vitamins, trace elements and balanced in essential amino acids. They are fed without the addition of other feeds [41].

The range of compound feeds TM "Best Mix" allows you to use two methods of fattening with prestarter feed and without the use of prestarter feed.

The composition of feed: wheat, corn, soybean meal, soybean meal, soybean extrudate, sunflower meal, sunflower meal, corn gluten, limestone, monocalcium phosphate, vegetable oil, salt, amino acids: lysine, methionine.

Starter feed, according to the recommendations, in 100 g should contain: crude protein - 22 g, metabolic energy - 1298 kJ, fiber - 4 g, calcium - 1.0 g, phosphorus - 0.8 g, sodium - 0.3 g , amino acids, vitamins. Finishing feed (4 weeks of age before slaughter) in 100 g should contain: metabolic energy - 319 kJ, crude protein - 19 g, crude fiber - 4.5, calcium - 0.9, phosphorus - 0.7, sodium - 0 , 3 years

As planting density increases, so does the number of products produced per unit area, but poultry growth decreases, feed costs increase, and meat quality decreases. Front of feeding at dry type of rations for chickens - broilers of 2,5 cm.

Unbalanced feeding provokes metabolic disorders and reduced immunity of birds. This, in turn, leads to the field viruses overcoming the immune barrier, then the conditionally pathogenic microflora becomes pathogenic, and the bird gets both viral and sequential bacterial problems.

For birds, water is no less important than food. The needs of poultry depend on air temperature, diet, physiological condition. Water consumption for watering for poultry is 0.25 - 0.30 liters per day per head [15, 41].

Ways to improve poultry meat productivity. The purpose of broiler production is to obtain the maximum yield per unit area of poultry at minimum labor costs and material and energy resources. That is why in broiler production the issues of adjusting the recommended programs for growing young animals in order to increase the intensity of its growth remain relevant. At the same time, it is equally important to improve the meat quality of poultry, as well as to achieve the maximum economic effect, which justifies the chosen direction of research.

In the conditions of modern production of poultry products the development of new technologies and also separate technological receptions is directed both on increase in production, and on decrease in specific expenses of material - power and other means. Currently, resource - saving technologies are gaining ground, the development of which is based on new achievements of biological sciences and scientific and technological progress [5].

In the conditions of modern production of broiler meat the following basic principles are allocated:

- use of highly productive hybrid poultry;
- growing broilers in poultry houses equipped with tools that provide full mechanization and automation of production processes and regulation of the microclimate, depending on age, high productivity;
- application of resource-saving technological methods;
- execution of production processes according to the technological schedule;
- the use of complete dry feed, which meet the biological needs of the body of the bird and allow to obtain high quality products;
- strict observance of sanitary and veterinary rules.

One of the decisive factors in obtaining high-quality meat with minimal feed costs is the optimal time for raising poultry. From an economic point of view, poultry production is more profitable the shorter the growing time, because at an early age the growth rate is the highest and the best feed payment. The increase in broilers with lower intensity lighting is higher, and feed costs per unit of production are lower [10].

Among the technological factors that have the greatest impact on poultry productivity should be noted the density of planting chickens. It has been found that by regulating the stocking density of broilers it is possible to increase productivity and economic efficiency of meat production. Planting density of 20 heads per square meter.

The efficiency of broiler meat production depends to a large extent on economically useful traits that contribute to the production of chickens with increased live weight. Such features are the lowest cost of labor and feed with a relatively short period of time of poultry.

Meat productivity - the most important economically useful property of the bird. It is characterized by the weight and meat qualities of the bird at slaughter age, as well as nutritional value - the quality of meat.

Meat productivity is the amount of meat and carcass components obtained from an animal or group of animals over a period of time.

Live weight is the main feature that determines the amount of meat in a bird of any age. Live weight is set by weighing. It is better to weigh the bird in the morning, before feeding.

Meat productivity is characterized by live weight, meat quality of poultry at slaughter age and nutritional value of meat. White broiler meat contains more than 20% complete protein and only 1-2% fat. The most effective is the breeding of hybrid poultry in the direction

of productivity, obtained by crossing specialized lines of meat and meat - egg breeds. Low feed costs per unit of growth, meat precocity, high mobility of the industry are important for the development of meat poultry [11].

Poultry productivity is assessed by the following characteristics:

- growth rate - an indicator characterized by the weight of the bird, which it reached at the slaughter age, or determined by the indicators of absolute, relative and average daily gain;

- weight - the main indicator used to determine the amount of meat in poultry of any age to obtain reliable indicators. Weight is determined by weighing in the morning before feeding.

When assessing the meat quality of poultry, be sure to pay attention to:

- weight before slaughter (before slaughter weight), which is determined after 12 - 16 hours. stay of birds without food and 4 hours. - without water;

- weight of unharvested carcass (slaughter weight) - weight of carcass without blood and feathers (waterfowl - down);

- the weight of the half-gutted carcass - the weight of the carcass without blood, feathers, head, limbs, wings to the elbow joint, in which all internal organs are removed, except the lungs and kidneys;

- weight of edible parts, such as limbs (paws), head, torso bones, gastrointestinal tract (esophagus, goiter, glandular stomach, cuticle, intestine with contents, pancreas, gallbladder), fallopian tube, ovary, testes, larynx, trachea;

- chest muscle weight.

Carcass category is the main indicator that characterizes the quality of meat. It is determined by fatness, taking into account the development of adipose and muscle tissue. The main components of the carcass are muscle, fat, bone and connective tissue, cartilage and ligaments. Muscle and fat increase the category and nutritional value of meat, while bones and cartilage reduce it. Significant amounts of adipose tissue reduce the relative protein content and digestibility of meat, but the location of adipose tissue in carcasses is important: intramuscular fat is more difficult to separate from meat than subcutaneous.

As the percentage of connective tissue in the carcass that contains defective proteins increases, the quality of the meat and its taste properties decrease. The most valuable carcasses in the ratio of muscle and bone tissue 4 - 4,5: 1 [10, 32].

Poultry meat quality indicators depend on the composition and properties of raw materials, conditions and modes of technological processing and storage. The chemical composition of meat varies depending on age, fatness, sex, type of poultry feeding and the percentage of its constituent tissues. In general, the main components of poultry meat are the same as the components of the meat of slaughtered farm animals: water, proteins, fats, extractives, enzymes. Because the most valuable in bird carcasses is muscle tissue.

Water is contained in the muscle tissue in a hydrated - bound or free state. Its amount varies between 47 - 78%, depending on the fatness and age of the bird. As the percentage of adipose tissue and the age of the bird increases, the water content of the meat decreases because the main water retention is protein.

Protein forms the nutritional value of meat. Their content in poultry meat is higher than 20% compared to other species of slaughtered animals. Because there is relatively little connective tissue in meat, the level of complete proteins (myosin and actin) is higher. Protein in poultry meat contains a complete set of essential amino acids: in broiler and goose meat, this ratio is optimal for the human body. Lipids in poultry meat are represented by glycides, phospholipids and cholesterol.

Enzymes are used to build tissues, their main function is plastic. Aspen-reducing enzymes peroxidase and catalase determine the degree of freshness of meat [11].

Meat productivity of poultry, as well as egg, is a complex quantitative feature. In addition to the above indicators characterizing meat productivity, the following are important: payment for feed growth, plumage rate and nutritional value of meat.

Feed costs are an indicator that determines the economic efficiency of raising poultry. The value of this indicator is difficult to overestimate, because the cost of meat production is 70% of the cost of feed.

The plumage rate and growth rate of young poultry are inherited qualities associated with the peculiarities of metabolism. Growth rate is a sign that is taken into account in young meat. The most intensive growth occurs in the first month of life.

There are significant differences in the growth rate of the bird depending on the species, breed, cross and age.

Influence of bird species. Birds of different species differ in growth rate, meat productivity, meat quality. Broiler chickens are widely used in poultry production, which are characterized by high growth rate, good feed payment, they have tender and juicy meat, soft sternum cartilage. Their meat is characterized by high nutritional and biological value. Broilers convert feed protein into food 1.5 - 2 times better than other animals. Broiler meat is low in fat (12%), while goose meat is 39% fat and duck meat is 38% fat. Broiler fat contains more unsaturated than saturated fatty acids, it is mainly found in the skin, not in muscle tissue [10, 38].

Meat birds differ from egg birds in high growth rates and higher live weight, good meat body shape (large width, depth, roundness of the body). Their meat is juicier and tastier.

Influence of sex. Due to the biological characteristics of each sex, there is a different growth rate of males and females. Male turkeys are 50% or more heavier than females, roosters - by 12 - 15%, kachurs - by 6 - 12%.

Male carcasses are more bony. The number of edible parts and muscles in females is slightly higher than in males. Muscle fibers are larger in males and smaller in females. Male meat has a higher moisture content and lower fat content than female meat. Female meat is superior to male meat in protein content. Rooster meat is less juicy than chicken.

Influence of age. The intensity of metabolism in birds and the intensity of their growth decreases with age. Feed costs are directly related to the age of the bird. With age, the relative muscle mass, carcass and edible

parts of the carcass increase, and the relative skeletal mass decreases. As the bird ages, the water content of the muscles decreases, the amount of dry matter, protein and fat increases, but the conversion rate of protein into food protein decreases. With the age of the bird, the ratio of complete and incomplete proteins in the meat deteriorates, which leads to biological deterioration of the completeness of the meat, the amount of unsaturated fatty acids decreases and the content of saturated ones increases, the tenderness and juiciness of the meat decreases.

One of the crucial factors in obtaining high-quality meat with minimal feed costs is the optimal time for raising poultry.

From an economic point of view, the production of poultry meat is more profitable with a short period of their cultivation, as at an early age the growth rate is highest and the payment for feed is the best [3, 10].

With the age of the bird increases the slaughter yield (percentage of slaughter weight to live weight of poultry before slaughter after starvation). However, this is more related to the increase in live weight than to age, because when the age of the bird is different, but the live weight is the same, the slaughter yield does not change.

The best time to raise young for meat: broilers - up to 6 weeks, turkeys - up to 17 weeks, ducks - up to 7 weeks, geese - up to 9 weeks, guinea fowl - up to 12 weeks, quail - up to 9 weeks.

Influence of live weight. There is a high positive correlation between live weight of poultry with slaughter yield, content of edible parts of the body, number of muscles of the chest and legs, feed consumption, carcass category. As the live weight increases, the fleshiness of the keel, thigh, shin, mass index, and chest angle increase.

Influence of feeding. The optimal amount of protein is necessary for intensive growth of a bird. Protein malnutrition is one of the main causes of poor growth and increased care of birds. However, an excess of protein in the diet is impractical, as protein in this case is not fully used, harms the body, delaying its development [33].

Increasing the energy value of feed mixtures contributes to a significant improvement in the quality of meat. Animal and vegetable fats are used as fatty impurities. Fatty impurities are not only carriers of energy, but also a set of fatty acids.

Mineral nutrition is important for the normal growth and development of birds. Excess minerals and their wrong ratio, as well as lack, causes disease in birds, delays the growth and use of nutrients in the diet.

Practice impurities in the feed mixture, which contribute to the growth of poultry productivity and improve the taste, smell, appearance, safety of products. These are enzyme preparations, antibiotics, antioxidants, drugs (for prophylactic purposes), growth stimulants, flavors (to improve feed consumption) and others.

Various growth stimulants, antibiotics, and drugs are eliminated from the bird's diet at least a week before slaughter to avoid residual meat.

Yellow carcasses are especially in demand. Such carcasses can be obtained by using yellow corn, grass flour, especially alfalfa, for feeding poultry.

Influence of the method of retention. When kept in a cage, the growth of young birds is more intense than when kept on the floor, the carcasses are fatter. Broilers with caged content have a live weight at the slaughter age higher by an average of 10 - 16%, feed payment is better by 5 - 17%, the yield of carcasses of category I fattening is higher by 10 - 37% than when kept on the floor.

Planting density. As the stocking density of poultry increases, the number of products per unit area increases, but the increase in poultry decreases, feed costs increase, and meat quality decreases. The optimal stocking density of birds is determined by their age, safety, feed payment, final live weight, meat quality, yield per unit area [19, 30, 54].

One of the most important indicators characterizing the meat productivity of poultry is the category of carcass. The fact is that a live bird is divided by weight and fatness only into standard and non-standard.

In accordance with GOST 18292-85 "Poultry for slaughter. Specifications ", a bird intended for slaughter, is divided into adults and young.

At this time, the largest share in meat poultry is the production of broiler meat. This is largely due to the high yield of meat in the carcasses of broiler chickens.

Carcasses of broiler chickens have a very high yield of edible parts: in roosters it is 82.3%, and in chickens - 82.7%, including muscle yield - 61.8% and 61.9%, respectively.

Due to the high meat qualities of broiler carcasses, they can be obtained by deep processing into various portions, as well as a wide range of products with a high yield of boneless meat.

The biological value of poultry meat depends on the quality of protein components, their ability to digest, the balance of amino acid composition. Biological value is determined taking into account the indicators of absence of harmful effects, nutritional value, biological activity, organoleptic properties [7].

Safety is characterized by the absence of specific and non-specific toxicity of poultry meat to humans.

The effectiveness of enzyme preparations in poultry. Enzymes are protein compounds formed from long amino acid chains and complex molecular compounds. Enzymes are specific proteins that act as biological catalysts in metabolic processes in living organisms [15].

All chemical processes in nature occur with the participation of enzymes. Enzymes are specific proteins that act as biological catalysts in a living organism. Enzymes, in contrast to hormones, biostimulants do not act on the body of birds, but on the components of feed in the gastrointestinal tract, they do not accumulate in the body and poultry products. By breaking down or synthesizing substances, the enzymes themselves may not change. They are not part of the final reaction products, are not consumed in the process and after the end remain in the same amount. Artificially added enzymes to feed are eventually digested and do not accumulate in animals and poultry [46].

The most important reason for the use of enzymes in the feeding of farm animals is the fact that they improve the absorption of nutrients in the diet. Despite the fact that enzymes are produced by animals, the efficiency of the digestive process is very low. The addition of enzymes to feed increases the efficiency of the digestive system, reduces unnecessary feed costs per unit of output, and minimizes the impact on the environment by reducing nitrogen and phosphorus emissions from animal feces, which is a significant factor in improving the environmental situation.

Digestive enzymes, which are synthesized in the body of birds, are released into the gastrointestinal tract and participate in the breakdown of feed nutrients into their simple components: proteins - to amino acids, fats - to glycerin and fatty acids, starch - to glucose. These low molecular weight substances can be absorbed through the mucous membrane and are used by the body to maintain vital functions and synthesis of products. However, plant foods contain some components that are resistant to the digestive enzymes of mono gastric. This is primarily fiber and the so-called non-starch polysaccharides - beta - glucans, pentoses, mannans, galactans, pectins and others. By increasing the content of non-starch polysaccharides in feed, they play the role of anti-nutrients, as they increase the viscosity of chyme in the digestive tract, complicating the function of digestive enzymes and absorption of nutrients, create a physical barrier for enzymes to access carbohydrates, proteins and fats. morphological structure of the mucous membrane of the digestive tract. To break down and reduce the negative impact of non-starch polysaccharides on the body of birds, it is advisable to use enzyme preparations [11, 46].

Disruption of membranous crops (barley, oats) reduces fiber levels, but does not solve the problem of beta - glucans and pentosans. Therefore, compound feeds that contain a high level of such crops also need to be enriched with appropriate enzyme preparations.

Enzyme preparations - products of microbiological synthesis, which contain the main enzyme, a number of other enzymes and ballast impurities. The use of enzyme preparations in the diet promotes the breakdown of substances that prevent the utilization of feed, improves the absorption of starch, proteins, non-starch polysaccharides, phytate fiber complexes, which are not completely broken down by the body's own enzymes. If enzymes that hydrolyze fiber are added to the feed, they begin to work in the gut, opening access to valuable nutrients that would be undigested. In addition, cereals (wheat, rye, oats, barley and other crops) contain large amounts of soluble fiber, which is an antinutrient factor, forms a gel in the intestines of animals, with high viscosity, which inhibits the activity of the body's own enzymes, absorption processes are more difficult, the risk of developing pathogenic microbes increases. All these negative phenomena are eliminated by adding feed enzymes, they accelerate the chemical reactions of metabolic processes [41].

Preparations that contain enzymes such as amylase and proteases activate the enzymolysis of starch and proteins, promotes digestibility and absorption of carbohydrates and protein feed.

Enzyme preparations - are products of microbiological synthesis, which contain a complex of enzymes - xylanase, beta - glucanase, cellulase, protease, amylase and others. Multienzyme preparations, breaking down hard-to-reach feed components into smaller fragments, reduce their negative impact on the body of poultry and increase the energy and nutritional value of plant feed by 3 - 8%, increase the content of feed components such as barley, wheat, wheat bran , peas, lupines. In enzyme preparations, depending on their direction (for the cleavage of which component they are intended), the main enzyme (or several), such as xylanase or beta - glucanase, has a higher activity, and there are associated enzymes (eg protease, amylase and others) - lower. This expansion of the spectrum of activity of the enzyme preparation also contributes to better digestion of feed. Enzyme preparations can be universal, ie intended for introduction into compound feeds containing various plant feeds with non-starch polysaccharides: wheat, barley, oats, sunflower, soy or with a predominant focus on individual ingredients.

Enzyme preparations have also been developed to increase the absorption of minerals, primarily phosphorus. In grain feeds, phosphorus is contained mainly in the composition of phytin complexes and is absorbed by poultry only by 20-30% [54].

The choice of the type of drugs needs special attention. Enzymes are characterized by narrow specificity and selective action on a single substance or substrate. For example, pepsin acts on proteins of plant and animal origin, and is inert to fats, starch, polysaccharides, so the choice of enzymes depends on the composition of feed, the quality of its components. To increase the effectiveness of the application and achieve the expected result, it is very important to choose the dose of enzymes. This should take into account the age of the bird, the level of grain maturity, the level of metabolic energy. With an increased level of metabolic energy relative to the amino acid background, productivity decreases during the use of enzymes, and with a slight deficit of metabolic energy, the use of enzymes will reduce the cost of feed, improve feed conversion, increase productivity. Only when changing the wheat variety, the diet of broiler chickens will reduce the energy value by 80 - 100 kcal per kilogram, and the use of an effective enzyme preparation can eliminate this nutritional deficiency. Freshly harvested grain creates viscosity problems and leads to reduced bird productivity, poor health and preservation. To prevent this, it is advisable to increase the dosage of the enzyme preparation.

We mainly distinguish two groups of exogenous enzymes. Some enzymes inactivate, break down antinutrient substances contained in feed. Such substances that reduce digestion, for example, are in wheat husks - xelan and glucans, the solution of the fraction of which in water impairs the digestion and absorption of nutrients. The use of the enzymes xelanase and glucanase in Northern Europe and the United Kingdom has been ongoing for several decades. In Hungary, their use is mainly justified when the presence of coarse grain products increases in compound feeds instead of corn.

The percentage of wheat introduction is growing [1, 46].

Another large group of enzymes are drugs that contribute to the fact that along with somatic enzymes completely undigested or only poorly digestible nutrients were also available to animals as well as widely used in Hungary phytase enzyme, which promotes better absorption of minerals, calcium, phosphorus, trace elements, and those enzymes that break down various fractions of fiber (cellulase, hemicellulose), helping to improve the availability of other nutrients. Various exogenous proteases, lipase and amylase promote digestion of birds, increasing the amount of assimilated nutrients.

The new generation of enzyme additives is required to have its activity calculated per unit of enzyme protein, if necessary, high; that there was a high enough stability against heat treatments; to be active under pH-specific pH conditions and to be stable even at normal ambient temperatures. Nowadays, there are already such phytase drugs, which even at a granulation temperature of + 90 ° C show an activity of 70 - 90%. The use of enzymes in the form of capsules also provides protection against heat treatment [52].

According to the number of declared activities, enzymes are divided into mono-enzymes and multi-enzyme complexes, which contain several enzymes that act on non-starch polysaccharides. The market of feed additives presents multi-enzyme complexes with different sets of enzymes, each drug is individual in quantity, composition and activity of enzymes, with different spectrum of action, which allow to introduce into the diet of cheap components with higher levels of fiber. A good effect of the enzyme preparation should be considered its ability to cause sequential enzymatic hydrolysis, on the principle of "cascade", when each subsequent enzyme is included in the work after the previous one. For example, the presence of phytases and proteases in one preparation will provide a consistent effect on phytates and then on proteins that have been released from phytatid bonds with phosphorus. An enzyme preparation that acts in a temperature range that coincides with the body temperature of animals and the acidity of the gastrointestinal tract is considered ideal. Effective enzymes begin to work in the oral cavity, retain their activity in the acidic environment of the stomach and show maximum activity in the small intestine. The use of complex enzyme preparations allows to increase the use of sunflower meal in the diets of broilers, partially replacing it with more expensive soybean meal and cake, as well as bran, barley, oats with films and rye [18].

Enzyme preparations are available in powder and liquid form and are added to premixes or compound feeds at the same time as other additives. Shelf life - from 6 months to 1.5 years, depending on the form of the drug and the manufacturer's recommendations.

Enzyme preparations of various manufacturers, mainly foreign, are presented on the market of Ukraine. Approximate norms for the use of enzyme preparations are from 0.2 to 1 kilogram per ton, depending on the specific preparation and the content of difficult-to-digest components in the feed. They should be used according to the manufacturer's instructions.

According to research by N. Slobodyanyuk [41], it was found that the use of the enzyme preparation avizim in poultry feeding had a positive effect on their growth and development. This indicates that under the influence of enzymes in the body of the bird is increased digestibility and absorption of nutrients, which significantly affects the replenishment of energy and the intensification of synthetic processes in the body.

When feeding enzyme preparations of the appropriate spectrum of action in the gastrointestinal tract of birds there is an increase in the processes of fermentolysis and microbial fermentation of nutrients (starch, proteins, fats), increase their digestibility and therefore increase the background of energy nutrition.

Celosim is used as a feed additive to increase protein digestibility, starch digestibility, raffinose and stachyose. The drug is optimal for diets high in corn, wheat, soy and processed products.

It contains a number of enzymes, the main of which are:

- amylase - 1000 units / g;
- protease - 5000 units / g;
- endo-1,4-beta glucanase (cellulose) -1700 IU / g;
- endo-1,4-beta xylanase - 500 IU / g;
- α-galactosidase - 20 units / year.

The drug is a light brown powder with a slight specific odor. In the body due to the action of a complex of hydrolytic enzymes contained in the drug, reduces the viscosity of chyme, increases the digestibility of feed nutrients, reduces the negative effect of anti-nutrient factors on poultry productivity and feed conversion.

The enzyme preparation is non-toxic, has no contraindications, does not interact with other substances.

Many years of experience and research in the field of poultry farming have shown that effective animal husbandry today is impossible without the use of enzyme preparations in different types of diets. Properly selected enzyme preparation increases the availability of energy and nutrients in the diet, resulting in increased productivity of poultry [11].

The purpose and objectives of the research are to study the effectiveness of the enzyme preparation "Celozyme" and its impact on the productivity of broiler chickens, for which a scientific and economic experiment was conducted.

The task was to study the following indicators:

- the effect of feed additives on the productivity of poultry;
- the effect of the drug on the slaughter performance of poultry;
- to investigate the condition of the internal organs under the action of feed additives;
- calculate the economic efficiency of the use of enzyme preparation.

Research methodology. The aim of the study is to study the effectiveness of the use of a new feed additive in the feeding of broiler chickens.

Object of research: live weight, growth intensity, slaughter rates, internal organs, enzyme preparation "Celozyme".

For the production of this experiment, 100 heads of broiler chickens of the Cobb cross - 500 four - day - old were selected. From them on the principle of analogues 2 groups on 50 heads are formed. The duration of the experiment is 42 days.

The first group - control, the second - experimental. The bird was kept on the floor with free access to water and feed in accordance with zootechnical standards for this species, the material for the litter was sawdust.

The birds of the control group throughout the rearing period received the basic diet (compound feed TM "West Mix"), balanced according to the norms of feeding.

The experimental group as an additive in addition to the main diet was fed the enzyme preparation "Celozyme" at a dose of 0.015% by weight of feed. The scheme of the experiment is presented in table 1.

Table 1

The scheme of the experiment

Group	Duration of the period, days	Number of chickens	Features of feeding
1 - control	42	50	OR (complete feed)
2-experimental	42	50	OR + "Celozyme" at a dose of 0.015% by weight of feed

Note. OR - the main diet.

The composition of the main diet: corn, wheat, soybean meal, sunflower meal, vegetable oil, limestone, monocalcium phosphate, vitamin-mineral mixture, coccidiostatic.

The enzyme preparation "Celozyme" is used as a feed additive to increase the digestibility of protein, digestibility of starch, raffinose and stachyose. The drug is a light brown powder with a slight specific odor. The enzyme preparation is not toxic, there are no contraindications, does not interact with other substances.

Live weight of broiler chickens was determined by individual weighing each week and calculated absolute, average daily and relative gains. To do this, we used the appropriate formulas, according to which we obtained indicators of live weight of birds.

They recorded the consumption of feed daily, respectively, for the entire period of cultivation.

At the end of the experiment, a control slaughter was performed, selecting 4 heads from two groups.

The following indicators were determined:

- before the slaughter mass;
- weight and yield of uncoupled carcass;
- weight and yield of semi-gutted carcass;
- weight and yield of gutted carcass;
- the mass of internal organs of various body systems.

Student's t-test was used to determine the differences between the mean values. The difference was considered probable, compared with the control at * P <0,05; ** P <0.01; *** P <0.001 [39].

Research results. Growth and development of experimental birds. One of the main indicators that characterize the level of meat productivity during the life of the animal is body weight and growth energy. In this regard, the study of the intensity of growth and development of the organism, as well as their management remains relevant in poultry to this day. Growth reflects the quantitative side of the body's development, is usually expressed through live weight and average daily gains. Development, on the contrary, reflecting the qualitative characteristics of growth intensity, is reflected in the exterior and interior of the animal.

The growth of a living organism is a complex process that subtly responds to any changes in feeding and housing conditions. The mechanism of growth is so sensitive that even the slightest changes in external factors can lead to changes in the fluctuations of live weight of an animal or bird.

Live weight is the main indicator of growth and development of poultry, which reflects the conditions of feeding and keeping in which broiler chickens are raised [5].

Feeding the enzyme preparation "Celozyme" to broiler chickens of Cobb-500 cross during the whole growing period had a positive effect on the intensity of their growth. The dynamics of the live weight of broiler chickens cross KOBB-500 during the experiment is shown in table 2.

Table 2

Live weight of chickens of broilers of a cross of KOBB-500, (M ± m, n = 50)

Age of animals, days	Groups	
	And-control	II-experimental
1	45,5±0,68	45,37±0,59
7	173,7±10,25	180,6±6,64
14	436,3±21,31	484,3±14,73
21	924,4±32,68	1035,6±27,33*
28	1588,7±39,65	1783,1±29,50***
35	2236,2±69,70	2468,1±69,66*
42	2769,4±70,83	3141,2±57,96***

Note. Probability of difference: * P <0,05; *** P <0.001.

In the first 3 weeks of rearing chickens broilers of the 2nd experimental group are not reliable, but prevailed in terms of growth intensity of their peers in the control group.

From the third week, the advantage in terms of growth intensity of the 2nd experimental group was significant. Thus, broiler chickens at the age of 21 days by live weight prevailed by 111 g (* P <0,05), which is 11.2%, at the age of 28 days by live weight of the birds of the experimental group prevailed by 194.4 g (*** P <0,001), which is 12.2%.

A similar trend was observed at the age of 35 and 42 days, the live weight of the experimental bird exceeded its peers in the control group by 231.9 g (* P <0.05), respectively, which is 10.3% and 371.8 g (*** P <0,001), which is 13.4%.

Feed consumption and growth are the two main features for summarizing the results of the development.

To determine the payment for feed in increments during the entire growing time, the feeding was recorded: the amount of given feed and uneaten leftovers was taken into account by the method of control weighing.

Accounting for feed consumption and live weight gain of the experimental bird allowed to calculate the amount of feed conversion during the experiment (Table 3).

Table 3

Feed conversion by the experimental bird (M ± m, n = 50)

Indicator	Група		
	Units of measurement	1-control	2-experimental
Total in the group	kg	254	270
On one head	kg	5,09	5,40
Per 1 kg of gain	kg	1,84	1,75

During the period of raising broiler chickens up to 42 days of age in the second experimental group was spent on 1 kg of gain 1.75 kg, and in the control group 1.84, which is 0.09 kg or 4.9% less.

Thus, the introduction of enzyme additives "Celozyme" to broiler chickens to complete feed helped to increase the intensity of their growth and reduce feed consumption per 1 kg of growth for the entire growing period.

Slaughter and meat performance of experimental birds. The main indicator that characterizes the meat qualities of poultry is their fatness. Birds of different fatness differ in the ratio in the carcasses of muscle, fat, bone and connective tissue.

In well-fed poultry, compared to under-fattened birds, the proportion of adipose tissue in carcasses increases, the proportion of muscle tissue decreases slightly and the proportion of bones, cartilage and connective tissue decreases significantly. As the ratio of tissues changes, the chemical composition of meat for industrial processing changes. In addition, with excessive fat content of meat deteriorates its nutritional and culinary qualities, reduced digestibility.

Fattening of poultry, its meat qualities depend on age, weight, article, breed and direction of productivity. When assessing the meat qualities of young animals, the main indicator related to meat productivity and meat quality is their live weight. Intensively raised and fattened to high weight conditions, the young are characterized by high overall meat yield and increased meat content due to well-developed muscle tissue [7].

Young meat has an optimal ratio of protein and fat, contains high nutritional and dietary properties, is tender, juicy and high taste. Fat is white.

Slaughter birds must meet the requirements of veterinary legislation, the rules of veterinary inspection of slaughter animals.

The consumer value of meat is characterized by its taste and nutritional qualities, the yield of edible parts, the ratio of bones and flesh.

Slaughter yield - slaughter mass to live weight, expressed as a percentage. It depends on the species, breed, age, sex and fattening. It is determined by which parts of the body belong to the slaughter mass.

In poultry, the carcass weight depends on the features after carcass processing: in ungutted poultry, it is the highest, as it includes the mass of bloodless and plucked carcass with fat, head, legs and internal organs; in semi-gut - a mass of carcass with fat, but without intestines; with complete evisceration, not only blood, feathers, down and intestines are removed; but also all internal organs, also the head to the second cervical vertebra, legs to the metatarsus and wings to the elbow joint.

Gutted carcasses can be with lungs and kidneys, without other internal organs.

As a result of the conducted researches it was established that the tested enzyme additive provided improvement of slaughter indicators of experimental broiler chickens (table 4).

The addition of the enzyme preparation allowed broiler chickens of the experimental group to have significantly (** P <0,01) higher weight of semi-gutted carcass by 347.3 g or 15.8% and the weight of gutted carcass by 282 g or 14.3% and slaughter yield by 0.6%.

Table 4

The results of slaughter of experimental birds, g, (M ± m, n = 4)

Indicator	Groups	
	And-control	III-experimental
Pre-slaughter live weight	2788,7±52,2	3161,5±45,0**
Weight of half-gutted carcass	2184,7±36,1	2532,0±46,8**
Entrance %	78,3	80,1
The weight of the gutted carcass	1963,5±27,8	2245,5±54,3**
Slaughter yield,%	70,4	71,0

Note. Probability of difference: * P <0,05; ** P <0.01

Thus, to improve the slaughter properties of broiler chickens cross Cobb-500, it is advisable to use in feeding the enzyme preparation at a dose of 0.015% by weight of feed.

The condition of the internal organs under the action of feed additives.

In comparison with other species of farm animals, the bird has a high intensity of metabolic processes, high ability to absorb and energy efficiency of feed, which contributes to precocity and high productivity.

In broiler chickens of the second experimental group, there was no significant difference in the mass of internal organs (heart, lungs, kidneys, liver, muscular and glandular stomach) relative to the control group (table 5).

Table 5

The mass of internal organs at the end of the experiment, (M ± m, n = 4)

Body	Group	
	And-control	II-experimental
Heart	12,9±0,97	16,7±0,36
Lungs	19,12±0,22	16,7±0,36
Kidneys	12,52±0,39	10,97±0,68
Spleen	2,60±0,05	2,63±0,09
Pancreas	6,73±0,17	6,14±0,39
Liver	68,0±4,35	65,23±1,22
Muscular stomach (without content)	42,70±2,12	50,33±3,49
Glandular stomach	8,07±0,43	9,73±0,34

Along with this there is a tendency to increase the weight of the heart by 3.8 g, which is 2.9%, the spleen by 0.3 g, which is 0.1%, the muscular stomach by 7.63 g, which is 15, 1%, glandular stomach at 1.66 g, which is 20.5%. Not a significant downward trend was observed in chickens of the second experimental group in terms of lung weight control by 2.42 g, kidney weight by 1.08 g, pancreas by 0.59 g and liver by 2.77 g.

In general, the feeding of the enzyme preparation "Celozyme" does not have a negative effect on the formation of internal organs. The mass of organs is within physiological norms, which is confirmed by the high level of growth intensity of birds.

The digestive system of poultry in its structure and functions is adapted to the reception and digestion of feed of plant origin. The system of birds' digestive organs consists of the following departments: main (pharynx); anterior (esophagus with goiter, stomach (glandular and muscular); middle (duodenum with liver and pancreas, duodenum and ileum); posterior (two cecum, rectum and cloaca).

The main features of the digestive tract of birds: shortened intestines; weak morphological and functional differentiation of the intestine into departments.

The intestines in birds are relatively short, but the secretion of bile and pancreatic juice is intense. Bile in birds per unit live weight is released 7 times more than in other species. The breakdown of feed and absorption of nutrients is intense.

The large intestine in birds is represented by only 2 rectums. Absorption of nutrients is carried out almost along the entire length of the intestine due to the presence of villi. The two appendages function as organs of absorption. In the large intestine there is a bacterial fermentation and synthesis of B vitamins, but in very small quantities, due to which they more often than other species of animals registered beriberi group B. Feed through the digestive tract of birds passes for 24 - 36 hours. Fecal masses in birds are excreted with urine through the cloaca [15].

It is known that the study of the morphology of the digestive tract of poultry largely determines the prospects for improving the productivity of poultry. The mass and linear measurements of the large and small intestines of the experimental birds are shown in tables 6 and 7.

In the study of the mass and length of the small intestine, a significant difference between the experimental and control groups is not observed. In the birds of the second experimental group, the weight of the duodenum increased by 2.1 g. The weight of the jejunum and ileum decreased by 2.4 g and 0.6 g, respectively.

The use of the enzyme preparation contributed to an increase in the total length of the small intestine by 12.7 cm, including 12-fold by 4.5 cm, empty by 6.2 cm, ileal by 2.05 cm.

Table 6

Mass and linear measurements of the small intestine of poultry, (M ± m, n = 4)

Indicator	Groups	
	And-control	II-experimental
Small intestine (gut mass, d)		
12-fold	13,6±1,55	15,7±0,47
empty	41,3±2,82	38,9±1,52
ileal	6,3±0,74	5,7±0,32
gut length, cm		
12-fold	30,5±1,53	35,0±1,82
empty	77,5±4,68	83,7±2,88
ileal	25,3±1,59	27,35±0,59

Under the conditions of the experiment there is an increase in the mass of the large intestine by 11.1 g, including the right blind by 5.6 g, the left blind by 4.9 g (** P <0.01) and the direct by 0.6 g

Studying the length of the large intestine, we found an increase in the length of the right blind by 1.4 cm, left blind by 3.2 cm and straight by 2.9 cm (* P <0.05).

Table 7

Mass and linear measurements of the large intestine of poultry, (M ± m, n = 4)

Indicator	Groups	
	And-control	II-experimental
Large intestine (gut mass, d)		
right blind	6,2±0,18	11,8±0,30
left blind	7,3±0,77	12,2±0,32**
rectum	6,6±0,37	7,2±0,75
gut length, cm		
right blind	21,1±0,94	22,5±0,74
left blind	17,5±0,74	20,7±0,73
rectum	8,1±0,37	11,0±0,62*

Note. Probability of difference: * P <0,05; ** P <0.01.

Therefore, when using the enzyme preparation at a dose of 0.015% by weight of complete feed, a positive effect on the formation of the digestive system of broiler chickens.

Economic evaluation of research results. In the production of broiler meat, the issue of adjusting the recommended programs for raising young animals in order to increase the intensity of their growth is relevant. In addition, it is very important to improve the meat quality of poultry, as well as to achieve maximum economic effect.

The cost-effectiveness of the use of the enzyme preparation in the feeding of broiler chickens is shown in table 8.

As can be seen from the above data, the introduction of the enzyme preparation in the complete feed fed increased the gross gain and weight of gutted carcasses by 21.1 kg and 15.8 kg, respectively, compared to the control indicators.

Table 8

Economic evaluation of the addition of poultry feed additives (M ± m, n = 50)

Indicator	Group	
	1-control	2- experimental
Number of goals in the group	50	50
Saving,%	96	98
Gross live weight gain, kg	132,9	154
Weight of gutted carcasses, kg	94,2	110,0
The cost of 1 kg of feed, UAH	12	12
Additional costs for the drug, UAH	-	21
The cost of chickens (age 1 day), UAH	22	22
Feed costs for the whole period, kg	254	270
The selling price of 1 kg of gutted carcass, UAH	56	56
Total cost, UAH	4148	4565
Sales revenue, UAH	5275	6160
Profit from sales, UAH	1127	1595
Profitability,%	27,2	34,9

The enzyme preparation used in the feeding of broiler chickens causes an increase in sales revenue by UAH 885. compared with the control group.

The profit from sales for feeding the enzyme preparation was at the level of UAH 1,595, while in the control group it was UAH 1,127, which is UAH 468. Less.

The level of profitability of broiler farming using an enzyme additive was higher by 7.7% compared to broilers that received only complete feed.

Thus, the results of studies on the effect of enzyme preparations on growth rate, slaughter rates and economic efficiency of broiler meat production confirm the positive effect of their use.

Conclusions and prospects for further research.

1. On the basis of the conducted researches, the scientific approach concerning use of enzyme preparation in feeding of chickens of a cross of Cobb-500 is experimentally and theoretically proved, its influence on growth intensity, slaughter indicators and a condition of internals is studied.

2. An increase in live weight of poultry for 42 days of rearing by 371.8 g (*** P <0.001), which is 13.4%, and a decrease in feed consumption per 1 kg increase by 0.09 kg or 4.9% .

3. The experimental group receiving the enzyme preparation in addition to the main diet had a higher weight of semi-gutted carcass by 347.3 g or 15.8% and the weight of gutted carcass by 282 g or 14.3% and slaughter yield by 0, 6%.

4. When using the enzyme preparation at a dose of 0.015% by weight of complete feed no significant changes were detected, all physiological parameters of the digestive system of broiler chickens were within the physiological norm.

5. The use of the enzyme preparation in the feed for broiler chickens is economically justified: an increase in revenue by 16.7%, profit from sales by 41.5% and the level of profitability by 7.7%

When raising broiler chickens on complete feed in order to increase their meat productivity, we propose to introduce an additional 0.015% by weight of feed enzyme preparation "Celozyme".

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ART STUDIES

«МЕТОДЫ ПРОЕКТИРОВАНИЯ В ГРАФИЧЕСКОМ ДИЗАЙНЕ НА ОСНОВЕ ЭКСПЕРИМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ»

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«DESIGN METHODS IN GRAPHIC DESIGN BASED ON EXPERIMENTAL RESEARCH»

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Аннотация

В статье затрагиваются все методы и методики проектирования графического дизайна. Рассматриваются способы решения востребованности инноваций в графическом дизайн-проектировании применительно к сегодняшним тенденциям в сфере визуальных коммуникаций.

Abstract

The article covers all methods and techniques of graphic design design. The article considers ways to solve the demand for innovations in graphic design in relation to current trends in the field of visual communications.

Ключевые слова: методика, методы дизайн-проектирования, графический дизайн, предпроектный анализ.

Keywords: methodology, methods of design, graphic design, pre-project analysis.

Графический дизайн – это проектно-художественная деятельность, с помощью которой создается или изменяется визуально-коммуникативная среда, в соответствии с конкретными задачами и потребностями. На сегодняшний день графическим дизайном пользуются большое количество спектр услуг как издательская деятельность, печать, так и кино, реклама, электронная и компьютерная техника и другие области массовой информации. [2]

Главной сутью графического дизайна является способность к изучению новых навыков и знаний, которые в дальнейшем преобразуются в метод проектирования, и будут являться основой для разработки дизайн-проекта. А так же, это способность видеть объект проектирования, и то, что вокруг него, правильно синтезировать и обобщать полученную информацию, выделать то, что действительно нужно для реализации идеи. Параллельно оценивать проблему или задачу, поставленную перед графическим дизайнером.

Методы проектирования в графическом дизайне. Общие понятия

Метод – это совокупность различных способов или практических действий или теоретическое освоение реальности, которые следуют решению определенной задачи.

Методика в дизайне – является правильным подходом к реализации поставленной цели, умению быстро абстрагироваться и оценить ситуацию, для решения поставленных задач, необходимых для получения нужного результата. Особенностью метода и методологии в дизайне считается направленность проектных действий одновременно и на прагматические, и на художественно-эстетические результаты, при этом сама иерархия надлежащих

установок и путей их реализации может измениться в процессе работы.

Предпроектный анализ

Проектирование – это сложный процесс разработки дизайн-проекта, который включает в себя все этапы исследования на теоретической основе графического дизайна.

Дизайн-проектирование делится на две ступени: *предпроектную и проектную.*

1 Предпроектная

Предпроектная ступень дизайн-проектирования, является главной, так как связана со сбором источников информации, сравнением достоинств и недостатков аналоговых решений, сделанные ранее, определением всех потребностей целевой аудитории и возможных способах решения поставленной задачи.

- анализ предпроектной ситуации, позволяет точно определить объект проектирования. На данном этапе, происходит сбор всей доступной информации об объекте проектирования. В дальнейшем следует выявление функциональных свойств будущего дизайн-проекта.

- выявление проблемы, которую нужно решить и реализовать все пути ее решения.

- определение целевой аудитории. Для того, чтобы реализация коммуникативных функций прошла успешно, нужен анализ визуальной культуры людей, которым будет направлен дизайн-продукт. Также следует определить потребности фокус-группы, возрастную категорию, вид деятельности, и на кого будет направлен данный дизайн-проект.

- поиск методов. Происходит поиск реализации методов, которые помогут использовать новые идеи, нейтрально относящиеся ко всем, либо использовать те методы, которые крепко зарекомендовали себя, но при этом модернизируя и совершенствуя их.

- разработка дизайн-концепции – это своего рода, создание и реализация главной идеи будущего замысла, т. е. дизайн-концепция проекта.

Также можно заметить, что развитие дизайн-концепции объединяют с «пограничной ситуацией», которая говорит нам о том, что предпроектный анализ завершается, и следует проектный анализ. [3]

Другими словами, дизайн-концепция – это реализация идеи будущего проекта, а также определение смыслового содержания идейно-тематической основы замысла, который создается графическими дизайнерами. Воплощение дизайн-концепции.

Как правило, задачи которые ставить перед собой графический дизайнер, ранее не зная других прототипов, предполагает множество разных вариантов их реализации – а именно, функциональных технологий. По этой причине дизайн-концепция, рассматривая сравнительные достоинства предложенных вариантов, формулирует будущие решения принципов работы.

Также главную роль дизайн-концепция играет и в объектах, которые имеют крупногабаритные размеры. В качестве примера можно привести, новый графический арт-объект, который появился в сквере Центрального района Воронежа. Яркое графическое изображение, было реализовано по мотивам мультика «Котенок с улицы Лизюкова-2» от студии «Wizart Animation». Это крупное граффити, которое появилось на сером бетонном заборе – Никитинском сквере.

Рис.1– Графический арт-объект в сквере Центрального района Воронежа

Мультяшный яркий арт-объект лаконично вписался в детскую площадку, поддерживая общую тематику сквера. С связи с этим, можно сделать вывод, метод дизайн-проектирования графического дизайнера полностью удался, а концепция, которая была запланирована осуществилась. Необходимо все это для того, чтобы:

- квалифицировать характеристики и свойства самого объекта;

- выявить все возможные графические и архитектурно-дизайнерские средства формирования того или иного архетипа среды;

- выявить больше путей набора этих средств;

- поставить дизайн-концепцию на дальнейшее формирование полноценных потребительских характеристик среды обновленного сквера.

Главный посыл концепции – создать благоприятные ощущения, облагородить данное место.

Подводя итог, можно сделать следующий вывод, положение дизайн-концепции осуществляется через структурную организацию объекта в течении его «идеального» формообразования. Также новизна и перспективность авторских предложений, зависит от дизайн-концепции.

2 Проектная

Проектный анализ – это направление, которое осуществляет реализацию дизайн-продукта. Проектная ступень дизайн-проектирования описывается следующими, этапами:

- сформирование функциональной схемы объекта проектирования, которая опирается на анализ требований, представляемый к нему с позиций системы «человек – объект», «объект – среда». Данный этап является не только главным, так как на этом этапе формируется функциональная схема создающегося объекта. Также от ее реализации будут зависеть способы проектной деятельности и функциональные свойства смогут быть примерами для критериев в оценке результатов проектирования;

- подбор и анализ аналогов согласно уже поставленной функциональной схеме. Здесь начинает происходить сбор информации из различных источников, касающиеся выбранных аналогов, а также просматриваются всевозможные материалы, сборники и т.п.);

- разработка композиционных решений, является своего рода визуальным поиском воплощения дизайн-концепции. На данный момент реализуется практическое решение проблемы соотношения формы и содержания через выполнения различных зарисовок, ручных эскизов, создание макетов;

- выбор рационального варианта проектного решения через анализ композиционного решения целостности и лаконичности формы, и характера всех ее элементов;

- презентация проекта, аргументирование задуманной идеи и проектного решения;

- заключение по дизайн-проекту, в том числе определение объективной оценки.

Делая следующие выводы, можно сказать, что процесс создания дизайн-проекта, реализуется не только в индивидуальном плане, а и осуществляется в работе или даже группе с другими компетентными мнениями в области графического дизайна. Также возможны следующие методики формировании проектного процесса:

- мозговые штурмы;
- работа в команде;
- опрос участников;
- семинары.

Подводя итог, выше сказанного, можно сделать вывод что главной задачей всевозможных методик дизайн-проектирования является в генерирование различных идей, что помогает отыскать наиболее удобное проектное решение. Следует отметить, что практическая деятельность по созданию графического дизайна, создает все условия для создания качественного проектного процесса из-за умения правильно и грамотно воспользоваться всеми знаниями, навыками для проведения функционального анализа объекта.

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СПЕЦИФИКА ПРИМЕНЕНИЯ РУЧНОЙ ГРАФИКИ ПРИ РАЗРАБОТКЕ ДИЗАЙНА ПЛАКАТОВ

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SPECIFIC APPLICATION OF HAND GRAPHICS IN POSTER DESIGN DEVELOPMENT

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Аннотация

В данной статье рассмотрена роль ручной графики в одной из наиболее интересных областей графического дизайна — плакате. На примере дизайн-проектирования серии авторских плакатов рассматривается специфика применения ручной графики. Выделены преимущества и недостатки использования ручной графики при создании современного плаката.

Abstract

This article explores the role of hand-drawn graphics in one of the most interesting areas of graphic design, the poster. On the example of the design of a series of author's posters, the specificity of the use of hand graphics is considered. The advantages and disadvantages of using manual graphics when creating a modern poster are highlighted.

Ключевые слова: ручная графика, плакат, дизайн, графический дизайн.

Keywords: hand graphics, poster, design, graphic design.

Плакат, как одна из самых рефлексивных областей графического дизайна, продолжает совершенствоваться благодаря внедрению новых технологий печати, применению и синтезированию разных художественно-графических средств. Разновидности плаката рассмотрены в научных трудах Ю. Ерохиной, Т. Игошиной, Н. Бабуриной, Е. Глинтерник.

Во время переизбытка информации борьба за внимание зрителя усиливается; эмоциональная реакция потребителя на спроектированный объект побуждает дизайнера прибегать к новым графическим приемам в дизайн-проектировании, а также к созданию ярких и выразительных образов. Плакат как источник информации должен быть лаконичным и понятным. Передача нужных идей в современном плакате осуществляется с помощью фотоизображений, фотоколлажа, компьютерной графики, шрифтовых композиций, ручной графики.

Стоит отметить, что ручная графика может лечь в основу разработки дизайна не только плаката, но и упаковки, этикетки, полиграфической продукции, обложек книг и журналов, сувенирной продукции и т.д. Актуальность рассмотренной темы определяется важностью применения ручной графики как ключевого компонента обогащения современного плаката в условиях всеобщей компьютеризации. В нынешних условиях уже невозможно игнорировать мировые тенденции в области технологий. Человечество уже не обходится без компьютерной техники как в обыденной жизни, так и на рабочих местах [4]. Распространенным является мнение, что компьютерная графика всё больше замещает ручную. Однако важно помнить, что работа над плакатом без предварительного проектного эскиза, поиска идеи сначала от руки, увлечение компьютерной графикой в искусстве плаката может приводить к шаблонным решениям.

Возникает вопрос, каким образом лучше применять ручную графику? Компьютер позволяет точно и качественно обработать и адаптировать этот вид графики в пространство плаката. Сочетание иллюстраций, выполненных вручную разными материалами - от туши, к примеру, до акварели, с типографикой, обработка и соединение их в графических редакторах (Photoshop, Illustrator, Corel) позволяет добиться в современном плакате большей оригинальности, самобытности. Создавая ручную графику, важно не только выбрать графический материал, но и учесть характер его наложения, фактуру бумаги [2].

При умелом использовании ручной графики в плакате достигается ощущение присутствия автора в работе, усиливается нетривиальность образа и степень воздействия на зрителя. Ручная графика в современном плакате зависит от мастерства и умения дизайнера-автора, а также от стоящих перед ним целей и задач, техники, в которой она будет воплощена.

В плакатах современных графических дизайнеров наблюдается смешение ручной и компьютерной графики, с упором на первое. Линда Линко — финский дизайнер и иллюстратор, Джулия Гарбин — итальянский графический дизайнер и иллюстратор, а также дизайнеры Мариос Калацис, Ватару Йошида — в проектах всех этих людей прослеживается тенденция использования ручной графики, в том числе, в плакатах. У каждого из них свой стиль, их дизайн отличается друг от друга, но объединяет их исключительная яркость и нетривиальность подхода, достигнутые путем применения ручной графики. Их плакаты несут в себе исчерпывающее сообщение, способны удивлять образностью элементов и целесообразностью графических приемов.

Примером использования такого вида художественно-графического средства может служить авторская разработка серии плакатов, посвященных арт-выставке «Провинция». Серия должна была состоять из 3-х плакатов. На рисунке 1 представлена ручная графика, выполненная черной тушью, сухой кистью и маркером.

Рисунок 1. Пример ручной графики для будущей серии плакатов

Размер плакатов - формата от А3 до А1, поэтому следующий шаг — сканирование иллюстраций и перевод ручной графики в вектор (рисунок 2). Это позволило сохранить хорошее качество при масштабировании рисунка либо его уменьшении. Для этого понадобился графический редактор CorelDraw.

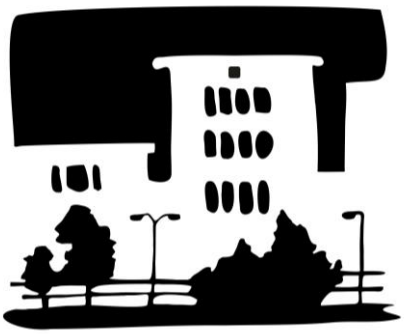

Рисунок 2. Переведенное в вектор изображение

Использование в векторной графике черно-белой палитры часто является мощным средством коммуникации, несмотря на кажущуюся простоту [1]. Необходимо было внести в серию минимальное количество символов, создать «настроение». Метафора – важный элемент в смысловой концепции плаката [3]. Поэтому было решено внести уже после обработки в графическом редакторе ручной графики дополнительный элемент, который будет акцентом и сделает образ законченным (рисунок 3). Красный круг олицетворяет солнце, которое придает изображению ощущение тревоги. В то же время это единственное яркое пятно на фоне серого провинциального пейзажа.

Композиционный центр — стилизованное изображение провинциального города. Внимание зрителя обращено к центру.

Рисунок 3. Переведенное в вектор изображение

Найденный лаконичный плакатный образ может использоваться не только в афишах стандартного размера, но и на традиционных носителях: текстиль, сумки, рекламные баннеры, открытки и т.д.

К положительным сторонам применения ручной графики можно отнести и вероятность пропорционального сочетания возможности творческой реализации с деловым интересом. Многоэтапность перевода ручной графики в вектор является особенностью применения такого художественно-графического средства, ведь чем больше деталей содержит рисунок для будущего плаката, тем скрупулезней нужно «отрисовать» изображение. Однако результат будет стоить потраченных усилий.

Подбор шрифта в сочетании с графикой осложняется стилем, в котором она выполнена. Анализ неповторимых особенностей стиля иллюстрации и подбор шрифта похожего начертания решает эту проблему. К примеру, когда картинка состоит только из прямых горизонтальных или вертикальных линий, то и шрифт ей подбирается такой же «прямолинейный». Продолжая эту мысль, стоит отметить, что в таких работах может присутствовать почерк автора, хотя не всегда заказчику нужно, чтобы это читалось в работе. Следует помнить, что ручная графика в рамках дизайн-проектирования плаката будет определяться его функцией (агитационная, информационная, рекламная и т.д.), материалом, способом его изготовления.

Следовательно, смелый подход к созданию и использование ручной графики делает богаче технику дизайн-проектирования плаката, придает по-

следнему большую эмоциональность, выразительность. И по-прежнему применение такой графики с последующей корректировкой в графических редакторах остается актуальным в работе современных дизайнеров.

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НОВАЦІЇ ПРОСТОРУ ТА СВІТЛА В ЖИВОПИСІ ПРОТОРЕНЕСАНСУ ТА РАННЬОГО ВІДРОДЖЕННЯ

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INNOVATIONS IN SPACE AND LIGHT OF PROTO RENAISSANCE AND EARLY RENAISSANCE PAINTING

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Анотація

Стаття розглядає трьохвимірний простір як грунтовну інновацію в часи Проторенесансу та Раннього Відродження, новизну в контексті живопису на зміні культурно-історичних епох та впровадження абсолютно нового підходу до ілюстрації, що відіграло ключову роль у встановленні основних технік сучасного живопису. Прийоми флорентійських та сієнських митців мають місце у структуризації творчості сучасників, виступаючи базою та прикладом для зображення цілісності просторово-часового твору.

Abstract

The article considers three-dimensional space as an innovation during the proto-Renaissance and Early Renaissance, a novelty in the context of painting at the change of cultural and historical epochs, and the introduction of a completely new approach to illustration, which played a key role in establishing the main techniques of modern painting. Techniques of Florentine and Sienese artists have a place in the structuring of contemporary art, acting as a base and example for the image of the integrity of the space-time work.

Ключові слова: перспектива, тривимірне зображення, простір, Проторенесанс, Раннє Відродження.

Keywords: perspective, three-dimensional image, space, proto-Renaissance, Early Renaissance.

In the Italian culture of the XIII-XIV centuries, against the background of still stable Byzantine and Gothic traditions, features of the new art of the future began to appear. The discovery of perspective marked a new stage in painting and became a key feature of the proto-Renaissance and early Renaissance. Modern painting is impossible to imagine without the influence of the greatest artists of the Renaissance. This work is a recognized classic, and it will always exist in the subconscious of artists of our days. It was during the Renaissance that most of the unique works of art appeared, of which painting is a part, and especially painting by masters of the Italian school.

Given the relevance of the techniques of the school of Florence and Siena and their exemplary aspect of the work of modern artists, it is advisable to

study the specifics of building a three-dimensional space, the space of the picture, and the space of the viewer. Development and modification of space on the example of paintings by artists in the aspect of the development of the proto-Renaissance and Early Renaissance. The focus is on the ideas and methods of artists ' work, their immersion in the depths of the real world in search of the laws of harmony and beauty, the description of many artistic forms expressed not only in secular painting but also in religious stories.

Among scientific studies, the theme of space and perspective in Proto-Renaissance and Early Renaissance painting is relatively popular. As a rule, the painting of the present era is considered from a departure from religiosity, a course to strengthen realism in creativity, and so on. Larkova M. L., an art critic, and publicist, considered the problem of space development in visual art in the figurative and compositional aspect in Antiquity (Ancient Greece and Rome) - the middle Ages (Byzantium) - Italy (from the Romanesque era to the High Renaissance). The author reveals the specifics of the artistic space of these periods, as well as identifies common features that emphasize their connection and some continuity. The change in the artistic space, which response to the process of changing the worldview of society, and the emergence of new cultural trends, expressed in the emergence of new compositional techniques, means of expression, techniques, etc., Played a major role in the development of fine art. Artist and art theorist Genen L.F. in "the Language of a painting", he described the spatial and temporal integrity of a painting, its materiality, and chiaroscuro, starting with primitive painting. Tumanov I.N. in his work "Morphological foundations of form formation in art and their significance for the manifestation of the phenomenon of the interaction of synthesis and symbiosis of arts" writes about the genetic basis of interaction and synthesis of two-dimensional and three-dimensional arts. Also, developments on the subject of a painting of the studied era are present in the works of Borisovskaya N.A. "encyclopedia of painting" and Kuzmina N.T. "History of foreign art", where the Florentine school of painting is considered.

The discovery of perspective marked a new stage in painting and became a leading feature of the proto-Renaissance and early Renaissance. If in the Middle ages the artistic method was built on the reverse perspective, when the scale of each image depended on the degree of its significance for understanding the inner meaning of the whole (that is, eternal truths), the art of the Renaissance sought to provide a vision that covers the space as a whole. This led to the discovery of perspective (first linear, and then aerial) when there is a single point of view from which the entire composition is perceived.

Changing the method of representation. The middle ages required an understanding of the language of symbols (which had a centuries-old tradition through which art was understandable for the chosen), while in the Renaissance it was addressed to anyone who saw and understood the beauty of the world and man. The language of art became understandable to the masses. There is an atmosphere of aestheticism and the Renaissance is called the" Golden age " of European art. Italian painter and architect Giotto di Bondone was the first representative of the proto-Renaissance era, which originated in the late middle ages in Florence. The master's works laid the foundations of Western art and demonstrated a new technique for depicting perspective and space, which was taken up and developed by the famous representatives of the Renaissance Leonardo da Vinci, Michelangelo, and Raphael. The artist enriches the painting with the art of chiaroscuro, which makes the figures appear as three-dimensional, relief. It introduces elements of landscape and linear perspective. In different genres, one can feel the realistic beginning, and Giotto is called the founder of the realistic direction in the art of the Renaissance. In this regard, it is interesting to compare the Byzantine icon "the Resurrection of Lazarus" (Fig. 1) and the fresco of the same content, painted by Giotto in the Scrovegni Chapel (Capella del arena) in Padua in 1303-1305 (Fig. 2). The iconography of these works is almost identical. The authority of Byzantium at that time was still very great, and many Byzantine icons served as models for European artists when painting religious paintings. Both in the icon and Giotto's fresco on the left, we see Lazarus 'sisters Martha and Mary kneeling at the feet of Jesus, a man who is removing the stone roof of the tomb where Lazarus' body is located, and people standing nearby, some of whom are holding their noses with a handkerchief, because the body is four days old. The icon is evenly lit with traditional icon slides that represent space and the body of Lazarus in a dark frame that symbolizes hell. Giotto's fresco depicts the hill where Lazarus ' body was buried and rebelled, and the landscape: against the dark blue sky, trees with green crowns are visible on the hill. This is an obvious attempt to convey the spatial depth and distance of trees. What Giotto created can no longer be called an icon. This is a picture. And in this picture, the landscape is plausibly depicted. In the way the landscape is depicted in this painting, what will develop in European fine art, and, centuries later, will be called realism, is born.

Fig.1,2.
the Byzantine icon "The resurrection of Lazarus" and "The resurrection of Lazarus" by Giotto di Bondone.

Instead of depicting the saints as solemn, statuesque, heavy, motionless figures, usually painted in full face, Giotto began to show them without idealization, as people moving in real earth space and living in earth time. A fine example of this is the fresco "Saint Francis preaches to the birds" (Fig.3). We can see Saint Francis from the outside. He is bent over, and his faces and eyes are turned towards the birds that are on the ground before him. This is a living person, outside of which, whose attention is not directed to the viewer, but the object of his care-the birds. It is noteworthy that Giotto was able to show how the birds listen carefully to Francis. Outside of Saint Francis is natural, his hands are in motion - he gestures, and his movements are directed towards the birds. This depiction of the Saint was a very bold and innovative act.

Fig. 3 "Saint Francis preaches to the birds" by Giotto di Bondone.

No less impressive is the fresco "Return of Joachim to the shepherds" (Padua, Capella del arena, 1303-1305) (Fig. 4). the Rock and sheep behind the shepherds are placed and painted so that we feel the depth of three-dimensional space. This, of course, optic illusion — painting (fresco) is two-dimensional and apparent to us three-dimensional space it is the result of a visual effect that gives the image of objects, their sizes, and their relative location on the plane. The impression of the volume of bodies and objects is achieved by applying the technique of light-and-shadow modeling, which at that time was just beginning to be mastered. It was thanks to Giotto that freedom in depicting the poses of people and animals in their natural movement was born in European art. In frescoes on the wall plane, in two-dimensional space, Giotto was able to convincingly show the three-dimensional space of the world in which earthly life takes place. Thus, the space of the picture became deep, three-dimensional (Fig. 5).

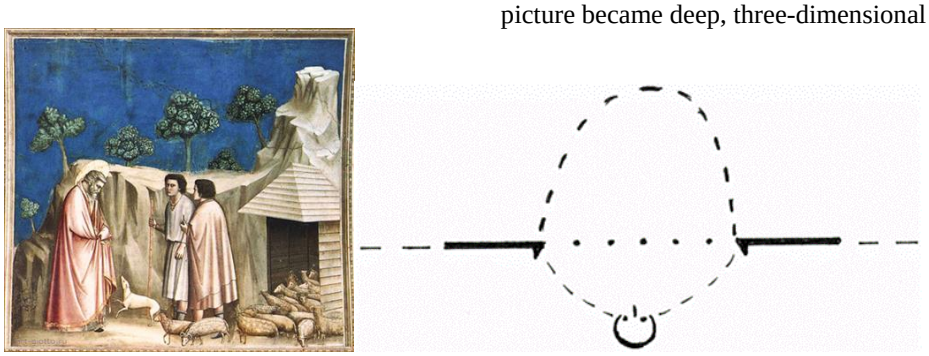

Fig. 4, 5. "Return of Joachim to the shepherds" by Giotto di Bondone; the space of the picture and the space of the viewer. Giotto recreated a deep three-dimensional space on the plane.

The meeting of views is perceived by us as a meeting of two spaces — the space of the viewer and the space of the picture. The viewer's eye and the looks of characters sent in opposite directions, so the space of the viewer and picture space are perceived as two different, separate spaces. And in this aspect, Giotto found a completely new, unusual, and bold technique in the visual arts. Let's look at the mural "Mourning for Jesus Christ" (Padua, Capella del arena) (Fig. 6). We see the Madonna bending over the face of the dead son, and many others mourning at the Body of Christ. It is striking that the two in this mural are depicted with their backs to the viewer. When depicting scenes with people in Europe, it has become common to use such a composition structure, in which the faces and views of the people depicted in the picture space are turned towards the viewer (or parallel to the viewer's space). This is shown schematically in the figure (Fig. 7). This makes a very special impression on the viewer. They are depicted with their backs to us, looking in the same direction as we are looking. Thus, in the space of the mural and in the space of the viewer, all views are coordinated and combined in a circular view. Psychologically, it is because of this that we feel that we are not only spectators but also participants in what is happening. A simplified conventional scheme of this mural is shown in the figure. the Direction of the viewer's gaze and the people depicted with their backs to us is the same. The space of the picture space and the viewer becomes in our perception share a single space to building in the fine art of common space, unifying the picture space and the space of the viewer, will seek many artists of subsequent ages. Art theorists will search for and justify appropriate artistic techniques.

The technique of constructing the composition of the fresco "Lamentation for Jesus Christ", found by Giotto, which allowed the viewer to feel that they are in the same space as the characters of the painting, adds another facet to the rich finds and discoveries of the work of this innovative painter.

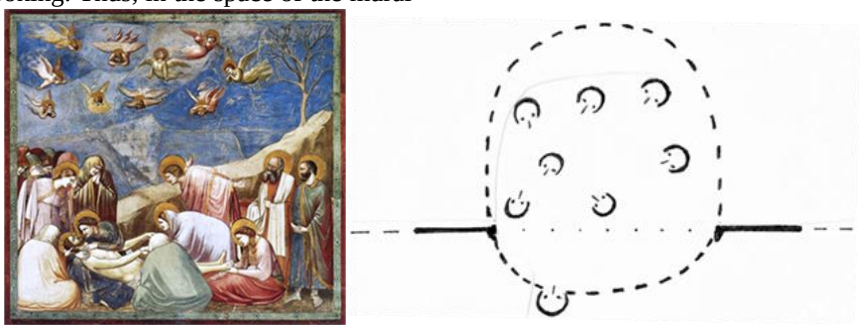

Fig. 6, 7. "Mourning for Jesus Christ" by Giotto di Bondone; Simplified scheme of the fresco "Mourning for Jesus Christ" the space of the viewer and space of the picture-a single space.

The fresco "Annunciation to Saint Anna" (Fig. 8) is of particular significance in this sense. the fresco shows the interior of Anna's house, depicted geometrically correctly in axonometry. Giotto did not allow himself to refuse the image of the building - the house in which the Annunciation takes place is also painted.

But to show both the house and the interior, Giotto had to "cut off" the front (closest to the viewer) wall of the house and open the interior. Particularly noteworthy is the fact that the size of the depicted objects (benches, chests, and others) we can judge the size of the room. The squares into which the ceiling is divided enhance the impression of the depth of the three-dimensional space of the room.

This painting by Giotto gave rise to the most important method in the history of art and science-the arithmetic of space. Since then, it has been used to divide the three-dimensional space depicted on the plane at the level of "single" shares, the possibility of which was indicated by the division of the ceiling of Anna's room into squares. Later this method received fruitful development in art.

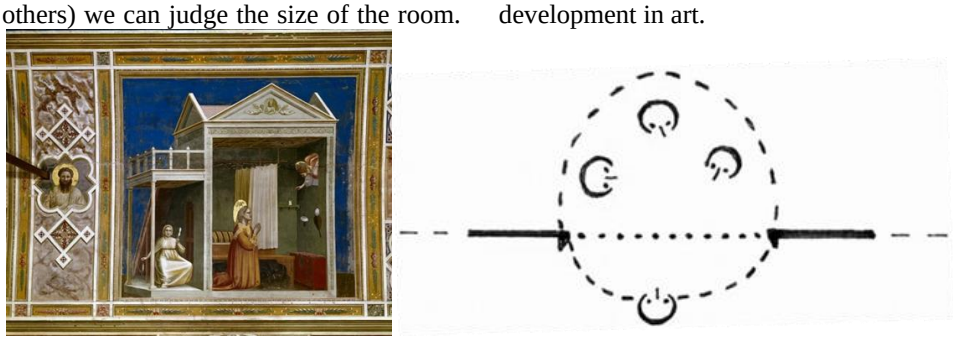

Fig. 8, 9. "Annunciation of Saint Anne" by Giotto di Bondone; the direction of the viewer's views and the characters in the picture (diagram).

Here it is appropriate to recall the artist and scientist Piero Della Francesca, a representative of the Florentine school of painting, in whose works and paintings the techniques of constructing three-dimensional space were scientifically justified and widely developed. He is rightly considered the father of descriptive geometry. The image in the painting Piero Della Francesca built as "the intersection of the cone of visibility with the picture plane". On the" picture plane " in the painting is

reproduced by the depicted objects. Consider his painting "The Flagellation of Christ" (Fig. 10), in which the artist uses a linear perspective as a means to enhance the emotionality of the action. The artist was alien to any external manifestation of passion. In the picture, everything is quite measured, but still "flagellation" stands out from other works of the master by the presence of an element of drama in it - only an element, because contemplation is the basis of this work. On the one hand, the scene of flagellation is placed in the depth of the portico, the foreground is occupied by three quietly standing figures. The measured rhythm of the composition is determined by the horizontals and verticals of the architecture. Only one executioner is represented in the movement. But on the other hand, the master uses the dynamic possibilities of linear perspective as in no other painting, and therefore this painting finds an emotional effect that is not present in other works. I would like to highlight the opinion that Piero Della Francesca deliberately uses a linear perspective to create a certain shade of dramatic mood.

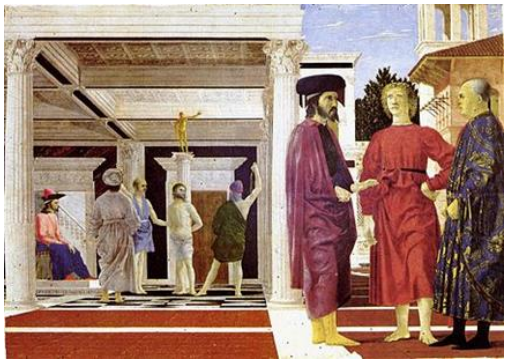

Fig. 10. «The Flagellation of Christ» by Piero Della Francesca.

In Piero Della Francesca, the role of light, which envelops figures and objects and spreads in the space itself, becomes of great importance. Depth in other artists paintings can be measured by the ratio of scale and proportion, or by the reduction of architectural lines. Here it is interesting to find out what role linear perspective played in the work of a master who knew it perfectly. One of the most significant works of the artist is the fresco cycle in the Church of San Francesco in Arezzo. The fresco "meeting of Solomon with the Queen of Sheba" shows two episodes: in the left part, the action takes place in the open air. Approaching the Palace of Solomon, the Eastern Queen kneels before a piece of sacred wood, guessing its mysterious fate. In the right part of the action takes place in the hall of the Palace. Surrounded by Solomon's courtiers, the Queen bows in greeting to the king. Figures and objects are interpreted generically and are close to the front edge. Wipper says that Piera Della Francesca avoids breaking through the wall with the illusion of an imaginary space, "on the contrary, he seeks to preserve the integrity of the wall, emphasize its flatness, delineating the composition in broad, solid masses, placing the figures exclusively in the foreground and unfolding their movements past the viewer. The artist does not refuse a spatial solution, moreover, most often he depicts a space of great depth. In the scene "Meeting of Solomon with the Queen of Sheba" (Fig. 11), the action takes place in the hall of the Palace. Horizontal beams and vertical pilasters and Columns limit the space, create compositional divisions, thereby creating a kind of ornament. However, this could lead to the negation of space, and Piero Della Francesca breaks the correct pattern of the horizontal and vertical lines with a diagonal beam and thus creates a minimum of the necessary picture field for the figures. Perspective plays the role of auxiliary means. The artist uses it only in these frescoes when there is a danger of space disappearing. He does not use it if he is painting a landscape from behind, in which case space is built with black-and-white transitions; if he is depicting the interior, he also uses perspective very carefully, while the perspective reduction is shown only in the upper part.

Fig. 11. "Meeting of Solomon with the Queen of Sheba" by Piero Della Francesca.

To sum up, we can say that the spatial composition of the period under consideration reached a three-dimensional image of figures due to the strict observance of geometric proportions of perspective, working with light and shadow. The Florentine school of painting was the center of the spread of aerial perspective among painters and became the base for the next generations, in particular representatives of the High Renaissance.

Having analyzed the works of the creators who gave rise to a new approach to creating a composition in painting, it is advisable to consider the problem of the phenomenon of space in art. The construction of space in the picture is not only for optical purposes but also serves to create the illusion of depth. Perspective effects can have a much deeper aesthetic impact, create a certain rhythm, enhance the action, dramatize, and evoke certain emotions and moods. In this sense, for example, you can compare the effects of straight and oblique perspectives. The solemn, perfectly elevated tone of the composition of Raphael («the school of Athens») and Leonardo («the last supper») is largely supported by the fact that the space of their paintings is built on strict principles of direct perspective. In Leonardo's «Last supper» a long table is placed completely parallel to the plane of the picture, and the point of convergence of all outgoing lines is in the very center of the picture, in the eyes of Christ, or, more correctly, in the infinite distance behind his head. This harsh simplicity of the background and its perfect calmness all the more highlight the dramatic intensity of the event taking place in the foreground. On the contrary, the oblique perspective sharply contradicts the spirit of the Renaissance, and therefore this technique becomes most popular in periods whose style is based on anti-classical principles-on asymmetry, dissonance, dynamic expression.

Protorenesans and the Early Renaissance were a turning point in painting because they brought in a share of realism, a completely new perception of space through the use of a three-dimensional perspective. How did the innovation of the proto-Renaissance transform through the epochs and how did it reach us? Of course, it resonates not only in the works of contemporary artists, but also manifested itself in a completely new form – computer graphics and became the basis of 3D visualizations. It gives the object a presence that goes beyond the local existence. The 3D visualization also proves to be a good tool to bring objects closer to the public. Through independent navigation and interaction, it offers the possibility to virtually take the viewer along, to let him experience his own presence on a virtual level.

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РАЗРАБОТКА ГАРНИТУРЫ АБХАЗСКОГО ШРИФТА КАК СПОСОБА ПОПУЛЯРИЗАЦИИ КУЛЬТУРНО-ИСТОРИЧЕСКИХ ЦЕННОСТЕЙ ПОСРЕДСТВОМ ГРАФИЧЕСКОГО ДИЗАЙНА

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DEVELOPMENT OF A HEADSET OF ABKHAZ FONT AS A METHOD FOR POPULARIZATION OF CULTURAL AND HISTORICAL VALUES THROUGH GRAPHIC DESIGN

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Аннотация

В статье рассмотрены и применены на практике варианты модификации гарнитуры шрифта для абхазского языка, как инструмента популяризации отрасли графического дизайна в Абхазии, для обеспечения доступности использования разных вариаций родного языка. Описаны особенности разработки авторских шрифтов.

Abstract

The article discusses and applies in practice options for modifying the typeface for the Abkhaz language, as a tool for popularizing the graphic design industry in Abkhazia, to ensure the availability of using different variations of the native language. The features of the development of author's fonts are described.

Ключевые слова: графический дизайн, шрифт, компьютерная графика, этника, дизайн.

Keywords: graphic design, font, computer graphics, ethnic, design.

Абхазский язык причислен к так называемым младописьменным языкам. За более чем 150-летнюю историю абхазской письменности, алфавит неоднократно подвергался изменениям.

Первый абхазский алфавит был создан русским ученным Петром Усларом в 1862 г. на основе кириллицы. В алфавите Услара было 55 знаков, большинство из них было перенято с русского алфавита, некоторые из них были изменены. Для передачи звуков были использованы латинский, греческий, сербский, старославянский и грузинский алфавиты.

Однако, в 1892 г. педагогом Сухумской горской школы Константином Мачавариани и его учеником Дмитрием Гулиа был издан букварь. Произошла значительная модификация алфавита, какие-то буквы были изъяты и их количество сократилось до 51. С этой поры абхазы и начали читать книги на родном языке (рис.1).

Рис.1 – Абхазский алфавит

Совершенно очевидно, что в наш век компьютерных технологий есть необходимость использования электронного наборного шрифта, с чем у абхазского алфавита имеется ряд проблем.

Стоит сразу отметить, что уже существует гарнитура «Arial», «Times New Roman», «Arial Bold», адаптированные для абхазского шрифта, однако, это все что имеется на данный момент. В связи с недостаточной популяризацией графического дизайна как профессии и рода деятельности, не происходит модификаций абхазских шрифтов, которые более чем необходимы в сфере жизнедеятельности страны и ее культуризации.

Существует ряд проблем, с которыми сталкиваются графические дизайнеры в Абхазии. Абхазский является государственным, соответственно, существует закон о необходимости ведения делопроизводства, а также рекламной деятельности на абхазском языке. Говоря конкретно о графическом дизайне, дизайнер может использовать в оформлении вывески любой язык, но только в соседстве с абхазским. Отсюда возникают немалые композиционные проблемы. В уже готовую выстроенную композицию дизайнер должен закомпоновать абхазское слово, напечатанное посредством строгой и рубленной гарнитуры. Также анатомия букв абхазского алфавита визуально грубая, что усложняет процесс построения текстового блока. Очевидно, что шрифт является одной из самых важных составляющих графической композиции, будь то логотип, плакат, вывеска и т.д. И даже одна не верно скомпонованная буква может испортить визуальное восприятие.

Существует огромное количество возможностей и вариаций проектирования графического стиля абхазского шрифта. Это могут быть семейства акцидентных, гротескных, антиквенных шрифтов с уникальной анатомией знака. Например, может существовать группа гротескных шрифтов, анатомия букв которых будет основана на таких популярных на Кавказе родовых знаках и фамильных гербах абхазов, которые представляют собой совокупность лаконичных линий. Благодаря чему процесс стилистической модификации будет не сложным, но стильным и узнаваемым (рис.2).

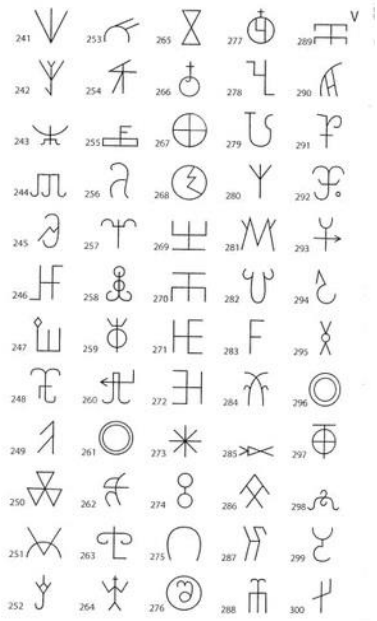


Рис.2 – Абхазские тамги

В виде примера автором были спроектированы следующие варианты графической визуализации шрифтовой гарнитуры.

Проектирование стилистического образа буквы также может быть построено на основе классических иллюстраций абхазского эпоса, визуальное восприятие которого имеет устоявшийся графический образ (рис.3). Это всегда угловатые, рубленные линии, острые и лаконичные очертания силуэтов. В основном это игра линии и пятна, т.к. подача цвета довольна аскетична и изображения выполнены преимущественно в черно-белых тонах, подражая технике линогравюры. Шрифт может относится к акцидентной группе (рис.4).

Рис.3 – Иллюстрации абхазского народного эпоса

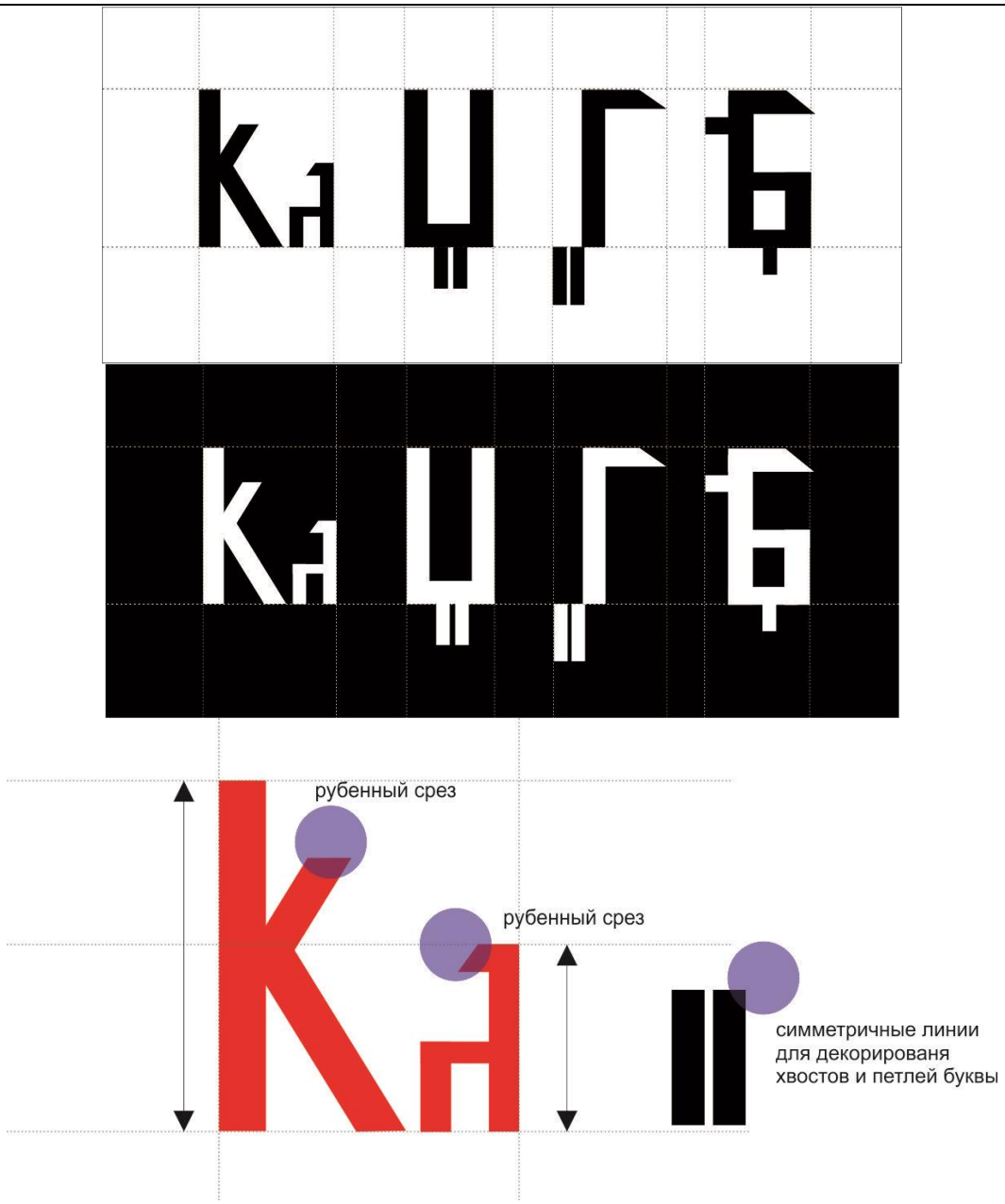
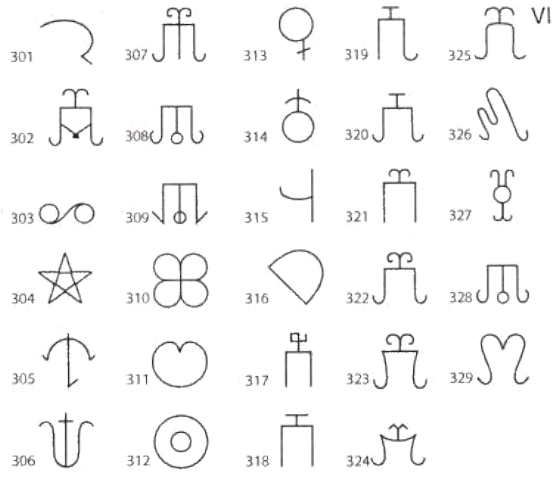


Рис.4 – Проектирование авторского шрифта.

Возвращаясь к вышеупомянутому образу букв на основе фамильных знаков. Вероятнее, что это будет представитель группы гротескных шрифтов (рис.5).



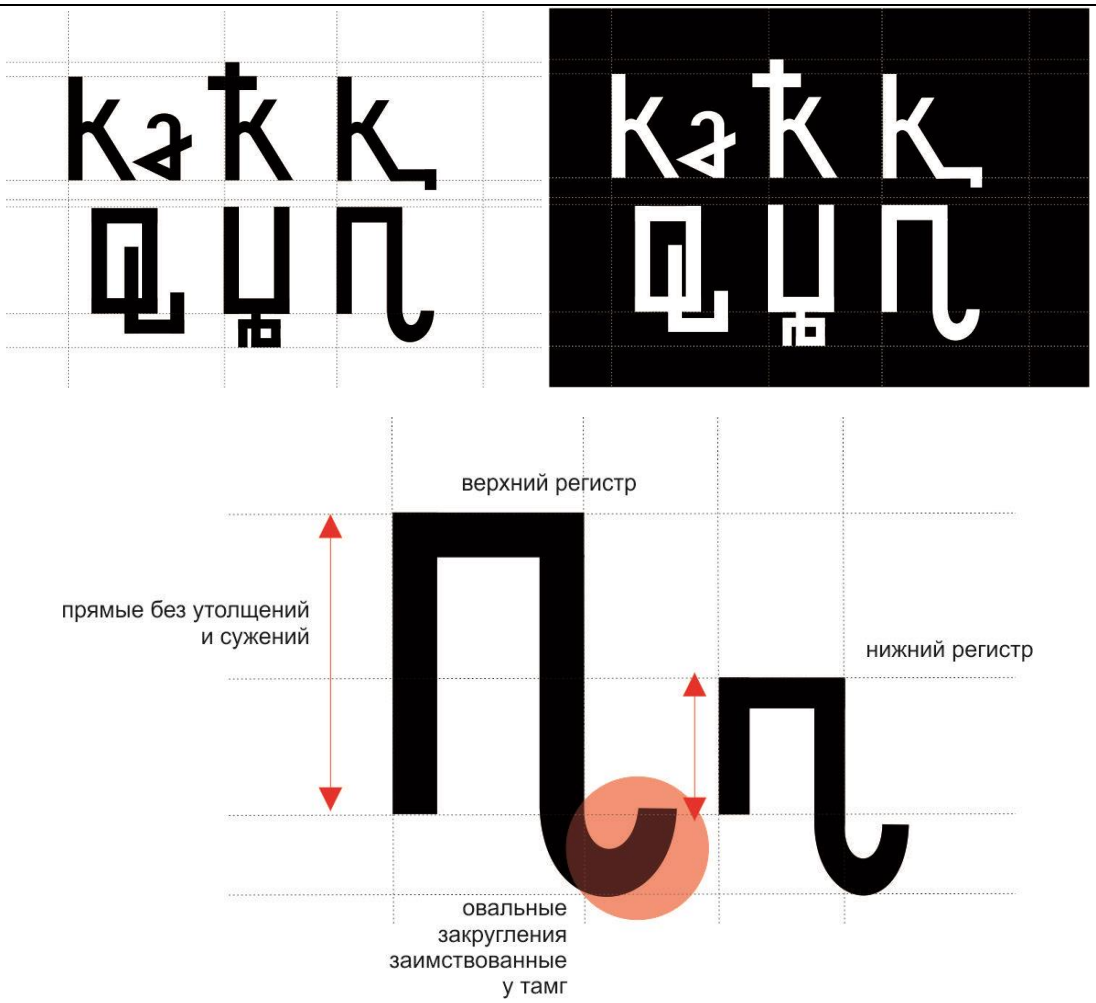


Рис.5 – Проектирование авторского шрифта

Форменные составляющие анатомии буквы прямые углы и овальные закругления. Толщина элементов может разниться в соотношении друг с другом. Исключены сужения и расширения одной прямой. Также можно обеспечить вариативность гарнитуры, а именно жирное и тонкое написание, курсив и т.д. (рис.6). В результате мы получим четкий и строгий ритм шрифта, подражающий древней абхазской символике.

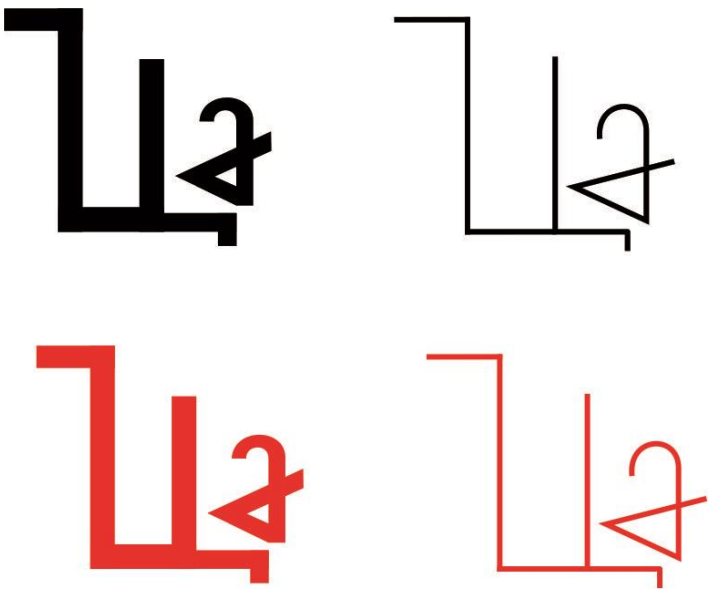


Рис.6 – Жирное и тонкое написание буквы авторского шрифта

Безусловно, создание шрифта очень долгий и сложный процесс, существует еще множество нюансов, которые обязательно нужно учитывать в процессе проектирования. Таким образом, в данной работе авторами были показаны варианты и перспективы модификаций абхазской гарнитуры.

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ФУНКЦИЯ И ПРИМЕНЕНИЕ ВИЗУАЛЬНЫХ СИМВОЛОВ В ГРАФИЧЕСКОМ ДИЗАЙНЕ

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FUNCTION AND APPLICATION OF VISUAL SYMBOLS IN GRAPHIC DESIGN

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Аннотация

Люди получают информацию в форме символов и в то же время выражают свое понимание вещей в форме символов. На протяжении всего процесса познания люди сначала узнают информацию в виде символов, а затем понимают и анализируют. Символы появились более ста лет назад, до сих пор различные символы постепенно интегрировались в различные научные знания, а также возник новый тип научных исследований - семиотика. Особенно это развилось в графическом дизайне, в основном символ передает информацию людям, поэтому использование визуальных символов так важно в повседневной жизни человека.

Abstract

People receive information in the form of symbols and at the same time express their understanding of things in the form of symbols. Throughout the entire learning process, people first recognize information in the form of symbols and then understand and analyze. Symbols appeared more than a hundred years ago, until now, various symbols have gradually been integrated into various scientific knowledge, and a new type of scientific research has emerged - semiotics. This has developed especially in graphic design, basically a symbol conveys information to people, which is why the use of visual symbols is so important in a person's daily life.

Ключевые слова: графический дизайн; визуальные символы; функции.

Keywords: graphic design; visual symbols; functions.

Визуальные символы в дизайне упаковки. В дизайне упаковки визуальные символы играют очень важную роль, их значение и характеристики невозможно заменить. В дизайне упаковки используются визуальные символы, ее инновационная ценность в основном отражается в следующих аспектах:

Во-первых, эффективное улучшение дизайн формы. В дизайне упаковки широко используются визуальные символы, такие как драматические модели макияжа лица или рисунки дракона и феникса. Во многих дизайнах упаковки не хватает инноваций. Если вы не будете активно внедрять инновации, это не приведет к полному использованию ценности упаковки. Только изучение новых и уникальных дизайнов упаковки может помочь в формировании корпоративного бренда. Таким образом, дизайнеры могут комбинировать современные методы дизайна и концепции дизайна, чтобы создавать новаторские визуальные символы, вносить новаторские улучшения в их внешний вид и сосредотачиваться на усилении коннотации символов и связи между изображениями продуктов.

Во-вторых, усилить коннотацию и значимость дизайна. При проектировании дизайнер должен сочетать определенные условия, отказаться от этих сложных традиционных текстовых символов, соответствующим образом улучшить или деформировать символы, еще больше усилить коннотацию и значение символов, выделить культурную коннотацию и уникальный шарм продукта, а также этим еще больше привлечь потребительский взгляд.

В-третьих, использование новаторского цвета. Цвет является ключевым фактором, позволяющим потребителям узнавать продукты. Дизайнеры не могут обойтись без использования цветных символов при разработке упаковки. Дизайнеры должны продолжать вводить новшества в элементы символов, улучшать визуальную коммуникацию и укреплять единство продуктов и цветового видения. Укрепляйте связь между дизайном упаковки и продуктом.

Визуальные символы в дизайне плаката. Суть успеха дизайна плаката зависит от того, сможет ли он привлечь внимание аудитории и позволить людям продолжать обращать внимание и понимать важность значения. Это неотделимо от использования визуальных символов. Дизайнеру плаката необходимо уметь гибко использовать визуальные символы, чтобы добиться эффекта признания и заинтересованности аудитории. Будь то рекламный плакат фильма или плакат общественного благосостояния, мы должны обращать внимание на новаторское применение визуальных символов. Во-первых, выражение графического языка. У дизайна плаката должна быть своя тема, чтобы добиться такого эффекта, плакат не должен быть отделим от всестороннего обобщения и анализа. Графический дизайн эквивалентен сублимации языкового выражения. При разработке плаката необходимо выделить символы, которые соответствуют требованиям из большого количества информации, и должны соответствовать содержанию, требованиям дизайна плаката. Например, при разработке постеров к фильмам основная цель постеров - коммерциализация фильма. Если для продвижения фильма используется только большой объем текста, он не только не сможет передать тему и основное содержание фильма, но также негативно этим повлияет на эффект рекламы. Люди не будут комментировать фильм. Необходимо привлекать больше внимания и интереса. Поэтому при разработке плаката к фильму дизайнер должен полностью учитывать изображение персонажа, фон сюжета фильма, расположение пространства и цветовую комбинацию, а также разумно расположить все визуальные символы, чтобы напрямую и эффективно выражать эмоции.

Во-вторых, выражение живописного языка. В процессе создания плакатов дизайнеры могут в полной мере использовать язык живописи. Будь то конкретные или абстрактные художественные эффекты, они могут использовать язык рисования для выражения эмоции. Аудитория может получать информацию, основанную на их собственном понимании и воображении, так что создатели могут взаимодействовать друг с другом.

Визуальные символы в дизайне логотипа. Дизайн логотипа — это очень узкий профиль дизайна. Он в основном полагается на простые слова, графику или цвета для передачи информации. В настоящее время визуальные элементы, содержащиеся в дизайне логотипа, имеют разные значения. В целом делится на два вида знаков: первый - статические знаки, другой - динамические знаки. Признаком статичности является то, что дизайнер вставляет несколько визуальных символов друг в друга, чтобы дополнять общий смысл. Например, дизайн логотипа Всемирной организации здравоохранения основан на синем цвете в качестве основного фона, а узор посередине является основным логотипом, то есть иглой, обернутой вокруг змеи. Основная концепция дизайна заимствована у древнегреческого бога медицины Аскоребо. Эта история исходит из мифологии, которую люди могут вспомнить и ассоциировать с исцелением и спасением людей. Линии широты и долготы также спроектированы в соответствии с шаблоном, чтобы представить влияние услуг здравоохранения на мир, а оливковые ветви спроектированы вокруг, чтобы представить хорошую экологическую среду в мире. Различные визуальные символы проходят друг через друга, образуя знак большого значения. В динамическом дизайне логотипа дизайнер в основном сочетает изображения и статическую графику, что не только делает логотип более богатым, но также делает его динамичным. Это больше не традиционный метод единого статического выражения, а эффект динамического представления логотипа. Он также неотделим от важных визуальных элементов: динамичный логотип может не только эффективно улучшить имидж бренда и повысить репутацию компании, но и оставить глубокое впечатление.

При разработке проектов большинство графических дизайнеров должны тщательно изучить функции, характеристики и методы создания визуальных символов, а также объединить свои собственные дизайнерские потребности для гибкого использования и трансформации, а также дать полную свободу коммуникационным и выразительным функциям визуальных символов в графическом дизайне, раскрывая очарование дизайна и создавая более профессиональные и интересные дизайнерские работы.

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MEDICAL SCIENCES

BODY DECOMPOSITION OR LUNG MYIASIS

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Abstract

Myiasis is a parasitic disease caused by fly larvae. They are most commonly found in necrotic tissue and deep, difficult to heal wounds. Cases of ear canal myiasis, nasal passages, pharynx, bronchial tubes and few lung cases have been described. We report a case of a 65-year-old man who was found in an abandoned house, in a terminal condition, with severe hypotension. The patient dies several hours after being visited by a medical team. The cause of death is recurrent myocardial infarction. The external examination during the autopsy revealed fly larvae in the right orbit, ear canals, nasal passages and oral cavity of the carcass. Vital parasitic forms were found on histological examination and in the lungs. Less than 24 hours have passed from the time of death to the discovery of the larvae of flies, suggesting that the laying of eggs occurred while the person was still alive. The lack of inflammatory cells around the larvae of the flies in the lung means that their movement to the lung parenchyma occurred within 1-2 hours before or shortly after death.

Keywords: myiasis of ear, myiasis of oral cavity, myiasis of nose, lung myiasis.

Introduction

Myiasis is a parasitic infestation of dead or living tissues of the human body with the fly larvae (maggots). The female fly most often lays her eggs in damaged and necrotic tissues. Once hatched, the larvae tear the skin and mucous membranes, penetrating the tissues of the host, causing deep and irritating wounds, subject to further infection. Myiasis is most commonly seen as a skin invasion in the human body, but can be seen in many areas such as the eye, ear, nose, throat, urogenital, intestinal, cerebral and tracheopulmonary. Pulmonary myiasis is a very rare condition [3, 8].

In pharyngeal myiasis, the site of the infestation was presumed to be the sinuses or upper respiratory tract [3, 4]. In intubated or patients with tracheostomy, fly larvae can enter the trachea and bronchi and from there reach the lungs [2, 8]. Their entry into the lung parenchyma is accompanied by inflammatory complications - eosinophilic pneumonia, granulomas type "Foreign body" [1, 5]. Pulmonary myiasis has also been diagnosed with open lung biopsy [6]. Cases of pneumonia-associated sepsis and pleural angiosarcoma accompanied by myiasis have been reported [7].

Myiasis of humans has been associated with low socioeconomic status, alcoholism, mental or neurological diseases, poor personal hygiene, patients with diabetes, malnutrition, advanced stage cancer, gingivitis and other oral cavity lesions [8].

Case report

An ambulance team visited the patient at 11:20 a.m. at his home. A terminal condition with severe arterial hypotension (BP 80/60) was found. The doctor and the relatives of the patient left around 12:00 p.m. At 3:00 p.m. a neighbor went to the patient again and found that he had died. The death was confirmed at 4:45 PM. by a medical team. The body of the deceased was transported for forensic examination. The autopsy was performed the next day, at 9:00 a.m.

Upon examination of the body, the skin in the area of the right eye socket is found to be grayish-brown, edematous with small larvae of flies. The same are found in the area of both ears and the ear canal. Small larvae of flies are found in the nasal passages and in the oral cavity. In the area of the lower third of the back and lumbar region, the posterior surfaces of the two buttocks, the left half of the penis, the left groin area, the scrotum and the anterior-outer surface of the left thigh in its upper third have their epidermis peeled off, with wosoble underlying reddish-brown dermis, with cherry black spots and the presence of purulent secretions on the periphery. In both groin areas, greenish skin discolorations are present, better expressed in the right one. Upon the internal examination there is foamy reddish fluid flowing from the incised surface of the lung. On the anterior wall of the left ventricle and the anterior third of the interventricular septum, whitish stripes in the myocardium are present. The periphery of the same areas and the apex of the heart has visible hyperemia. An atherosclerotic plaque obstructing more

than 75% of the vascular lumen was found in the descending branch of the left coronary artery.

Materials and methods

The histologic specimens were made with fixative of 10% neutral formalin and embedded in paraffin. The cut sections were 4 mkm thick and stained with hematoxylin and eosin (HE).

Results

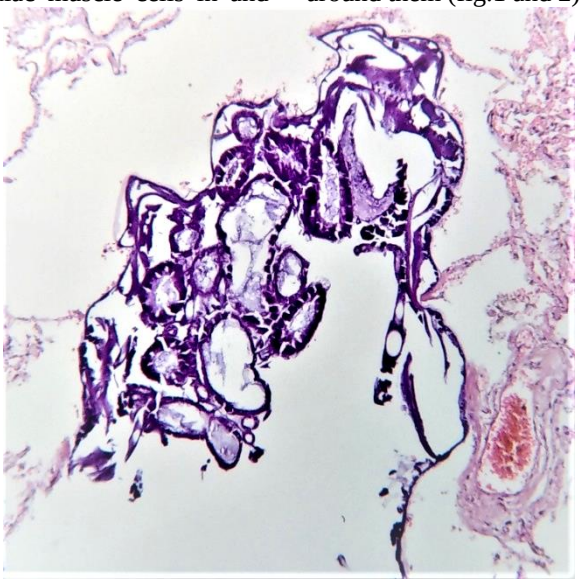
Coronary artery - with fibrous atherosclerotic plaque, blocking more than 1/2 of the vascular lumen.

Heart - extensive cicatrix in the myocardium, with necrotic changes in the cardiac muscle cells in and around the sections with connective tissue, hypertrophy of stored cardiomyocytes, and large focal myocardiosclerosis.

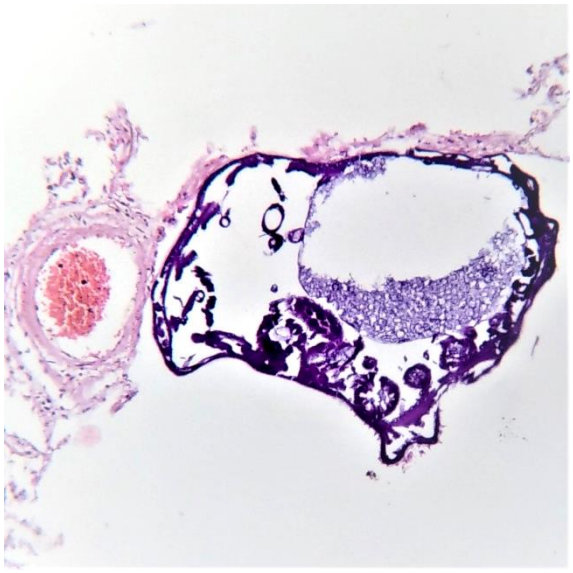
Liver, spleen and kidney - with pronounced congestion.

Brain - with perivasal and pericellular edema.

The lungs are with a severe blood stasis and edema in some lung fields and in others - atelectasis and emphysematous changes. Vital parasitic forms occur in two pneumatized sections of the lung parenchyma without an accompanying inflammatory reaction around them (fig.1 and 2).



Tracheae and salivary glands of fly larvae - magn. x 40 (fig.1)



Gut and gastric region of fly larvae - magn. x 40 (fig. 2)

Disscusion

The cause of death in this case is a recurrent myocardial infarction that developed around the postinfarction cicatrix, along the anterior wall of the left cardiac chamber and the anterior portion of the interventricular septum. The myocardial infarction is 12-24 hours old, according to the autopsy findings in the heart and microscopic changes in the myocardium in the same area.

Superficial ulcers, with suppuration and necrosis of the skin in the back, waist and buttocks, left groin area, left thigh, scrotum and penis are due to congestive heart failure. Lung swelling is also the result of myocardial infarction, and vital parasite forms in the lung parenchyma are fly larvae.

Less than 24 hours have passed from the time of death to the detection of fly larvae in various organs of the carcass during the autopsy. Given the time required for the larvae to hatch, under the most favorable environmental conditions, the laying of eggs on the patient's

body occurred before death. That supports the diagnosis of myiasis. The lack of inflammatory cells (even neutrophils) around the larvae of flies in the lungs means that their movement to the lung parenchyma (probably from the upper respiratory tract through the trachea and bronchi) occurred up to 1-2 hours before death or shortly after that.

Conclusion

In seasons of the active biological cycle of flies, finding their larvae on the surface of the body and in the internal organs of the deceased is used in forensic medicine as an indicator to determine approximate time since death. However, the case presented shows that the laying of eggs may have occurred during life and may be a case of myiasis, falsely giving the impression of a longer time since death. The possibility of the insects laying eggs before the death occurred should be taken into consideration by forensic specialist, when determining the time since death. Microscopic verification of fly larvae in internal organs, in forensics, is not always part of the initial corpse decomposition. In some cases, it may be due to myiasis, despite the lack of an inflammatory reaction in the tissues around the parasitic forms.

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PHYSICAL SCIENCES

EFFECT OF $CaSiO_3$ ADDITIONS ON THE LATTICE CONSTANTS AND CRYSTAL STRUCTURE OF ZrO_2 (3%MgO) CERAMICS

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Abstract
The effect of $CaSiO_3$ additions on the lattice constants and crystal structure of zirconia partially stabilized with magnesia were studied. It has been established that the sintering temperature and an increase in the wollastonite content affect the change in the structure, lattice parameters of the phases included in the composite material, and a decrease in the size of the crystallites of the material in the ZrO_2 (3% MgO) — $CaSiO_3$ system. Analysis of physical broadening of X-ray reflections picked microdeformation ceramic crystal lattice system "zirconia — wollastonite" depending on the size of the zirconia crystallites. It is shown that with a decrease in the size of zirconium oxide crystallites, which leads to a change in microdeformation, while the microdeformation of the wollastonite lattice does not depend on the crystallite size.

Keywords: lattice constants, crystal structure, wollastonite, zirconia partially stabilized with magnesia.

I. INTRODUCTION

Zirconium dioxide is one of the most studied ceramic materials due to its properties. It is used in various products. Zirconium dioxide stabilized with magnesium oxide has a special place because of its unique combination of properties [1]; high refractory, wear resistance, heat resistance, chemical resistance, resistance to radiation note is biological compatibility. Ceramics ZrO_2 (MgO) is demanded in metallurgy because of high refractory and heat resistance, good resistance by reacting with molten metal and slags. It should be noted that the strength properties of ceramics are based on a plasma chemical of powders ZrO_2 (MgO) studied insufficiently. However, the main disadvantage of ceramics is based on the strong dependence on the strength properties of the temperature when the hardening effect due to tetragonal-monoclinic transition under load is not realized [2]. Possibility of the creation of porous materials based on zirconia dioxide, in the case of porous materials based on zirconium dioxide, porous structure can act as an effective relaxation stress concentrator, which occurs during mechanical loading. Another embodiment of mechanical strength at elevated temperatures is to introduce the second phase, particularly in the form of fibers. For these purposes, it is possible to use a natural compound of wollastonite [3]. In [4] the estimation of activation energy for densification, which is between 45-63 kJ/mol., activation energy is corresponding to the mechanism of surface diffusion. The process of grain growth in zirconia – wollastonite" is determined by surface diffusion and sintering temperatures.

In [5] the density changes in the range from 1.56 to 4.91 g/cm^3, and the porosity decreased by 73-17% with an increase in the sintering temperature. The maximum compressive strength has reached 270 MPa sintered at 1650°C with samples containing 1 vol.%, and 5 vol.% $CaSiO_3$ sintered at 1300°C. The strength and modulus of elasticity of zirconia – wollastonite" ceramic composites were accompanied by a decrease in the proportion of the tetragonal phase due to the tetragonal — monoclinic transformation in zirconia, and their density increases with increasing sintering temperature.

However, the studies in [6,7] about the change in the crystal structure and lattice parameters of the phases formed were not carried out.

Therefore, the purpose of this work is to the continuation of these studies on the change in the crystal structure parameters of the phases formed at different sintering temperatures and with different contents of $CaSiO_3$ and determine the relationship with the properties.

II. EXPERIMENTAL PROCEDURE

The materials used in this research are the powders

ZrO_2 (3%MgO), obtained by the decomposition of liquid precursors in high plasma and natural wollastonite ($CaSiO_3$) powders. The average particle size of zirconia was 1-10 μm and wollastonite powder with a particle size between 10-60 μm. Mixing of powders with different contents of $CaSiO_3$ of 1-25 volumes.%, mix these two powders homogeneously by using a ball milling machine. The samples were pressed into a cylindrical shape on cold isostatic pressing with compacting hydraulic pressure 300 MPa. The samples were sintered at different temperatures 1000-1650°C in the furnace. The heating rate was used during the sintering at a maximum heating rate of 5°C per minute and a maximum cooling rate of 10°C per minute. The pressed and sintered specimens were measured for geometric dimensions and weight, and green density, sintered specimen density, and theoretical density were calculated. The shrinkage value of the samples was calculated from the change in the dimensions of the sample before and after sintering.

The phase analysis, crystalline size, and lattice parameters of samples were determined by X-ray diffraction (XRD). X-ray diffraction analysis was carried out using CuKα (λ = 1.54178 nm) radiation source at a voltage of 40 kV and a current of 20 mA. Continuous scanning was carried out from 15° as 2θ start position to 120° as 2θ end position, with a step size of 0.05 and step time of 1 sec. The duration of an X-ray exposure at each point has enough to produce, a relative error on the background count rate of less than 3%. The relative size of the coherence length (CL) was carried out by the broadening of the most intense X-ray reflections at small-angle scattering and diffraction [8].

The XRD profiles were refined by the Rietveld technique to obtain information on the crystallite size, lattice parameters, and the phase composition of the mixture. These data were corrected for Lorentz and polarization factors as well as for absorption. The data analyzed for phase identification using an X-ray diffractometer (XRD). Comparison of the full-width data at half the height of the diffraction peak with the known standards of the international centre for diffraction data (ICDD) maintains a database of powder diffraction patterns, the powder diffraction file (PDF), including the d-spacings (related to the angle of diffraction) and relative intensities of observable diffraction peaks.

III. RESULTS AND DISCUSSION

Lattice parameters were determined by the Rietveld method and compared with reference data from the international centre for diffraction data (ICDD). Rietveld Refinement on X-Ray Diffraction Patterns for the investigated samples are shown in Tables 1-2, which shows the change in the parameters of the crystal structure of the phases at different sintering temperatures in the range from 1000 to 1650°C and $CaSiO_3$ with different content in the samples.

Table 1 presents the change in the lattice parameters of monoclinic zirconia in the samples containing 10% vol. of $CaSiO_3$ at the sintering temperature 1000-1650°C. The lattice parameters ***a*** and ***b*** decreased and ***c*** increased with increasing sintering temperature. The angle ***β*** [°] in monoclinic zirconia decreases at a sintering temperature from 1100 to 1650°C as shown in Fig.1.

Table 2 shows the lattice changes of monoclinic wollastonite (m-$CaSiO_3$) in the samples containing 25% vol. of $CaSiO_3$ at the sintering temperature 1000-1650°C. It has been shown that the lattice parameters ***a*** and ***b*** decreased and ***c*** increased with increasing sintering temperature.

Table 1.

Lattice parameters of monoclinic zirconia

Temperature (°C)	**Lattice parameters**				
	a [Å]	***b [Å]***	***c [Å]***	***β [°]***	***V [Å³]***
1000	5.348	5.218	5.186	96.92	143.7
1100	5.294	5.203	5.167	99.31	140.4
1200	5.263	5.192	5.205	98.83	140.6
1300	5.137	5.188	5.297	99.33	139.3
1400	5.153	5.184	5.308	98.69	140.1
1500	5.289	5.173	5.274	96.76	143.2
1650	5.239	5.175	5.272	95.97	142.2

Table 2.

Lattice parameters of monoclinic wollastonite

Temperature (°C)	**Lattice parameters**				
	a [Å]	***b [Å]***	***c [Å]***	***β [°]***	***V [Å³]***
1000	15.205	7.041	7.045	95.221	751.1
1100	15.334	6.962	7.071	95.193	751.8
1200	15.411	6.971	6.815	99.499	722.1
1300	15.208	7.478	7.434	91.048	845.3
1400	15.143	7.213	7.047	95.964	765.4
1500	15.110	7.292	7.031	95.286	771.4
1650	14.829	7.478	6.995	95.953	771.4

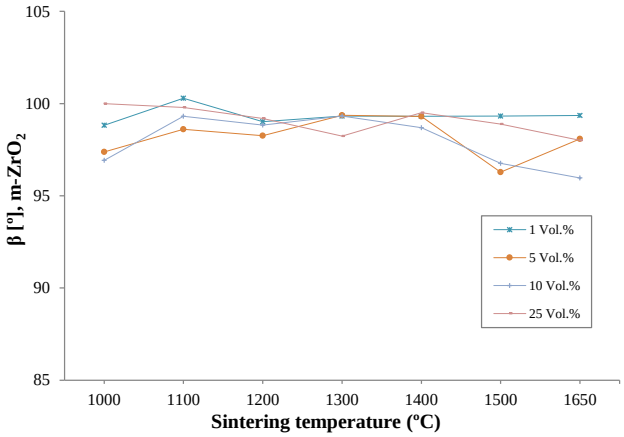

Fig.1.
*Dependence of the angle **β** of monoclinic zirconia on the sintering temperature with different contents of $CaSiO_3$*

Figure 2 shows the dependence of the angle ***β*** of monoclinic wollastonite on the sintering temperature with different contents of $CaSiO_3$. It was found that during sintering at a temperature of 1300°C, the angle ***β*** [°] of the monoclinic phase of wollastonite in samples containing 10 vol% $CaSiO_3$ was significantly increased due to a change in the lattice parameters ***a*** and the angle ***β*** [°] were anomalously increased. In the samples containing 25 vol.% $CaSiO_3$, the angle ***β*** [°] of the monoclinic phase wollastonite decreased due to the fact that the lattice parameter ***c*** was anomalously increased effective as shown in Fig. 2.

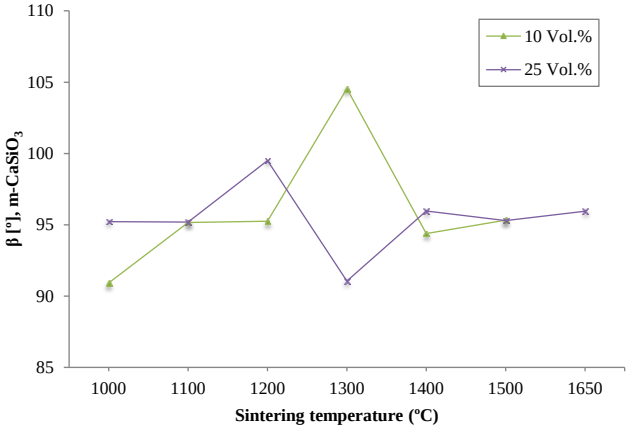

*Fig. 2. Dependence of the angle **β** of monoclinic wollastonite on the sintering temperature with different contents of $CaSiO_3$.*

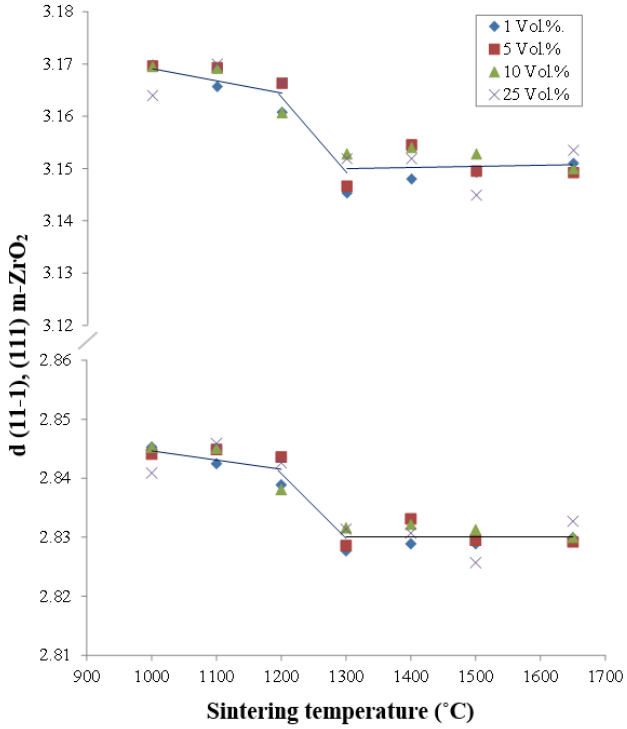

Fig.3. Changing the interplanar spacing d (11-1),(111) monoclinic zirconia sintered at different temperatures

Figures 3, 4 shows that changed in interplanar distances that had been sintered at different temperatures ranging from 1000 – 1650˚C. This shows that interplanar distances of (111) plane of monoclinic zirconia (ZrO_2) were varied in the range between 2.8257Å – 2.8459Å, and d (11-1) range of 3.1449 – 3.17Å and also d (-431) plane of monoclinic wollastonite ($CaSiO_3$) was varied in the range of 1.9826Å – 1.994Å. In Fig. 3, show that a sharp change at various sintering temperatures in the range from 1200 to 1300˚C, of the transition phase from tetragonal to monoclinic zirconium. Indeed, it can be seen from the determination of interplanar distances from diffraction patterns that their sharp change is observed in the temperature range from 1200 to 1300˚C [9]. At a time when there is an intense interaction between the components of the composite material.

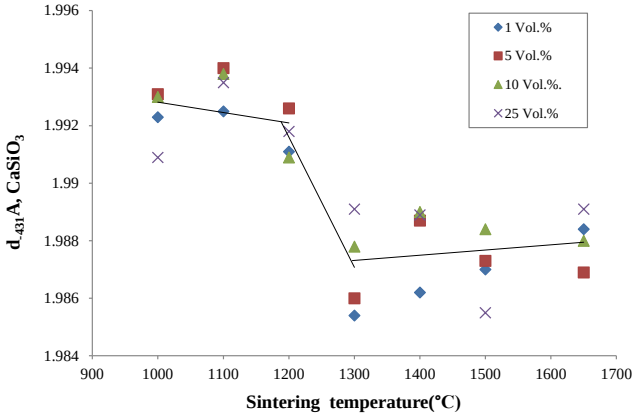

Fig.4. Changing the interplanar distance d ($_{-431}$) monoclinic wollastonite sintered at different temperatures

It was shown that an increase in temperature from 1200 to 1300˚C, intense interfacial interaction between zirconium dioxide and wollastonite is observed, leading to changes in its lattice parameters in the phases: tetragonal cubic, and monoclinic phases of zirconium dioxide and triclinic and monoclinic phases of wollastonite.

Dependence of interplanar distances on density (in Fig.5 and 6). The interplanar distances in the phases of zirconia and wollastonite abruptly changed at temperature 1200–1300˚C that determines the intensity of the interaction between the components of the composite material. This is consistent with the density range. An analytical study of the relationship between interplanar distances and the density of the material. Indeed, it can be seen from the determination of interplanar distances from diffraction patterns that their sharp change is observed in the temperature range from 1200 to 1300˚C. At this temperature, the compression was observed due to interfacial interaction, which manifested itself in a change in the structure of the composites, and their density increased with decreasing the average grain size of the sintered materials and also lead to changes in the parameters of the crystal structure.

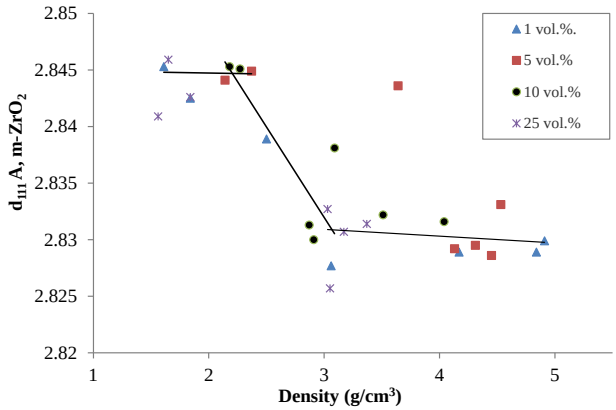

Fig.5. Changing the interplanar distance d (111) of monoclinic zirconia and density

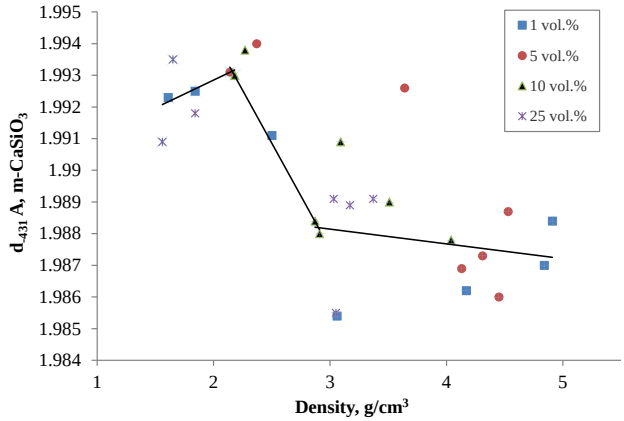

Fig.6. Change in interplanar distance d (-431) of monoclinic modification of wollastonite and density

The average crystallite size of all studied samples was determined from the full width half maximum (FWHM) of the {hkl} peak in the X-ray diffraction pattern using Scherrer's formula:

$$OKP = \frac{K\lambda}{\beta \cos\theta} \quad (1)$$

Where λ — wavelength diffraction β — adjusted full width at half maximum, θ — the angle of diffraction, and K — Scherrer constant, which is close to unity.

In Fig.7, it shows the change in the crystallite size of m-ZrO_2 (111) ranged from 35 to 65 nm. Crystallite size of the monoclinic zirconia is higher at lower sintering temperatures. The maximum crystallite size (67 nm) of the monoclinic phase was observed in samples sintered at a temperature of 1000°C, in which the volume content of $CaSiO_3$ was 1 vol%. At temperatures from 1100 – 1300°C, a tendency to a decrease in the crystallite size was observed in the samples in which the volume content of $CaSiO_3$ was 1 and 5 (vol%), and with an increase in the sintering temperature within the range from 1400 to 1650°C, the crystallite size increased.

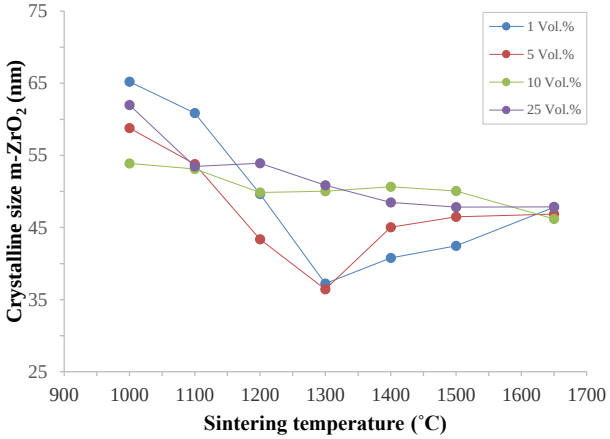

Fig.7. The dependence of the crystallite size of the monoclinic zirconia on the sintering temperature with different contents of $CaSiO_3$

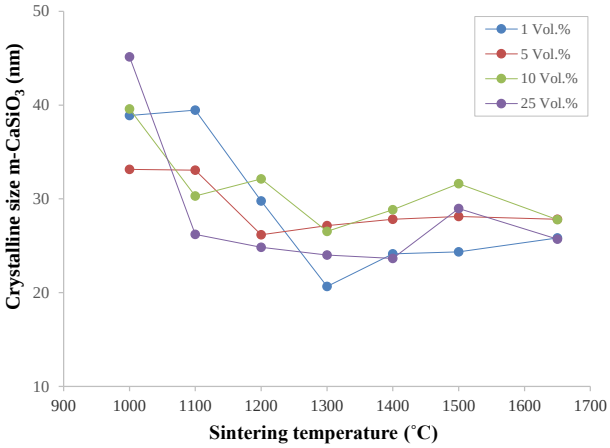

Fig.8. The dependence of the crystallite size of the monoclinic modification wollastonite on the sintering temperature with different contents of $CaSiO_3$

The crystallite size of the monoclinic modification of wollastonite in the samples with content of 1–25% Vol., $CaSiO_3$ at sintering temperatures of 1000 – 1650°C, ranged from 21 to 45 nm. The crystallite size is generally increased with increasing the sintering temperature from 1200 – 1650°C. Corresponding data is also shown in Fig.8. The crystallite size in the wollastonite phases also decreases with an increase in the sintering temperature; this abnormal behavior is due to the interaction between zirconium and wollastonite. In this case, the grain size dispersion also decreases, which indicates the formation of a more uniform structure with an increase in the $CaSiO_3$ content.

In Fig.9, it has shown the dependence of micro strain on the crystallite size of monoclinic zirconium dioxide in sintered composites (microstrain was calculated from the diffraction maximum, and the crystallite size was calculated from the peak of the monoclinic modification of ZrO_2).

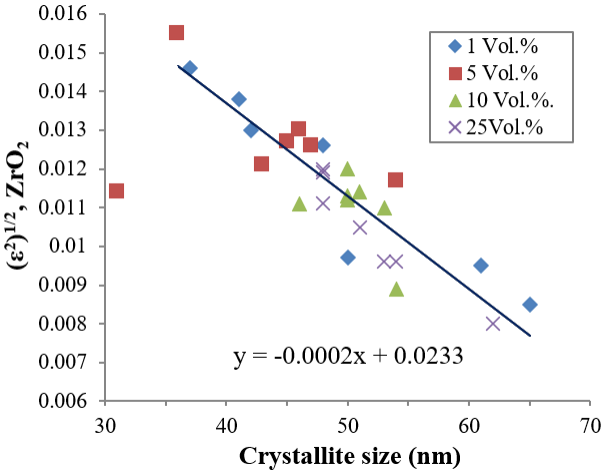

Fig.9.
Dependence of microstrain on the the crystallite size of monoclinic zirconium dioxide in sintered composites

IV. CONCLUSIONS

It has been established that an increase in the $CaSiO_3$ content in ceramics and an increase in the sintering temperature lead to the appearance of a complex phase composition and a decrease in the crystallite size in the ZrO_2 (3% MgO) — $CaSiO_3$ system, and the density of sintered materials increases with a decrease in the crystallite size of sintered materials.

It was found that, with a decrease in the size of zirconium oxide crystallites, which leads to a change in the microstrain of material composites. It can be seen that an increase of the temperature and an increase in the content of $CaSiO_3$ affect the change in the formation of their structure, complex phase composition, and parameters in the crystal structure of ceramic composites "zirconia – wollastonite".

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INFLUENCE OF TEMPERATURE ON THE PROPERTIES AND PHASE TRANSFORMATIONS IN ZrO_2(MgO) — $CaSiO_3$ SYSTEM

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Abstract

The influence of temperature on the properties and phase transformations of ceramic composites based on zirconium dioxide stabilized by magnesium and wollastonite were studied. The results revealed that the influence of sintering temperature and an increase in the content of wollastonite has been established to affect the change in the formation of their structure, complex phase composition, phase transformations in the ZrO_2 (MgO) — $CaSiO_3$ system. It has been found that interfacial interaction, which manifests itself in a change in the structural state of zirconium dioxide, is the main factor that determines the complex nature of the formation of the structure and the properties of composites based on zirconium dioxide and wollastonite.

Keywords: temperature, the property, phase transformation, zirconia, wollastonite.

I. INTRODUCTION

Zirconium dioxide is one of the most studied ceramic materials due to its properties. It is used in various products. Zirconium dioxide stabilized with magnesium oxide has a special place because of its unique combination of properties [1]; high refractory, wear resistance, heat resistance, chemical resistance, resistance to radiation note is biological compatibility. Ceramics ZrO_2 (MgO) is demanded in metallurgy because of high refractory and heat resistance, good resistance by reacting with molten metal and slags. It should be noted that the strength properties of ceramics are based on a plasma chemical of powders ZrO_2 (MgO) studied insufficiently. However, the main disadvantage of ceramics is based on the strong dependence on the strength properties of the temperature when the hardening effect due to tetragonal-monoclinic transition under load is not realized [2]. Possibility of the creation of porous materials based on zirconia dioxide, in the case of porous materials based on zirconium dioxide, porous structure can act as an effective relaxation stress concentrator, which occurs during mechanical loading. Another embodiment of mechanical strength at elevated temperatures is to introduce the second phase, particularly in the form of fibers. For these purposes, it is possible to use a natural compound of wollastonite [3]. In [4-6] was shown that the estimation of activation energy for densification, which is between 45-63 kJ/mol., the process of grain growth in this system is determined by surface diffusion and sintering temperatures. Apparently, the interfacial interaction, which manifests itself in a change in the structural state of composites, leads to

changes in its lattice parameters in the phases: monoclinic, cubic, tetragonal phases of zirconium dioxide and monoclinic, triclinic phases of wollastonite in the system.

However, in [4-6] studies of phase transformation behaviour, its properties and their relationship with temperature was not carried out.

Therefore, the purpose of this work is to the continuation of these studies on the influence of temperature on phase transformations and the characteristic properties of ceramic composites "zirconia–wollastonite", with different sintering temperatures in a wide range of wollastonite content and determination of the relationship between phase and properties.

II. EXPERIMENTAL PROCEDURE

The materials used in this research are the powders ZrO_2 (3%MgO), obtained by the decomposition of liquid precursors in high plasma and natural wollastonite ($CaSiO_3$) powders. The average particle size of zirconia was 1-10 μm and wollastonite powder with a particle size between 10-60 μm. Mixing of powders with different contents of $CaSiO_3$ of 1-25 volumes.%, mix these two powders homogeneously by using a ball milling machine. The samples were pressed into a cylindrical shape on cold isostatic pressing with compacting hydraulic pressure 300 MPa. The samples were sintered at different temperatures 1000-1650°C in the furnace. The heating rate was used during the sintering at a maximum heating rate of 5°C per minute and a maximum cooling rate of 10°C per minute. The pressed and sintered specimens were measured for geometric dimensions and weight, and green density, sintered specimen density, and theoretical density were calculated. The shrinkage value of the samples was calculated from the change in the dimensions of the sample before and after sintering.

The phase analysis, crystalline size, and lattice parameters of samples were determined by X-ray diffraction (XRD). X-ray diffraction analysis was carried out using CuKα (λ = 1.54178 nm) radiation source at a voltage of 40 kV and a current of 20 mA. Continuous scanning was carried out from 15° as 2θ start position to 120° as 2θ end position, with a step size of 0.05 and step time of 1 sec. The duration of an X-ray exposure at each point has enough to produce, a relative error on the background count rate of less than 3%. The relative size of the coherence length (CL) was carried out by the broadening of the most intense X-ray reflections at small-angle scattering and diffraction [7]. The XRD profiles were refined by the Rietveld technique to obtain information on the crystallite size, lattice parameters, and the phase composition of the mixture. These data were corrected for Lorentz and polarization factors as well as for absorption. The data analyzed for phase identification using an X-ray diffractometer (XRD). Comparison of the full-width data at half the height of the diffraction peak with the known standards of the international centre for diffraction data (ICDD) maintains a database of powder diffraction patterns, the powder diffraction file (PDF), including the d-spacings (related to the angle of diffraction) and relative intensities of observable diffraction peaks.

III. RESULTS AND DISCUSSION

Figure 1 shows XRD patterns related to the phase composition in the bulk samples after sintering at the temperature of 1650°C, with the contents of 1 and 5% Vol. $CaSiO_3$ is sintered at 1300°C as shown in Fig. 2. It was shown that the phase composition of ceramic composites $ZrO_2(MgO) – CaSiO_3$ changes after sintering are comprised of five phases, a combination of tetragonal, monoclinic and cubic phase zirconia and a mixture of the monoclinic and triclinic wollastonite [5]. Quantitative analysis of phase composition using X-ray diffraction methods. X-ray analysis of the phase composition of the composites based on ZrO_2 (MgO) – $CaSiO_3$ shown the phase content of the ceramic with different contents of $CaSiO_3$, 1 and 10 (Vol.%) and sintering temperature range from 1000°C to 1650°C as shown in (Fig.3).

Determination of phase compositions of ceramic composites $ZrO_2(MgO) – CaSiO_3$, the obtained data is converted to percent by using the following equation:

$$\text{Phase composition (\%)} = \frac{\sum_i A_i}{\sum_{ij} A_i + B_i + C_i} \times 100 \quad (1)$$

Where,Equation Section (Next) $\sum_i$ – an independent observation

$\sum_{ij}$ – the sum of independent observations

A, B, C – the number of phases

According to the data obtained by X-ray diffraction, the content of the tetragonal zirconia phase in the samples decreases with increasing temperature in the range 1100°C to 1300°C. It has been seen that after sintering temperature higher than 1300°C, the tetragonal zirconia phase was not detected in which of these samples. The tetragonal phase zirconia (t-ZrO_2) content in the ceramic composites was between 3 to 19%, depending on the contents of $CaSiO_3$ and the sintering temperature as shown in (Fig.4).

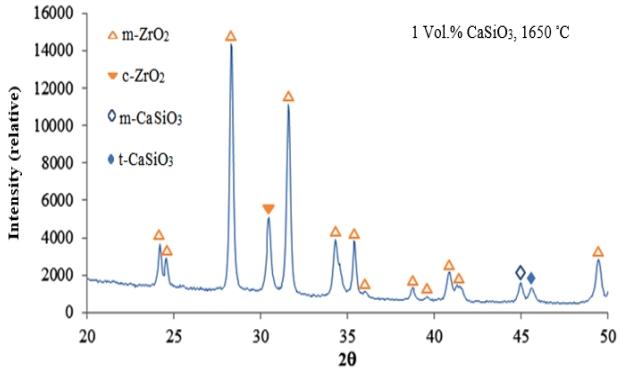

Fig.1. X-ray diffraction (XRD) patterns of ceramic composites ZrO_2 (MgO) – 1% Vol. $CaSiO_3$, sintering temperature of 1650°C

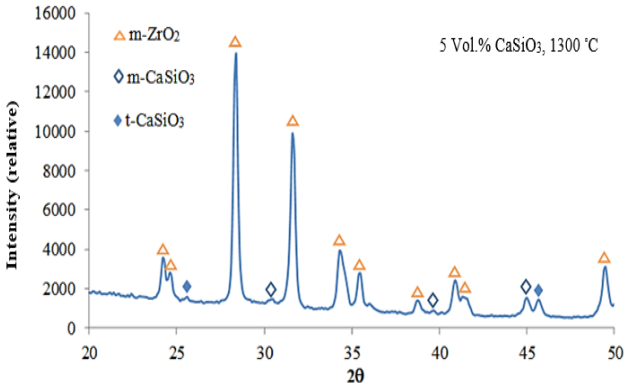

Fig.2. X-ray diffraction (XRD) patterns of ceramic composites ZrO_2 (MgO) – 5% Vol. $CaSiO_3$, sintering temperature of 1300°C

The cubic phase zirconia (c-ZrO_2) has occurred in the content of the samples of $CaSiO_3$ 1 and 5 (% Vol.), that had been sintered at different temperatures ranging from 1300°C to 1650°C, which consists of 3-13%. The cubic phase was not formed in samples containing 10 and 25% Vol. $CaSiO_3$ regardless of the sintering temperature. An increase in the sintering temperature affected the content of cubic zirconium phases in the composite, while an increase in the amount of $CaSiO_3$ does not affect the phase composition of the cubic phase of zirconium dioxide.

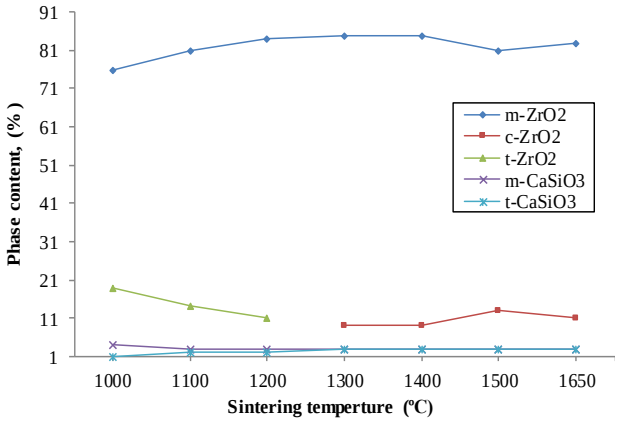

Fig. 3. The phase composition of composites at sintering temperatures from 1000°C to 1650°C, in the samples containing 1% vol. of $CaSiO_3$

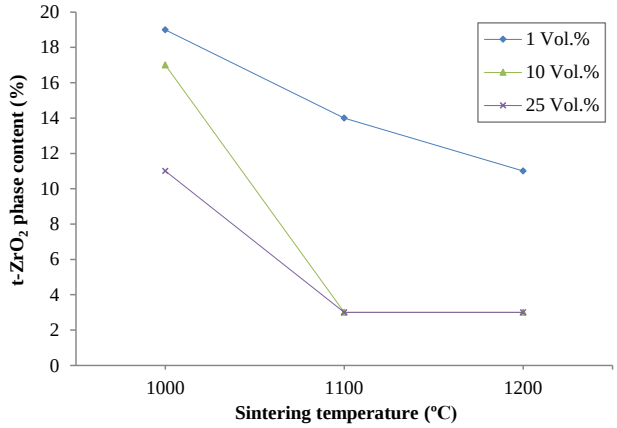

Fig. 4. Dependence of the content of the tetragonal phase zirconia (t-ZrO_2) on the sintering temperature with different contents of $CaSiO_3$

Figure 5, shows the monoclinic zirconia (m-ZrO_2) which is the main phase in these phases of the ceramic composites based on ZrO_2 (MgO) – $CaSiO_3$ system. It was found that the monoclinic phase content was the highest value of 94% in the samples containing 5% vol. of $CaSiO_3$. The content of the monoclinic phase wollastonite (m-$CaSiO_3$) has remained virtually unchanged in the system when the increase in the sintering temperature from 1000 to 1650°C was increased.

However, when added $CaSiO_3$ at high volume (25%) and sintering temperature increased from 1100 – 1500°C, the phase content of the monoclinic wollastonite (m-$CaSiO_3$) was increased consists of 3-8 % as shown in (Fig. 5). It has been established that the monoclinic phase zirconia and a mixture of monoclinic and triclinic modification of wollastonite in the system of ZrO_2 (MgO) – $CaSiO_3$ composites. It can be seen that their content almost does not change when the increasing temperature is increasing.

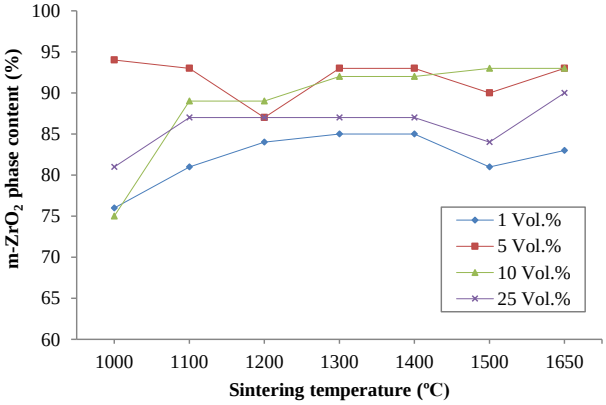

Fig. 5. Dependence of the content of the monoclinic phase zirconia (m-ZrO_2) on the sintering temperature with different contents of $CaSiO_3$

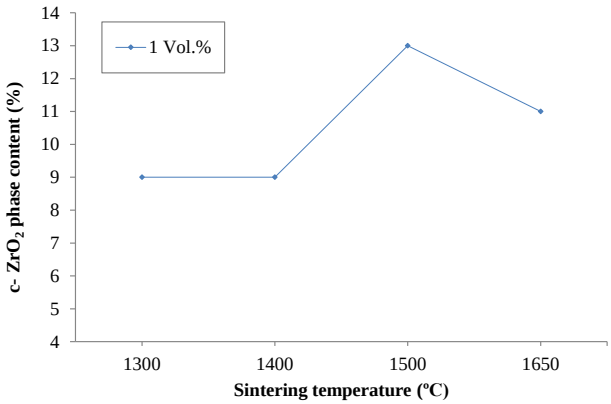

Fig. 6. Dependence of the content of the cubic phase zirconia (c-ZrO_2) on the sintering temperature with the content of 1% Vol.$CaSiO_3$

Figure 7, presents the change in the percentage of the triclinic phase wollastonite (t-$CaSiO_3$). The amount of triclinic wollastonite (t-$CaSiO_3$) varied from 1 to 5% as shown in Fig.8. Therefore, it can be seen that different sintering temperatures and different $CaSiO_3$ contents affect the content of the triclinic phase wollastonite (t-$CaSiO_3$). It has been found that the influence of sintering temperature and an increase in the content of wollastonite to effect on the changes in the formation of their structure, complex phase composition, phase transformations in the ZrO_2 (MgO) – $CaSiO_3$.

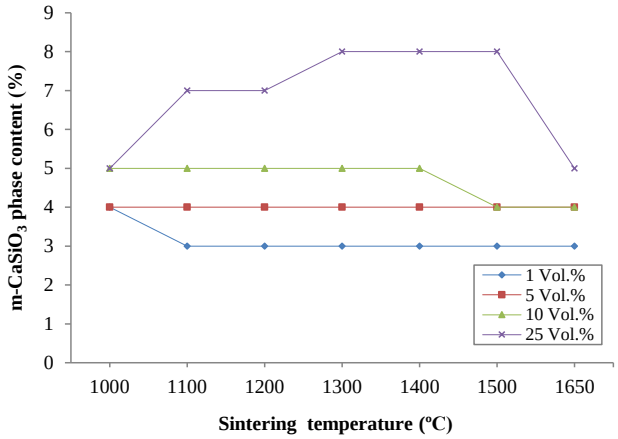

Fig. 7. The content of the monoclinic modification of wollastonite with a change in sintering temperature and the concentration in the initial mixture

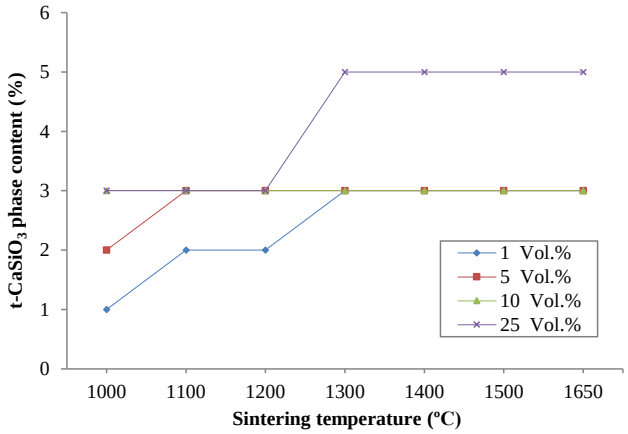

Fig. 8. The content of the triclinic modification of wollastonite with a change in the sintering temperature and the concentration of wollastonite in the initial mixture

It was shown that intensive interfacial interaction of the components between zirconium dioxide and wollastonite during the sintering temperature between 1100–1300°C is manifested in changes in the structure of ceramic composites, which are the main factors in changing the structures such as; phase composition, and phase distribution in the samples [8]. Figures 9 and 10 shows that changed in interplanar distances that had been sintered at different temperatures ranging from 1000 – 1650°C. It shows that interplanar distances of {11-1} plane of monoclinic zirconia (ZrO_2) was varied in the range between 3.1449Å - 3.17Å and {-431} plane of monoclinic wollastonite ($CaSiO_3$) was varied in the range of 1.9826Å - 1.994Å.

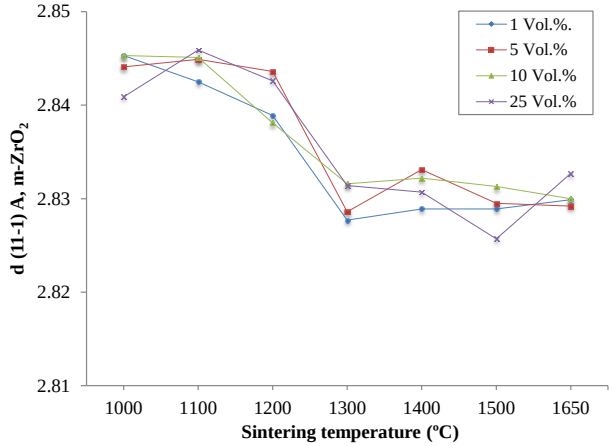

Fig.9. Changing the interplanar distance d (11-1) m-ZrO_2 sintered at different temperatures

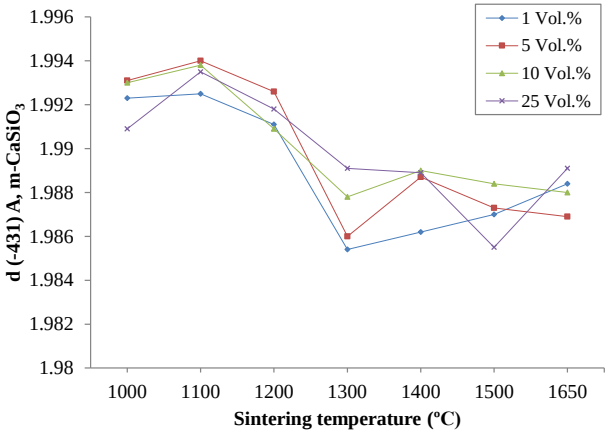

Fig.10. Changing the interplanar distance d (-431) m-$CaSiO_3$ sintered at different temperatures

In Fig. 9, they show that a sharp change at various sintering temperatures in the range from 1200 to 1300°C, of the transition phase from tetragonal to monoclinic zirconium. Indeed, it can be seen from the determination of interplanar distances from diffraction patterns that their sharp change is observed in the temperature range from 1200 to 1300°C. At a time when there is an intense interaction between the components of the composite material.

Calculation results of the intensity ratio of zirconium dioxide and wollastonite is given in Fig. 11. It was shown that the change ratio of the relative intensities of the peaks from the sintering temperature was given.Variations in the calculations from ideal intensities are associated with anisotropic effects in the samples. Considering all the factors affecting the relative diffraction light emitted from the lattice planes of the crystal structure, it is possible to calculate the theoretical diffractogram of a crystalline material.

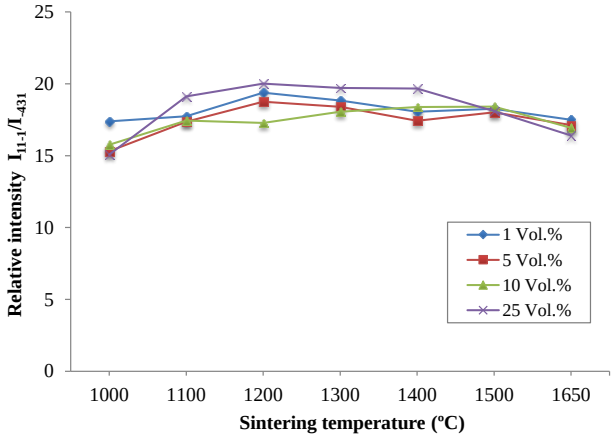

Fig.11. Change in the ratio of the relative intensities of the m-ZrO_2/m-$CaSiO_3$ peaks versus the sintering temperature

V. CONCLUSIONS

According to the X-ray diffraction analysis data has shown that phase composition changes during the sintering process. It is shown that the phase composition at high temperature from 1300–1650°C is a mixture of monoclinic zirconia and a mixture of monoclinic and triclinic wollastonite. The amount of m-ZrO_2 phase content increased with increasing sintering temperature. It has been found that the amount of monoclinic phase of zirconium dioxide was 75-94%, cubic phase varied from 3 to 13%, and tetragonal phase ranged from 3 to 19%. The amount of monoclinic wollastonite was varied from 3 to 8% and the triclinic wollastonite also ranged from 1 to 5%. These results show that an increase of sintering temperature and an increase in the content of wollastonite affect the change in the formation of their structure, complex phase composition, and parameters in the crystal structure of ceramic composites based on ZrO_2 (MgO) – $CaSiO_3$ system. It has been found that the interplanar spacings according to the diffraction patterns, as in the ZrO_2 phases and $CaSiO_3$ phases, change sharply at a temperature of 1200–1300°C. Apparently, the interfacial interaction, which manifests itself in a change in the structural state of zirconium dioxide, leads to changes in its lattice parameters in the phases: monoclinic, cubic, and tetragonal phases of zirconium dioxide and the monoclinic phase of wollastonite in the ZrO_2 (MgO) – $CaSiO_3$ system.

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ТЕОРЕМА О ВОЗМОЖНОСТИ СОЗДАНИЯ ВЕЧНОГО ДВИГАТЕЛЯ ВТОРОГО РОДА

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THEOREM ON THE POSSIBILITY OF CREATING A PERMANENT ENGINE OF THE SECOND KIND

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Аннотация

Работой представлены теорема о возможности создания вечного двигателя второго рода и уточненная редакция второго закона термодинамики.

Abstract

The paper presents a theorem on the possibility of creating a perpetual motion machine of the second kind and a revised version of the second law of thermodynamics.

Ключевые слова: вечный двигатель второго рода, тепловая машина, тепловой двигатель, холодильная машина, тепловой насос, теплонасосный двигатель, законы термодинамики (первый и второй).

Keywords: perpetual motion machine of the second kind, heat engine, heat engine, refrigeration machine, heat pump, heat pump engine, laws of thermodynamics (first and second).

1. Взгляд на возможное через призму очевидного.

Одно из определений вечного двигателя 2-го рода (далее *ВД*) гласит: *«в.д. 2-го рода – воображаемая тепловая машина, которая в результате совершения кругового процесса (цикла) полностью преобразует теплоту, получаемую от какого-либо одного «неисчерпаемого» источника (океана, атмосферы и т.п.), в работу»* [1].

Приведенное определение *ВД* хотя в категоричной форме и не отрицает возможность его создания, однако едва ли оно может нам говорить и о возможности его практической реализации. К тому же несет оно и ряд далеко не бесспорных положений. Укажем их:

- во-первых, отнесение «*тепловой машины*» к категории «*воображаемой*» априори исключает ее из числа реально присутствующих в природе объектов, вследствие чего и всякую попытку реализации такого устройства скорее всего следует воспринимать как заведомо неосуществимую;

- во-вторых, определение не несет в себе те причинно-следственные связи, которые способны с позиции научных знаний исключить *ВД* из объектов практической реализации;

- в-третьих, определение устанавливает тезис-требование о *«полном преобразовании теплоты в работу»,* которое выходит не только за рамки экономической целесообразности, но и достигнутого цивилизацией уровня техники.

Рассматривая последнее из трех представленных положений, отметим очевидную абсурдность требования, связанного с *«полным преобразованием теплоты в работу»* в условиях задействования дарового и совершенно *«неисчерпаемого» источника (океана, атмосферы и т.п.)»* теплоты. Непонятно из чего проистекающая термодинамическая скаредность составителей формулировки вполне логично дополняется общеизвестным: «*полное преобразование теплоты в работу»* остается невозможным в осуществлении даже с использованием идеальной тепловой машины, термодинамический цикл которой был установлен в 1824 году Сади Карно.

В самом деле, теоретически возможный КПД такой машины, как было установлено исследователем еще в начале XIX века, находится на уровне много ниже единицы. Несмотря на колоссальный прогресс в науке и технике, остается он таковым и спустя столетия. Причем не только вследствие потерь работы на преодоление сил трения в расширительных цилиндрах реально действующей тепловой машины, но и по причине невозможности преодоления технических сложностей с идеальным (без потерь) подводом и отводом теплоты. Последнее техническое несовершенство (не полное преобразование теплоты в работу) по обыкновению связано еще и с необходимостью сброса весьма существенной части подведенной теплоты в окружающую среду (холодильник).

Следовательно, завершая обобщение разбора выше приведенной формулировки *ВД*, как минимум она носит технически не корректной характер. Причину образовавшегося «недоразумения» скорее всего следует искать в плоскости банального непонимания ее составителями технических границ возможного, устанавливаемого самой природой. Вполне возможно, в условиях много-векторной неопределенности, сохраняющейся и по сей день в термодинамике, не могли не повлиять на ситуацию с формулировкой и чисто психологические аспекты, заставившие ее авторов повторить то, что было в весьма усеченном варианте заявлено их предшественниками – некими великими авторитетами, которые могли почерпнуть «канонические» заблуждения от своих, не менее авторитетных учителей второй половины XIX века: Клаузисом, 1850; Томсоном, 1951-1852; Гельмгольцем, 1854; Оствальдом, 1888 [2].

И будь все с точностью до наоборот, человечество, надо полагать, давно бы уже попрощалось и с углеродными источниками энергии, теми же углем, нефтью и газом, как с источниками химической энергиями, так и с ядерным топливом - источником ядерной энергии. Между тем очевидный кризис в науке, в основе которого находится в том числе и постулат о непременно «*полном преобразования теплоты в работу»* всяким *ВД* благополучно переступил уже рубеж XXI века. Например, в работе [3] именно на этом основании произошло «уравнивание в правах» понятий вполне естественной недостижимости всякой тепловой машиной термического коэффициента полезного действия (КПД) на уровне 100% с причиной невозможности создания *ВД,* которое в авторской претензией на определение второго начала термодинамики гласит: *«Стопроцентное превращение теплоты в работу посредством тепловой машины невозможно»*. В дальнейшем, там же, следует уже укоренившееся в сознании многих исследователей пояснение: «тепловой двигатель, который всю подведенную теплоту превращает в работу, называется вечным двигателем второго рода».

В очередной раз указывая на ничем неоправданно завышенную планку требований в вопросе полного использования ничем не ограниченных в потреблении энергоресурсов, вынужденно укажем на их нулевую стоимость для привода *ВД*. Тогда, принимая во внимание вполне всем очевидное: массы атмосферного воздуха, вод Мирового океана, являясь общедоступными массами, не могут не нести в себе и общедоступную теплоту, а, стало быть, не могут не являться даровыми от самой природы носителями энергии. Исходя из этого понимания вполне обыденных вещей теплоту земной атмосферы, как и теплоту вод Мирового океана следует воспринимать далеко не тем видом энергии, который требовал бы к себе сколько-нибудь значимого внимания, отчего постулирование достижимости *ВД «стопроцентного превращения теплоты в работу»* следует признать надуманным и всецело ошибочным.

Более того, будем всецело объективны, всякий реально действующий *ВД* с КПД уже более 2 – 4% мог бы быть тем вполне рентабельным в различных отраслях человеческой деятельности устройством, которое могло бы совершать полезную для человека работу. Проявляемый нами оптимизм является, отнюдь, не беспочвенным и имеет прямое отношение к тем действующим тепловым машинам, которые могут совершать полезную работу с использованием двух источников природной теплоты, например, поверхностных и глубинных океанических вод. Обладая разностью температур в интервале всего лишь 15 – 25 градусов, океанические воды могут обеспечивать КПД таких машин на уровне порядка 5% [4]. Циклопических размеров сооружение (вес одной лишь подъемной трубы для энергетической установки с нетто-мощностью не менее 50 МВт составляет 2500 т) хотя и является далеко не дешевым в процессе создания и эксплуатации сооружением, тем не менее даже этот, далекий от термодинамического совершенства генерирующий работу объект по расчетам предполагает период разумной окупаемости.

Итак, развеяв скопления самых невероятных суждений и по сей день сопровождающих тему *ВД,* перейдем непосредственно к доказательству теоремы о возможности его создания, уже изложенную нами в [5]. Для этого представим прообраз *ВД* в виде некого «черного ящика», способного в адиабатическом режиме поглощать теплоту Q в неограниченных количествах и трансформировать ее в работу A (см. рис.1). При этом условимся о следующем: *ВД* является циклической, обратимо действующей тепловой машиной, находящейся в некой однородной по температуре природной среде, которая может оставаться в этом состоянии бесконечно большой промежуток времени. Эти исходные параметры, как не трудно заметить, полностью соответствуют массовому представлению об истинно «идеальном» *ВД* и не менее «идеальной» зоне его рабочего пребывания.

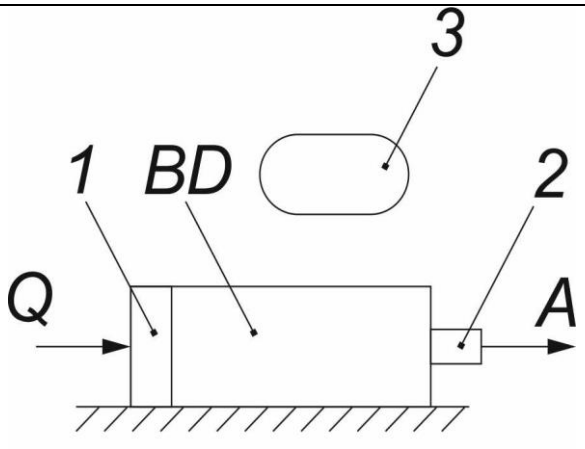

Рис.1

Разумеется, рассматриваемый *ВД* будет снабжен поглотителем теплоты 1, а также валом отбора мощности 2. При этом поглотитель теплоты 1 обладает температурой *Тб*, существенно ниже температуры *Та* – температуры окружающей среды 3. Тогда, после запуска *ВД* в работу перед нами непременно возникает дилемма: либо мы имеем дело с банальным накопителем конечного уровня теплоты - бомбой, которая неминуема должна с течением времени взорваться, либо перед нами находится некое устройство, вал отбора мощности, которого через определенный промежуток времени должен сам собой провернуться с присутствием на нем некого крутящего момента. Выбирая в качестве превалирующей значимости полезную работу над процессом разрушения, мы приходим к выбору последнего варианта. Тем более, что в мыслительном эксперименте это нам ровным счетом ничего не будет стоить.

Запишем математический ключ к пониманию всякой тепловой машины, включая понимание теории ***ВД,*** в основе которой не может не находиться первое начало термодинамики.

$$Q + A = \Delta U, \qquad (1)$$

где Q – сумма количества теплоты, подведенной к рабочему телу;

A – работа, которая производится при рассматриваемом процессе;

ΔU – изменение внутренней энергии рабочего тела за цикл.

Исходя из понимания равенства нулю изменения величины внутренней энергии ΔU рабочего тела за период времени, кратного одному рабочему циклу, запишем выражение (1) в виде:

$$Q = - A \qquad (2)$$

Знак плюс, находящийся в левой части выражения (2), характеризует направление движения энергии, в данном случае поток энергии направлен на поглощение теплоты *ВД* к нему подводимой, тогда как знак минус, находящийся в правой части этого же выражения характеризует эмиссию полезной работы, генерируемой *ВД* из подведенной к нему теплоты Q.

Раскрывая значение количества подводимой теплоты Q, имеем

$$Q = cm\Delta t, \qquad (3)$$

где c – удельная теплоемкость;

m – величина массы рабочего тела, принявшей участие в цикле;

Δt – изменение температуры рабочего тела за цикл от t_1 до t_2.

Из выражений (2), (3) в абсолютном виде следует

$$A = cm\Delta t \qquad (4)$$

Анализ выражения (4) не оставляет нам ничего иного, как в очередной раз признать торжество учения Сади Карно о способе получения работы, подтверждающего необходимость обладания не менее двумя источниками теплоты: «высшего» или нагревателя и «низшего» или холодильника. Тогда, воспринимая t_1 в виде температуры окружающей среды или температуры нагревателя, следует полагать о необходимости обладания источником с температурой t_2, соответствующего температуре холодильника, которая по определению второго начала термодинамики должна быть существенно ниже температуры t_1, что в естественных условиях достичь невозможно. Термодинамический тупик, из которого действительно нет выхода?

Практически невыполнимое, на первый взгляд, в естественной-природной среде условие, явным образом не удовлетворяющее второму началу термодинамики, однако может быть без особых технических сложностей преодолено. Как? Путем использования искусственно созданной человеком природы – псевдохолодильника, выполненного на основе некой теплонасосной системы.

С этой целью соорудим симбиоз двух тепловых машин, работающих в режиме прямого и обратного циклов. При этом свяжем их механически и процессами переноса двумя хорошо известными термодинамическими процессами. При этом, попутно договоримся, первый будет поддерживать цикл Ренкина, тогда как второй – некий, безразлично какой теплонасосный цикл (см. рис.2).

Сделаем этот, многое что определяющий в развитии цивилизации шаг вполне осознано. А еще вопреки настоятельным предостережениям со стороны общепризнанных корифеев науки и техники в области тепловых насосов, в категорической форме утверждавших о полной тщетности получения в данном случае положительного результата на том-

де, по их мнению, веском основании, что всякий подобный эксперимент непременно завершится встречей с вечным двигателем второго рода!

Тогда, имея в своем активе почти тривиальную, как само колесо, термодинамическую систему, покажем справедливость следующей теоремы: *«если один из двух тепловых входов холодильной машины является подключенным к естественно-неисчерпаемому источнику теплоты и его привод осуществляется тепловым двигателем, холодильником которого является второй тепловой вход холодильной машины, а нагревателем - тепловой выход холодильной машины, то тепловой двигатель способен совершать полезную работу с условием постоянства режимов».*

Коротко говоря и отталкиваясь в рассуждениях от законов термодинамики, докажем расчетными выкладками и анализом тепловых процессов, с использованием схемы оригинальной тепловой машины, не совсем на сегодняшний день очевидное: теплота как энергия окружающей среды действительно может быть переведена в полезную работу. Или, что полностью идентично, докажем ныне наукой отрицаемое: *вечный двигатель второго рода* возможен в осуществлении.

Для этого рассмотрим принципиальную схему, объединяющую в себе термодинамическое и механическое взаимодействие циклически действующего, не излучающего теплоту в окружающую среду теплового насоса *ТН* с обратимой, не излучающей теплоту в окружающую среду парокомпрессионной тепловой машиной *ТМ*, работающей по прямому циклу Ренкина, которые в совокупности определяют конструктивную суть оригинального *ВД* (см. рис.2). При этом тепловой насос *ТН* и тепловая машина *ТМ*, по условиям работы *ВД*, участвуют в процессах взаимных превращений теплоты и работы. Все направления потоков энергии, соответствующих теплоте и работе, на схеме отображены стрелками.

Тогда, при нахождении *ВД* в условиях термодинамического равновесия, тепловой насос 1, в соответствии с принципом своего действия, потребляет за некий промежуток времени, кратный циклу, внутреннюю работу *Авн*, генерируемую тепловой машиной 4. Работа *Авн* идет на покрытие энергетических затрат, связанных с приводом теплового насоса 1, выполняющего двойную функцию: принудительного преобразования входящей низкотемпературной теплоты окружающей среды – *Qос* в высокотемпературную теплоту *Qв* и отбор теплоты рабочего тела тепловой машины 4. Соответственно тепловая машина 4 также выполняет две функции: генерирует работу *Авн*, идущую на привод теплового насоса 1 и генерирует полезную работу *Ап*.

При этом высокотемпературная теплота *Qв* через парогенератор 3 подводится к тепловой машине 4, а низкотемпературная теплота *Qн*, достаточная для поддержания процесса устойчивого перевода парообразного рабочего тела в жидкое состояние, отводится через холодильник 6 к тепловому насосу 1 через конденсатор 6.

Далее, мысленно запустим *ВД* работу и, абстрагируясь, дождемся такой равновесности состояния всей термодинамической системы, при которой во всех точках системы будут наблюдаться постоянство параметров рабочих тел: как по температуре, так и по давлению. В единичном цикле такое условие, разумеется,

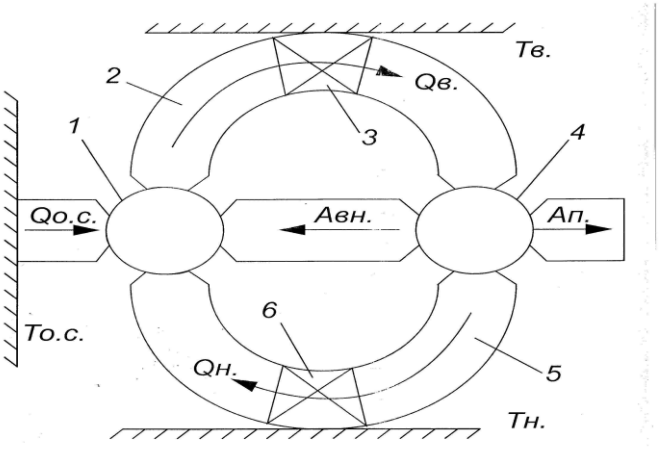

Рис. 2: 1-Тепловой насос; 2- Теплопровод переноса высокотемпературной теплоты Qв; 3- Парогенератор; 4 – Паровая машина, производящая полезную (Ап) и внутреннюю (Авн) работы; 5- Теплопровод низкотемпературной теплоты; 6- Холодильник (конденсатор пара) переноса низкотемпературной теплоты Qн.

достичь невозможно, а вот для состояния с усредненными параметрами, установленными за бесконечное число циклов, такое условие является выполнимым. Тогда, в соответствии с достигнутым равновесным состоянием для одной ее части, например, тепловой машины 4, в соответствии с первым законом термодинамики и для периода времени ее работы, кратного одному циклу, можно записать следующее уравнение:

$$Qв = Авн + Ап + Qн \quad (5)$$

Аналогичное уравнение, охватывающее процессы перехода энергии за тот же период времени, можно записать и для равновесного состояния теплового насоса *ТН*:

$$Qв = Qос + Aвн + Qн, \quad (6)$$

где *Qос* – подводимая теплота окружающей среды.

Так как левые части выражений (5) и (6) являют собой одно и то же число, приравняем между собой их правые части и, осуществляя преобразования, получаем термодинамическое тождество, полностью соответствующее *первому началу термодинамики*:

$$Qос = Aп \quad (7)$$

При этом, следует иметь в виду, изменение величины внутренней энергии рабочего тела за период, кратного одному циклу, произойти не могло, так как в обратимых тепловых машинах эта величина в любом случае остается равной нулю.

Далее, отвечая на многих интересующий вопрос о соответствии рассматриваемого *ВД второму началу термодинамики*, отметим очевидное:

- все переходы теплоты в теплообменниках 3 и 6 произошли естественным образом, то есть самопроизвольно и от более нагретых тел к менее нагретым телам;

- весь комплекс процессов превращений теплоты в работу совершился не самопроизвольно и в полном соответствие с известными постулированными условиями.

Рассмотрим эти условия в развернутом виде. Итак, для того чтобы от *ВД* можно было получить полезную работу - *Ап*, требуется выполнение комплекса следующих условий.

- необходимо иметь рабочее тело, посредством которого осуществляется взаимное превращение теплоты и работы;

- необходимо наличие по меньшей мере двух источников теплоты с разными температурами – верхний (высший) источник теплоты (ВИТ) или нагреватель и нижний (низший) источник теплоты (НИТ) или холодильник;

- работа тепловой машины (*ВД*) должна быть циклической, то есть рабочее тело, совершая ряд процессов, должно возвращаться в исходное состояние.

Проводя сравнительный анализ между общепризнанной теорией, описывающей второй закон термодинамики и вновь нарождающейся его интерпретацией, связанной с доказательством возможности *ВД*, несложно установить их полную и неукоснительную согласованность.

В самом деле, для превращения теплоты в работу вполне очевидно наличие у представленной тепловой машины-*ВД* рабочего тела; двух источников теплоты с разными температурами; рабочее тело (симбиоз тел), которое совершая ряд процессов – прямой и обратный циклы, возвращается в исходное состояние, подтверждая тем самым наличие в термодинамической системе принципа обратимости процессов. Однако, источники теплоты, обеспечивающие тепловой машине - *ВД* разность температур, являются на самом деле псевдо-источниками и для предложенной системы они являются внутренними. Кажущийся парадокс обеспечения разности температур, преодолевающий второй закон термодинамики техническими средствами, очевидно, следует воспринимать точно таким же образом, как и ту самую данность, с которой человечество свыкалось на протяжении целого столетия, глядя при этом в упор на открывшийся его взору тепловой насос.

Таким образом, подводя итог нашим исследованиям, можно сделать окончательный вывод: работа *ВД*, выполненного по рассмотренной принципиальной схеме, позволяет преобразовывать тепло окружающей среды - *Qос* в полезную работу - *Ап* в полном соответствии с первым и вторым законами термодинамики. На этом все, теорема доказана.

Исходя из представленного доказательства теоремы о возможности создания *ВД,* можно сформулировать и обновленное, на основании вновь открывшихся обстоятельств, изложение второго закона термодинамики**,** пожалуй, в наиболее полной форме, отвечающего всем требованиям просветленного ума на объективно существующие реальности нашего мироздания: *«переход теплоты окружающей среды (океана, атмосферы и т. п.) в полезную работу может происходить с участием такой тепловой машины, которая способна трансформировать теплоту окружающей среды на два различающихся по температуре тела, один из которых находится существенно ниже температуры окружающей среды».*

Это определение носит универсальный характер и содержит минимум одно следствие: потребляемая тепловым насосом работа является внутренней, способной переходить в теплоту, не выходя при этом за термодинамический контур *ВД*, а от того может являться сколь угодно значимой по величине.

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TECHNICAL SCIENCES

DECISION SYSTEM BASED ON BEHAVIOR MODELS

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Abstract

This paper addresses to specific issues of Multi-Agent systems for decision-making in complex processes. At the base of the Multi-Agent system is the notion of behavior that integrates the knowledge, strategies and target objectives of the Agent. The knowledge and strategies applied by the Agents present a dynamic process that is updated in time respecting the target objectives and the parametric restrictions of the complex process.

Keywords: Multi-Agent systems, collective decision-making, complex problems, behavior model, target objectives, optimal solutions.

Today, Multi-Agent systems present the most acceptable model for solving complex problems based on the concept of collective decision-making [1,5,7]. From the point of view of the field of application, Multi-Agent models are of interest for such sectors as: marketing, economic and strategic management, logistics, and economic, social and political relations [2]. All these sectors of the economy can be considered as dynamic and complex models based on partnerships, coalition, competition and conflicts in which the decisive role is played by the humans [3].

The presence of the human factor in collective decisions can lead to significant financial losses because the correctness of some decisions can be influenced by the emotional state or physiological fatigue of the person. In order to exclude this disadvantage, the human presence as a decision-maker is excluded, but maintaining their behavioral abilities by applying behavioral models based on knowledge, strategy and purpose (Artificial Intelligence models) [4].

A decision-making system based on behavior models presents a N set of Agents $A=\left\{A_i, i=\overline{1,N}\right\}$ which acts collaboratively in order to solve a complex common CP problem. Each Agent is defined by a behavior model that identifies it in the set of Agents and assigns it some rights and obligations in solving that problem [5].

Let the complex problem be defined by the model (1):

$$CP=\begin{cases} f\left(x(t)\right)-g\left(x(t)\right)\rightarrow \max\limits_{x(t)\in X}, \\ X=\left\{x(t)\left|\varphi_j\left(x(t)\right)\le 0, \forall j=\overline{1,M}\right.\right\}. \end{cases} \quad (1)$$

where: $f\left(x(t)\right)$ are the planned actions of the Agents A in solving the problem CP; $g\left(x(t)\right)$ are the actions applied by competitors in order to destabilize the solution of the CP problem; $\max\limits_{x(t)\in X}$ are the target objectives of the activities of Agents A obtained as a result of solving CP problem; X is the validity space of CP problem.

The behavior model of an Agent is defined by the expression (2):

$$A_i=\left\{K_i\cup S_i\cup G_i\right\}, \quad (2)$$

where: K_i is the available knowledge, S_i - are the applied strategies and G_i - are the target objectives of the Agent A_i for solving the CP problem.

The knowledges K_i of an Agent is defined by the model (3):

$$K_i(t)\xrightarrow{K_i(t):\left(f(x(t)),g(x(t))\right)}K_i(t+1), \quad (3)$$

where: $K_i(t):\left(f\left(x(t)\right),g\left(x(t)\right)\right)$ determines the dynamics of knowledge that is obtained at each decision-making step t based on existing knowledge $K_i(t)$ and of actions $f(x(t))$ and $g(x(t))$ planned for Agents [6,7].

The strategies S_i applied to the Agent are defined by the model (4):

$$S_i(t)\xrightarrow{K_i(t):\left(f(x(t))\right)}S_i(t+1), \quad (4)$$

where: $K_i(t):\left(f\left(x(t)\right)\right)$ determines the dynamics of the strategies applied by the Agent which are

calculated on the basis of current knowledge $K_i(t)$ and of the planned actions $f\left(x(t)\right)$.

As an example, can be examined the application of the decision-making system based on behavioral models for the field of furniture production.

Let be defined the CP problem, which specifies the activity of a furniture company. A set of Agents $A=\left\{A_i, i=\overline{1,N}\right\}$ are used for production management process, as well as for the logistics and marketing process.

The activity of each Agent is regulated by model CP (1), where: $f\left(x(t)\right)$ defines the technological process for production, logistics and marketing; $\max_{x(t)\in X}$ presents the target objectives for obtaining a maximum profit as a result of economic activity; X are the restrictions related to financial resources, labor, production spaces, technological insurance, etc.; $g\left(x(t)\right)$ represents the presence of competitors who deliver the same products on the market.

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USING STATISTICAL TEXT PARAMETERS TO DETERMINE AUTHOR'S SCIENTIFIC DOCUMENTS WRITTEN STYLE

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Abstract

The rapid growth of information volume in the world is contributing to the appearance of new information and linguistic tasks related to word processing. One of such tasks is to determine the author's style of writing. The article investigates the use of statistical features of the text to identify the author's style of scientific texts in Russian. Based on a set of statistical features by using machine learning methods from a certain set of applicants, a potential author of the text is determined. The quality of the classification is assessed using F-Measure. As a result of experiments the F-Measure value is received from 0,219 to 0,799. The following stages of the research are aimed at improving the accuracy of classification to determine the potential author of the text.

Keywords: Authorship Identification, Writing Style, Statistical Properties of Text, Machine-learning methods.

Introduction

The task of defining the author's style is not a new task. The first attempts to identify the author's writing style were made in the 19th century [1]. Scientists around the world continued research on the topic. At the present stage, a foundation has emerged that has brought the investigation of the writing style to a qualitatively new level. This is the rapid development of information technology for information searching, machine learning, and natural language processing, some of them:

– effective methods for presentation and classification of large texts have been developed;

– the use of machine learning algorithms for processing multidimensional data was initiated;

– developed standard evaluation methodologies to compare different approaches;

– developed tools for natural language processing (NLP – Natural Language Processing), able to effectively analyze text and provide new features for style representation (for example, based on syntactic functions).

The technology of determining the author's writing style can be applied in various fields [2]:

– intelligence (attribution of messages or proclamations to known terrorists, linking different messages by authorship);

– criminal law (identifying writers of harassing messages, verifying the authenticity of suicide notes);

– civil law (copyright disputes);

– computer forensics (identifying the authors of source code of malicious software);

– traditional application to literary research.

The task of identifying the author based on the author's writing style can be divided into three classes. Their description is presented in table 1.

Table 1

Classes of tasks for author identification

№	Name	Description
1.	Authorship identification	Based on the analysis of other works of a particular author determines the probability that the text was written by this author.
2.	Authorship characterization	Summarizes the characteristics of the author and forms the profile of the author based on his works.
3.	Similarity detection	Compares several texts and determines whether they are written by one author without actually identifying the author.

This article examines the problem close to the third grade, namely the identification of similarities in the style of writing of different texts and their classification by writing style. It is assumed that documents from one class have one common author.

In this article, we explore the statistical parameters of the text that can characterize the author's style of the text writing. Based on them, we can identify texts that are similar in writing style and with some probability confirm or deny the authorship.

Various methods and technologies for determining the author's style are successfully investigated in the world [2-6]. However, not all methods and technologies are equally effective for texts of different types and written in different languages. Precisely because, research continues for texts of a certain style and written in a certain language.

Data Set Description

This article examines the author's style of individual scientific publications in Russian. The data source is the repository of the National Technical University "Kharkiv Polytechnic Institute" (http://repository.kpi.kharkov.ua). From these sources, groups of authors' documents were selected for the text corpus, which have several articles written by them without co-authors. The total number of authors – 8, documents (individual publications) – 77 (table 2).

The scientific article has a certain structure, which consists of elements: title, abstract, keywords, text of article, references. The investigation of the writing style was conducted on the basis of the main text of the article. The main text of the article best reflects the style of the author.

An important characteristic of a scientific article is size. The articles included in the experiment have different sizes. The minimum number of words in the main text of the document is 153 words (theses). That is why the main text of each article was divided into fragments of about 150 words. The total number of fragments is 928 (table 2). A collection of fragments of articles has been formed for each author. So, the text body represents a set of data based on copies (fragments), all documents of which are considered individually. The article implements the approach to the study of the author's style by instances (instance-based approaches).

Table 2

Statistical features of the data

	Russian
Number of authors	8
Number of documents	77
The average number of documents per author	9
Number of fragments	928
Dividing of fragments between authors (1/2/3/4/5/6/7/8)	123/96/122/72/ 158/44/231/82
The average number of fragments per author	116
min/max fragments on the author	44/231
Total size (tokens)	139718
The average number of tokens per author	17464
The average number of tokens in the fragment	150
The total number of sentences	8771
The average number of sentences per author	1096
The average number of sentences in a fragment	9

Statistical characteristics of the text are obtained by means of own program "Determination of statistical features of text fragments". This program is focused and adapted to the formation of basic data to solve the problem of determining the author's writing style. The processing of text data according to own algorithm for the purpose of formation of a wide range of statistical parameters of the text is realized. Calculations are performed at different levels for the following elements: sentences; words; symbols; sampling (user choice).

4 sets of characteristics were defined for the experiment. Are presented in Table 3.

Table 3

Sets of statistical characteristics for the study

№ set of characteristics	Number of indicators	Description
1 set of characteristics	8	The average number of words in a sentence, the average word length, the average frequency of use of the word, punctuation marks.
2 set of characteristics	28	Number of words from 1 to 20 characters long The number of words with a frequency of words from 1 to 8 times
3 set of characteristics	33	The number of letters used in the Russian alphabet
4 set of characteristics	58	Number of used of stop words and pronouns (optional and frequency from 25)

Machine-Learning Methods

For conducting experiments, machine learning methods were used, which demonstrate good practical results for solving similar classification problems [7, 8].

The authors [8] who conducted a study – a review of publications on the topic (2007-2017) and determined that most often the task of determining the author is considered as:

– Classification – 70% (Support Vector Machine, Naive Bayes, Bayesian Network, Decision Tree, Nearest Neighbors, Random Forest);

– Clustering – 12% (Expectation Maximization, k-means, hierarchical agglomerative clustering);

– Deep Learning – 4%;

– other proprietary technologies – 14%.

The methods of classification in this experiment were classical ones and included Bayes Based Algorithms (Naive Bayes Multinomial), Support Vector Machine (SMO), Decision Trees (LMT, J48). We used Weka implementations of these algorithms for classification conducting (https://www.cs.waikato.ac.nz/ml/weka/). Weka is tried and tested open source machine learning software that can be accessed through a graphical user interface. It is widely used for teaching, research, and industrial applications, contains a plethora of built-in tools for standard machine learning tasks. In experiment 9/10 of all files were used for training and 1/9 part was the test set.

The results of experiments of the classification of texts for different sets of features are presented in Table 4.

Table 4

The results of the classification of texts for different sets of features

№ of feature set	Algorithm	Number of indicators	Correctly Classified Instances	Precision	Recall	F-Measure
1	Naive Bayes Multinomial	8	24,3534 %	0,247	0,244	0,219
1	SMO	8	28,9871 %	-	0,290	-
1	LMT	8	47,306 %	0,444	0,473	0,451
1	J48	8	35,2371 %	0,349	0,352	0,349
1, 2	Naive Bayes Multinomial	36	35,8836 %	0,396	0,359	0,351
1, 2	SMO	36	57,0043 %	0,554	0,570	0,544
1, 2	LMT	36	60,5603 %	0,594	0,606	0,594
1, 2	J48	36	40,7328 %	0,405	0,407	0,406
1, 2, 3	Naive Bayes Multinomial	69	59,2672 %	0,625	0,593	0,598
1, 2, 3	SMO	69	76,9397 %	0,770	0,769	0,765
1, 2, 3	LMT	69	80,1724 %	0,798	0,802	0,799
1, 2, 3	J48	69	51,5086 %	0,516	0,515	0,515
1, 2, 3, 4	Naive Bayes Multinomial	127	62,3922 %	0,655	0,624	0,629
1, 2, 3, 4	SMO	127	79,4181 %	0,794	0,794	0,790
1, 2, 3, 4	LMT	127	79,8491 %	0,797	0,798	0,797
1, 2, 3, 4	J48	127	49,7845 %	0,501	0,498	0,497

According to the results of the experiment, we conclude that the sets of features affect the quality of the classification result. The feature set consists of many indicators, but not all indicators improve the accuracy of classification. Indicators that are important in determining the author's style are considered style markers. The best results were obtained for 1, 2, 3 and 1, 2, 3, 4 feature sets using SMO and LMT algorithms. This F-Measure value is close to 0.79. Simultaneous use of 1, 2, 3 and 4 sets of features affected the accuracy of classification in different ways.

The dependence of the quality of the F-Measure classification on the number of indicators (different sets of features) is presented in Figure 1.

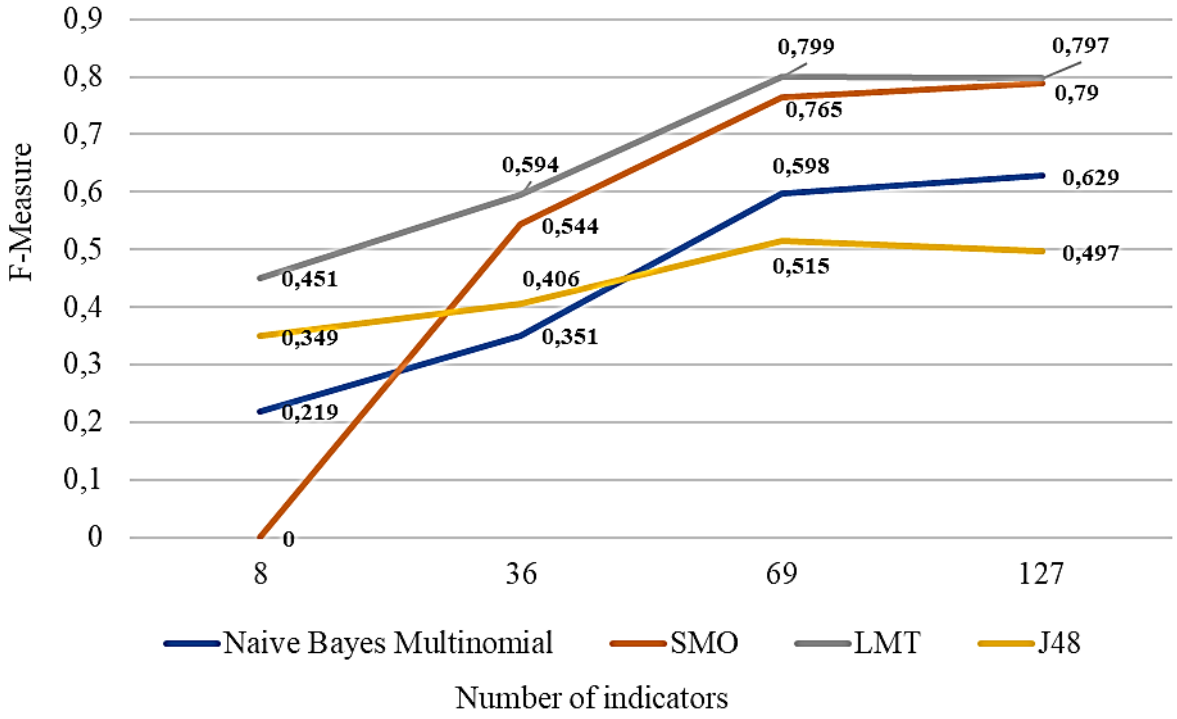

Figure 1 – Dependence of the quality of the F-Measure classification on the number of indicators

Conclusion

The problem of identifying authorship is a very important task and it has many opportunities for use in various fields. We used statistical features of text for determining the style of writing works. Experiment is implemented on the corpus of scientific texts in the Russian language.

Experiments have shown that increasing the number of indicators does not guarantee an improvement in the quality of classification. Therefore, in the future, research is planned in two directions: identifying indicators that are not markers of style and removing them from the sets of features; search and application of new indicators (statistical parameters of the text) that will be able to maximize the accuracy of classification. It is also planned to use and analyze the results of using the feature sets presented in the publication for texts in other languages.

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ДОСЛІДЖЕННЯ ПАРАМЕТРІВ ТОНКИХ ПЛІВОК ОКСИДУ ЦИНКУ ДЛЯ РОЗРОБКИ ДАТЧИКА АЦЕТОНУ

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RESEARCH PARAMETERS OF ZINC OXIDE THIN FILMS FOR THE DEVELOPMENT OF ACETONE SENSOR

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Анотація

Ацетон - це добре відома летюча органічна сполука, яка широко використовується в різних промислових і побутових областях, а також для діагностики стану здоров'я. Таким чином, дуже важлива реалізація чутливих і селективних сенсорів для розпізнавання ацетону.

Серед різних газових сенсорів широко відомі резистивні газові сенсори на основі наноструктурованого оксиду завдяки їх високій чутливості, швидкій динаміці, високій стабільності і низькій ціні.

Дані про чутливості і селективності тонкої плівки ZnO до парів летючих органічних сполук (ЛОС) можуть бути використані для розробки датчиків ацетону. Для розрахунку чутливості, селективності і межі виявлення проби була протестована велика кількість звичайних парів ЛОС. Згідно з результатами, в дослідженому температурному діапазоні найкраща чутливість і межа виявлення зразка відносяться до парів ацетону, який широко використовується в діагностуванні фізичних відхилень людського здоров'я.

Abstract

Acetone is a well-known volatile organic compound that is widely used in various industrial and household applications, as well as for the diagnosis of health conditions. Thus, the implementation of sensitive and selective sensors for the recognition of acetone is very important.

Among various gas sensors, resistive gas sensors based on nanostructured oxide are widely known due to their high sensitivity, fast dynamics, high stability and low cost.

The data on the sensitivity and selectivity of a thin ZnO film to vapors of volatile organic compounds (VOCs) can be used to develop acetone sensors. A large number of common VOC vapors have been tested to calculate the sensitivity, selectivity and detection limit of the sample. According to the results, in the studied temperature range, the best sensitivity and detection limit of the sample belong to acetone vapor, which is widely used in the diagnosis of physical abnormalities in human health.

Ключові слова: Оксид цинку, тонкі плівки, ацетон, ЛОС, сенсор газу, чутливість, селективність.

Keywords: Zinc oxide, Thin film, Acetone, VOCs, gas sensors, sensitivity, selectivity.

Вступ

Як правило, хімічні сполуки, що містять у своїй молекулярній структурі хоча б один атом вуглецю (С) і один атом водню (Н), називають органічними сполуками [1]. Їх називають летючими органічними сполуками (ЛОС), коли вони стають летючими при температурі навколишнього середовища [2]. Ацетон (CH_3COCH_3) важливий член ЛОС та широко використовувана речовина [3].

Ацетон має молекулярну масу 58,08 г / моль, щільність 0,79 г/см^3 при 20 °С і інтенсивний запах, він широко використовується в промисловості і також зустрічається в багато звичайних вітчизняні товарах. Однак його можна легко вдихнути, що може серйозно вплинути на здоров'я людини [4]. Концентрація ацетону вище 173 ppm може серйозно вплинути на центральну нервову систему і пошкодити важливі органи тіла [5]. Більш того, пошкодження очей та носа - це ще один ефект тривалої дії ацетону [6]. Відповідно, порогове значення для ацетону було встановлено на рівні 250 ppm з урахуванням 8-годинного середньозваженого значення за часом [7]. Поряд з негативним впливом на організм людини, це горюча речовина з нижньою межею вибуховості (НПВ) 2,6% і верхньою межею вибуховості (ВПВ) 12,8% [8].

ЛОС формуються або всередині організму (ендогенні ЛОС), або з зовнішніх джерел, таких як прийом їжі та зовнішнього середовища (екзогенні ЛОС). Видихаємe людиною повітря містить ~ 3500 різних ЛОС [9], а аналіз ЛОС у видихаємому повітрі може стати багатообіцяючим неінвазивним інструментом та простою методикою перевірки стану здоров'я, який можна проводити як дома, так і в медичній установі для медичної діагностики та лікування, моніторингу успішності терапії [10,11]. Наприклад, аналіз дихання можна використовувати для ранньої діагностики таких захворювань, як рак легень [12], застійної сердечної недостатності [13], діабет [14] та астма [15]. Крім того, висока концентрація газоподібного водороду в диханні вказує на наявність бактеріального росту в тонкій кишці у пацієнтів, що страждають такими симптомами, як тошнота, здуття живота, рвота, діарея, втрата апетиту та ваги[16]. Ацетон вважається важливим біомаркером діабету 1 типу і, відповідно, повідомляє,

що видихаєме діабетиком повітря містить більш високе значення концентрації ацетону (> 1,8 частин на мільйон) за порівнянням із здоровими людьми (0,3–0,9 частин на мільйон) [17]. Контроль вмісту ацетону у видихаємому повітрі може розглядатись як корисний спосіб спостереження за пацієнтами, що притримуються приписаного режиму харчування, а також для спостереження за пацієнтами з діабетом [18]. Крім того, існує кореляція між ацетоном та рівнями глюкози в крові, і, таким чином, його моніторинг може використовуватися для контролю інсуліну [19].

Концентрацію ЛОС можна виміряти за допомогою стандартних методів, таких як газова хроматографія, мас-спектрометрия [20] та високоефективна рідинна хроматографія [21]. Ці методи володіють високою чутливістю та точністю для виявлення різних ЛОС. Проте вони громоздкі, складні, дорогі, трудоємні та потребують кваліфікованих операторів для контролю газу [22].

Тому вкрай необхідна розробка надійного, недорогого, невеликого, портативного та швидкого пристрою, який може легко виявити пари ацетону.

Серед різних датчиків газу резистивні датчики газу дуже популярні завдяки простому принципу роботи, невеликому розміру, високій чутливості та низькій вартості [23]. Резистивні датчики газу виявляють навколишню газову суміш, зменшуючи її електричний захист і часто виробляються з оксидів металів [24].

У порівнянні зі звичайними методами низькорозмірний наноструктурований *ZnO* завдяки чудовим хімічним, фізичним і чутливим властивостями [25-27] може бути хорошим кандидатом для виявлення ЛОС [28-32].

Деталі дослідження

У наявних дослідженнях вивчалася чутливість тонких плівок *ZnO* до газів водню і метану і оптимізувалася чутливість тонких плівок *ZnO* щодо методу осадження [26], умов післявідпалу [27], а також товщини [33]. Грунтуючись на знаннях, отриманих з даних робіт, тонка плівка Zn товщиною 100 нм була нанесена на підкладку SiO_2 / *Si* методом електронно-променевого випаровування, а потім піддана подальшому відпалу в горизонтальній трубчастій печі при 500 ºС з потоком кисню 200 стандартних кубічних сантиметрів за хвилину протягом 60 хв. Детальна інформація про підготовку підкладки, умови осадження і після віджигальних процесах приведена в роботі. [27].

Структурно, морфологічно і хімічно зразок характеризували за допомогою рентгенівського дифрактометра Philips з кроком 0,02º і часом кроку 1 с, польової емісійної скануючої електронної мікроскопії (CamScan MV2300, Чехія і Англія). Для виготовлення газочутливих елементів на основі тонкої плівки *ZnO* на тонку плівку *ZnO* методом електронного променевого випаровування була нанесена пара Au електродів розміром 3 × 3 мм^2 з використанням маски, призначеної для використання в цьому додатку. Електричний опір зразка було виміряно в сухому повітрі і в присутності великої кількості парів ЛОС, включаючи ацетон (C_3H_6O), формальдегід (CH_2O), оцтова кислота (CH_3COOH), мурашина кислота (CH_2O_2), ацетилен (C_2H_2), толуол (C_7H_8), бензол (C_6H_6), етанол (C_2H_5OH), метанол (CH_3OH) і ізопропанол (C_3H_7OH) в інтервалі температур 200-400 ºС. Схема і установка газовимірювальної системи і методика розрахунку концентрації і обсягу закачування парів наведені в [27, 30] відповідно. Основні параметри, які будуть використовуватися для дослідження чутливих властивостей, перераховані нижче:

• Відгук (S) визначається як відношення R_a / R_g $(S = R_a / R_g)$, де R_a і R_g - опір металооксидних напівпровідників в повітрі і наявність летючих парів відповідно [28].

• Час відгуку або відновлення оцінювалося як час, за який вихідний сигнал датчика досяг 90% свого насичення після подачі або виключення цільового [28].

• Селективність датчика визначається як відношення його реакції до певного об'єкту до реакції інших об'єктів, як $K = S_A / S_B$. S_A і S_B - це відгуки датчика на цільовий газ (газ *A*) і заважаючий газ (газ *B*) відповідно [34].

• Межа виявлення - це найменша кількість аналіту / пару, яку може виявити датчик [26].

• Відтворюваність сенсора оцінюється по зміні чутливості після багаторазового перемикання між станом «вкл» і «викл» [34].

• Стабільність - це параметр для оцінки здатності датчика зберігати свої властивості, коли він безперервно використовується у екстримальних середовищах протягом тривалого часу [32].

Результати та обговорення

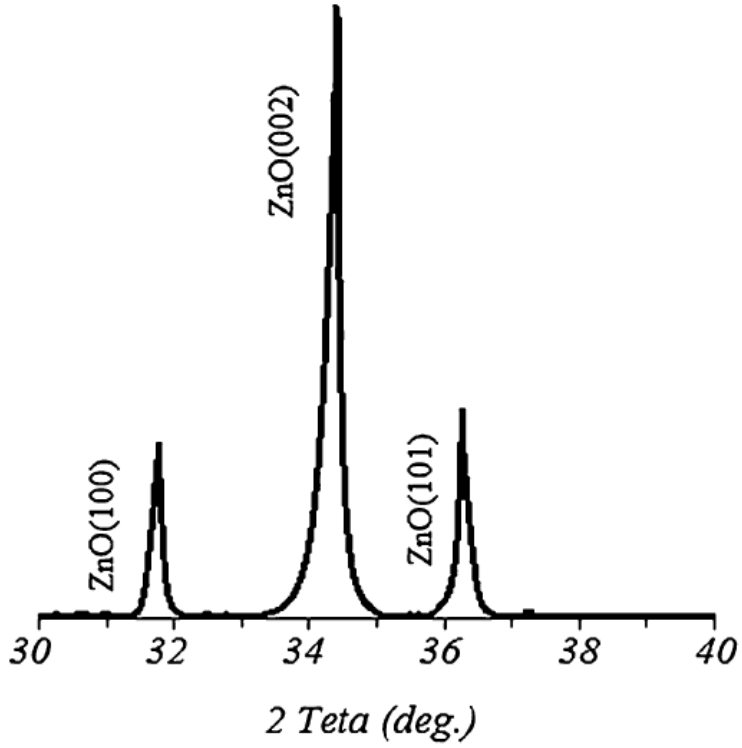

Рис.1. Рентгенограма отриманої тонкої плівки ZnO

На рис. 1. представлена рентгенограма тонкої плівки *ZnO*, отриманої в ході цього дослідження. Дифракційні лінії дуже добре збігаються з лініями, наведеними на мапі JCPDS № 36-1451, що стосується гексагональної структурі вюрцита. Легко помітити, що орієнтація (002) є кращою, а отриманий зразок має велику частку граней (002). Хімічний склад тонкої плівки ZnO визначається за допомогою енергодисперсійного рентгенівського (EDX) аналізу, а EDX-спектр зразка показаний на рис. 2. Результат показує, що відношення *O* до *Zn* становить 1,15 і підтверджується *ZnO* структура. На рис. 3 представлена мікрофотографія FESEM тонкої плівки *ZnO*. Видно, що зразок демонструє структуру нанолистів. Докладне дослідження залежності кристалографічної структури, хімічного складу і морфології поверхні від методу осадження і процесу віджигу було проведено в попередніх дослідженнях [25-27].

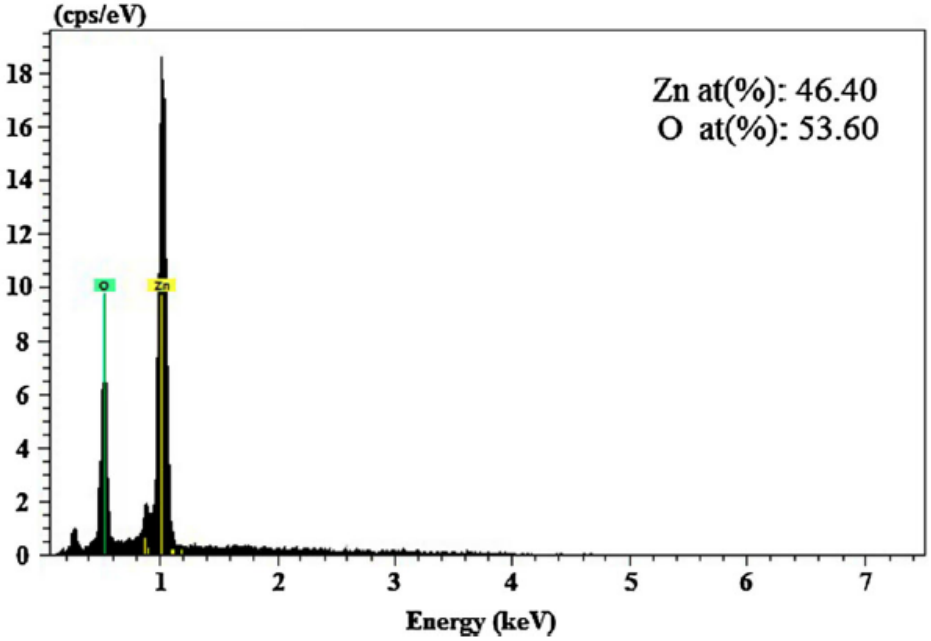

Рис. 2. Енергодисперсійний рентгенівський (EDX) спектр тонкої плівки ZnO.

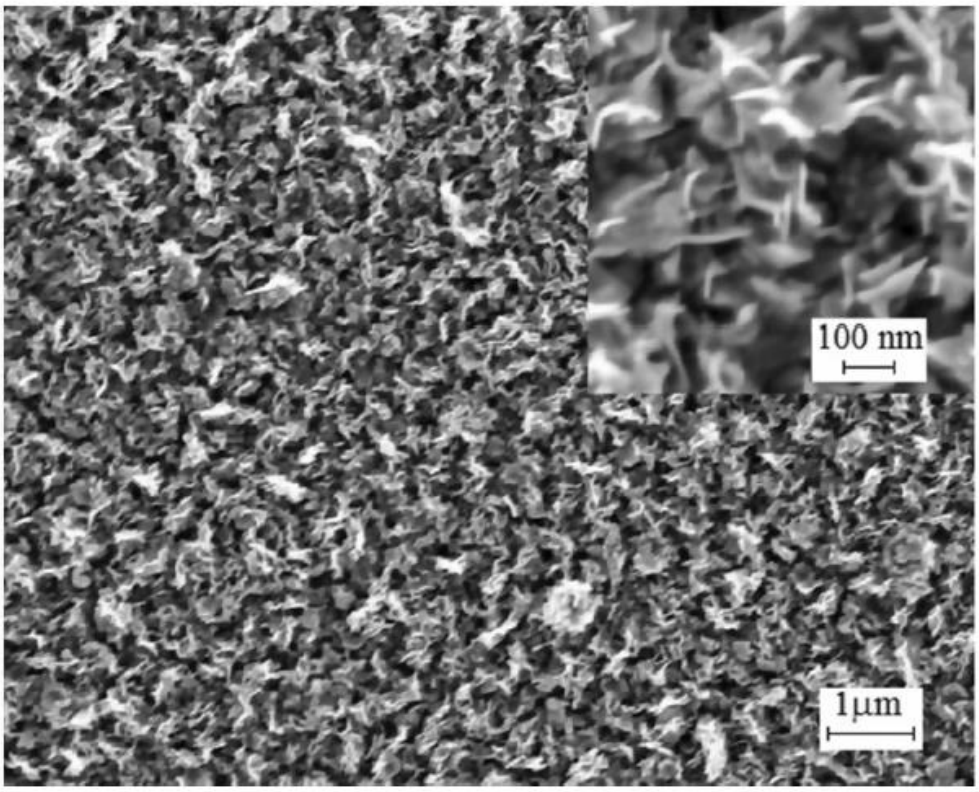

Рис. 3. Мікрофотографія FESEM тонкої плівки ZnO.

Для дослідження чутливість зразка, отриманого в даній роботі, для виявлення різних парів ЛОС, згаданих в попередніх розділах, електричний опір було виміряно на повітрі і в присутності концентрації різних парів ЛОС 100 ppm в діапазоні температур 200-400 °C. Реакція зразка на різні леткі органічні сполуки при різних температурах наведено в таблиці 1, а гістограма цих даних показана на рис. 4. Слід зазначити, що найвище значення реакції для різних парів досягається при різних температурах в наступному порядку: формальдегід (11) при 360 °C, оцтова кислота (11) при 320 °C, ацетилен (8) при 360 °C, мурашина кислота (7) при 360 °C, толуол (8) при 360 °C, бензол (7) при 360 °C, ацетон (30) при 280 °C, етанол (14) при 320 °C, метанол (10) при 360 °C і ізопропанол (23) при 280 °C. Така поведінка може бути пов'язана з тим, що енергія адсорбції, реакції і десорбції різних парів на поверхні плівки розрізняється. З цих даних також можна зробити висновок, що найбільша чутливість пов'язана з парами ацетону при різних температурах; проте він стає максимальним при робочій температурі 280 °C. На рис.5 показана селективність тонкої плівки ZnO по відношенню до ацетону в порівнянні з іншими парами при робочій температурі 280 ° C. Видно, що тонка плівка *ZnO*, отримана в цій роботі, демонструє чудову селективність до парів ацетону в порівнянні з іншими ЛОС. Щоб пояснити таку поведінку, варто почати з огляду механізму виявлення парів ЛОС тонкої плівки *ZnO*. Коли *ZnO* піддається впливу повітря, молекули кисню хемосорбуються на поверхні плівки в різних формах, таких як іони O_2^-, O^- або O^{2-}, за рахунок захоплення електронів із зони провідності. Перенесення електронів із зони провідності знижує щільність вільних носіїв і викликає утворення збідненої електронами області на поверхні плівки, що, в свою чергу, збільшує опір плівки *ZnO* [35]. Після цього тонка плівка ZnO (металооксидний напівпровідник n-типу) піддається впливу парів ЛОС, адсорбований пар реагує з хемосорбованими аніонами кисню на поверхні плівки, а потім іони кисню вивільняють захоплені електрони назад в зону провідності, що призводить до зменшення опору датчика. Рентгеноструктурний аналіз показує, що отриманий зразок має велику частку граней (002), і добре відомо, що всі атоми *Zn* на (002) поверхні гексагонального *ZnO* є ненасиченими координованими, демонструючи найбільш звисаючі частини. Ці обірвані зв'язки призводять до переваги відкритих полярних граней (002), які сильно поляризовані і містять більше згаданих вище кисневих вакансій [28, 36]. З іншого боку, ацетон в порівнянні з іншими дослідженими в даній роботі ЛОС має найбільший дипольний момент (таблиця 2), що, в свою чергу, полегшує адсорбцію і процеси реакції з полярними гранями (002) при більш низькій температурі [28].

Таблиця 1.

Реакція тонкої плівки *ZnO*, отриманої в даній роботі, на 100 ppm різних парів ЛОС при різних температурах.

Пари	Формула	200ºC	240ºC	280ºC	320ºC	360ºC	400ºC
Формальдегід	CH_2O	-	2	5	8	11	8
Оцтова кислота	$C_2H_4O_2$	1.5	3	6	11	8	7
Ацетилен	C_2H_2	-	-	2	5	8	6
Мурашина кислота	$C_2H_2O_2$	-	-	1.5	4	7	6
Толуол	C_7H_8	-	-	3	5	8	5.5
Бензол	C_6H_6	-	-	2	4	7	5
Ацетон	C_3H_6O	11	20	30	22	16	13
Етанол	C_2H_5OH	2	4	7	14	10	8
Метанол	CH_3OH	-	1.5	4	8	10	8
Ізопропанол	C_3H_7OH	7	14	23	17	12	9

Для дослідження межі виявлення тонка плівка *ZnO* піддавалася впливу парів ЛОС з різними концентраціями в діапазоні 5-400 частин на мільйон при відповідній робочій температурі, і найкращі результати були отримані в наступному порядку: 2,5 для 20 частин на мільйон формальдегіду при 360 °C, 2 для 20 ppm оцтової кислоти при 320 °C, 4 для 50 ppm ацетилену при 360 °C, 3 для 50 ppm мурашиної кислоти при 360 °C, 4 для 50 ppm толуолу при 360 °C, 3 для 50 ppm бензолу при 360 °C, 2 для 10 ppm ацетону при 280 °C, 3 для 20 ppm етанолу при 320 °C, 2,5 для 20 ppm метанолу при 360 °C і 5 для 20 ppm ізопропанолу при 280 °C.

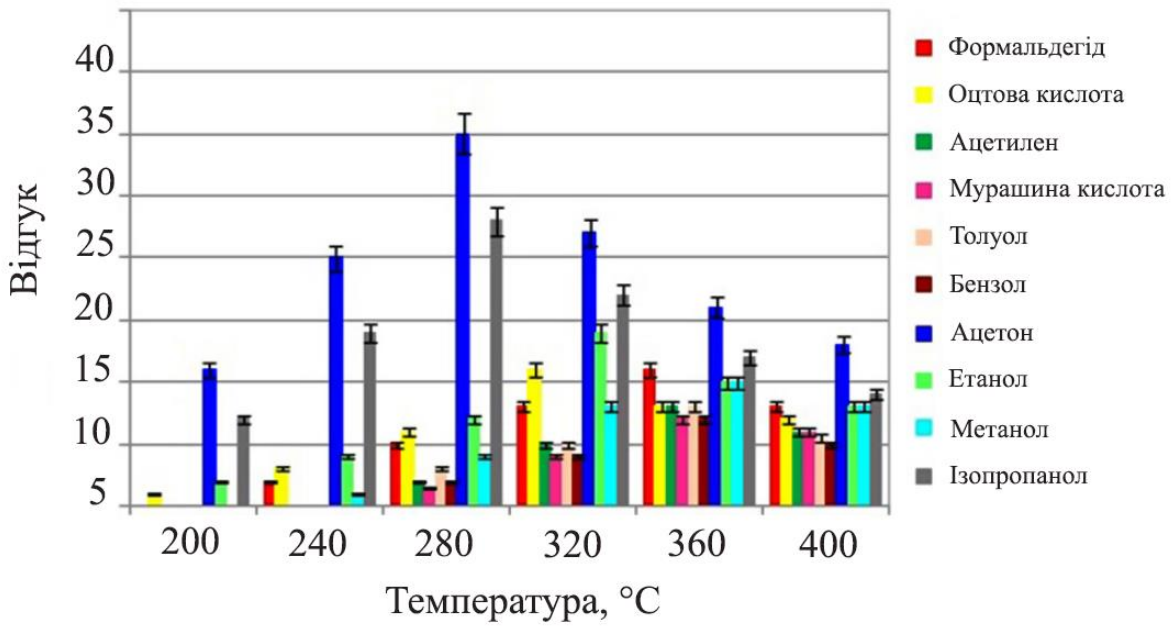

Рис.4. Електричний відгук тонкої плівки ZnO на різні пари ЛОС при різних температурах.

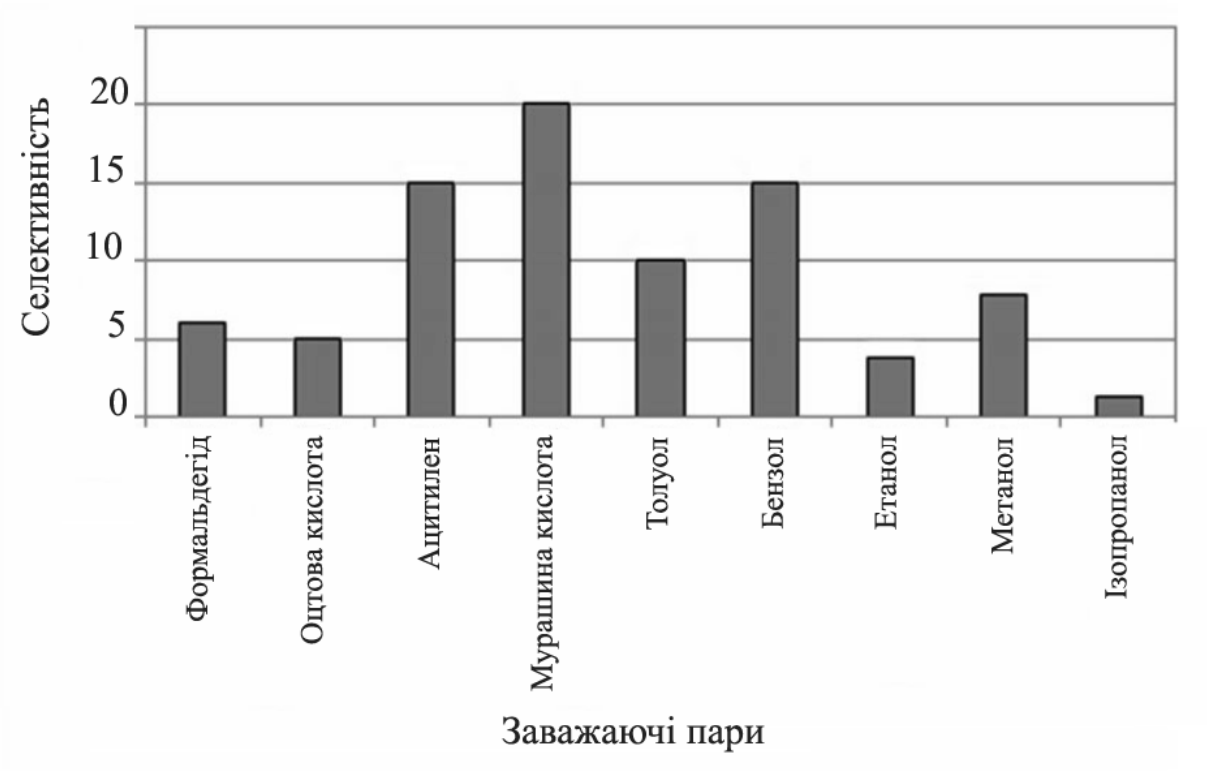

Рис.5. Селективність тонкої плівки ZnO. Цільовий пар: ацетон, робоча температура: 280 ° C

З цих досліджень можна зробити висновок, що датчик на основі тонкої плівки *ZnO*, підготовлений в цьому дослідженні, показує кращу чутливість, селективність і межу виявлення парів ацетону в порівнянні з іншими парами ЛОС, вивченими в цій роботі.

Таблиця 2.

Дипольний момент різних парів ЛОС, використаних в даній роботі [37].

Пари	Дипольний момент
Формальдегід	2.33
Оцтова кислота	1.7
Ацетилен	0
Мурашина кислота	1.41
Толуол	0.0375
Бензол	0
Ацетон	2.88
Етанол	1.69
Метанол	1.7
Ізопропанол	1.58

На рисунку 6 показані динамічні зміни відгуку тонкої плівки *ZnO*, яка піддавалася впливу парів ацетону з різними концентраціями (10-300 частин на мільйон) при робочій температурі 280 °C. Відгук, час відгуку і час відновлення в залежності від концентрації ацетону, отримані з кривих на рис.6, показані на рис.7. Можна помітити, що збільшення концентрації ацетону викликає посилення відгуку і зменшення часу відгуку. Цілком логічно, що збільшення концентрації ацетону призводить до того, що більша кількість атомів пару реагує з поверхнею плівки *ZnO* в одиницю часу, і в результаті зміни опору відбуваються більше і швидше. Однак очікується, що датчик насичується, коли всі поверхневі атоми вступають в реакцію з атомами пару.

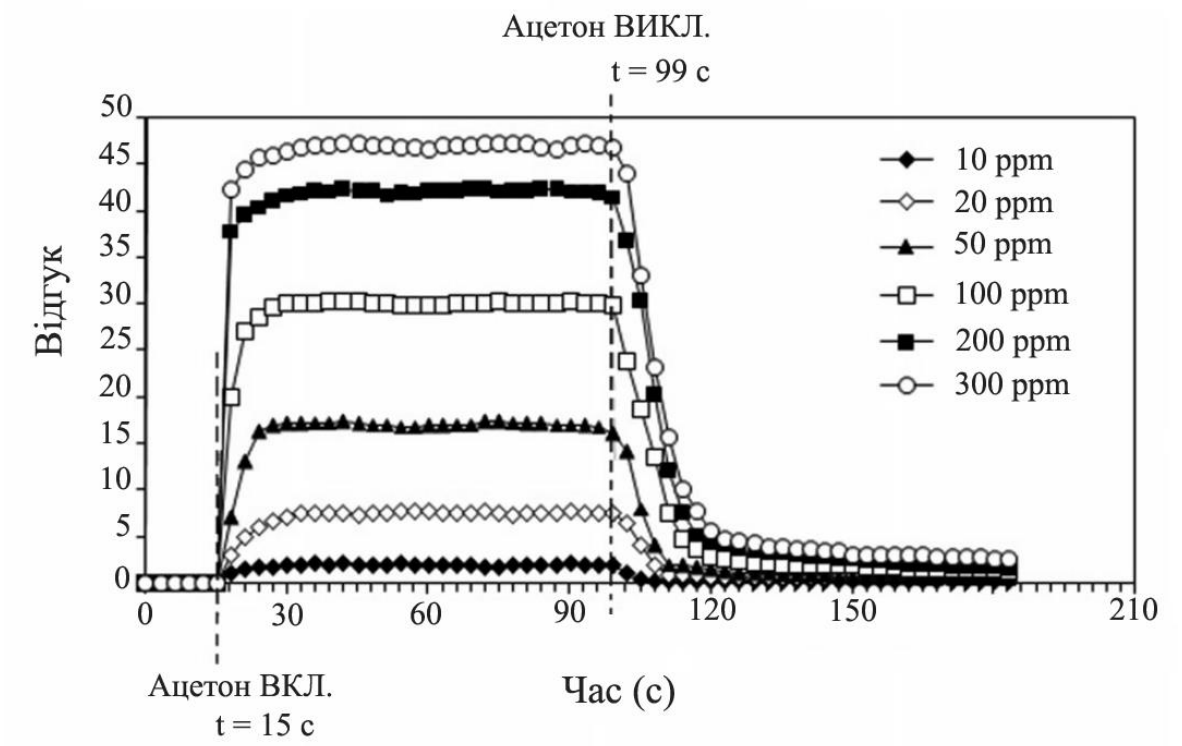

Рис.6 Динамічний відгук тонкої плівки ZnO, для різних концентрацій парів ацетону при робочій температурі 280 ° С.

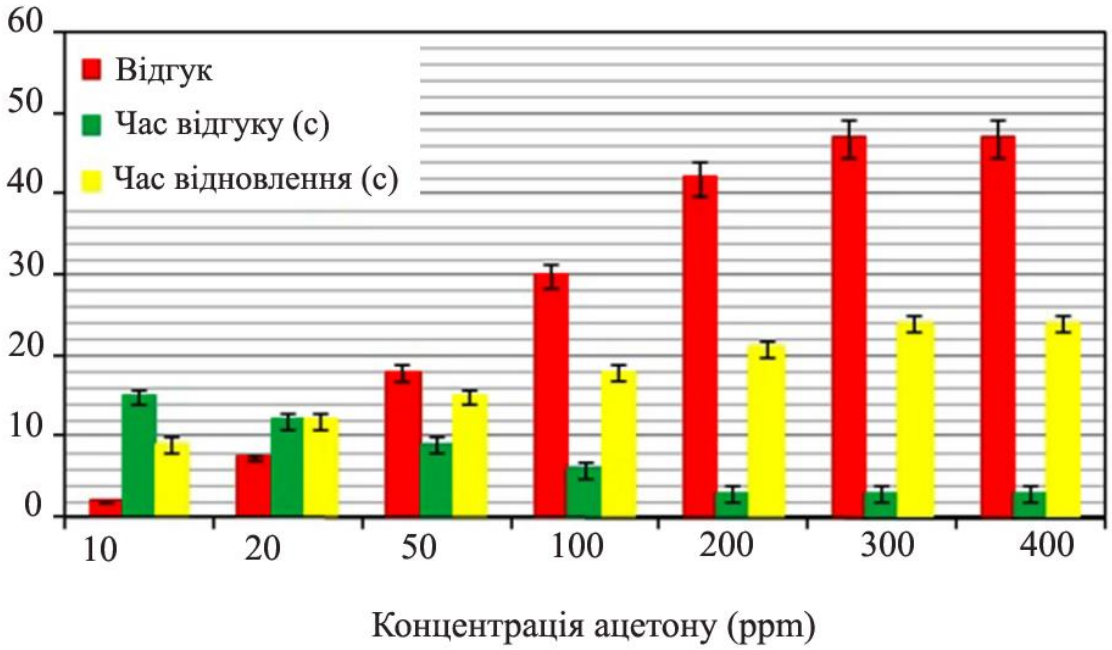

Рис.7 Відгук, час відгуку і час відновлення тонкої плівки ZnO, як функція концентрації ацетону при робочій температурі 280 °С.

Подробиці опублікованих робіт по чутливості тонких плівок *ZnO* до газів ацетону, отриманих різними методами [23, 28, 35, 38-41], і результати цих досліджень наведені в таблиці 3. Порівняння результатів показує багато відмінностей між виготовленими різними методами зразками; проте, схоже, що зразок, розглянутий в цій роботі, може бути хорошим кандидатом в якості сенсора ацетону. Відмінності між результатами, наведеними в таблиці 3, можуть бути пов'язані з різними факторами, такими як спосіб і умови виготовлення, підкладка, товщина і електрод, які, в свою чергу, впливають на кристалічність, пористість, морфологію поверхні, а також на механізм виміру.

Крім чистого ZnO, є багато повідомлень про чутливість до парів ацетону інших напівпровідників оксидів металів, таких як WO_3 [42], α-Fe_2O_3 [43], In_2O_3 [44], SnO_2 [45] і Fe_2O_4 [46] легований *ZnO* [38, 47, 48], зведення їх результатів наведено в таблиці 4. З результатів, наведених в цій роботі і таблицях

3 та 4, можна зробити висновок, що *ZnO* добре підходить для виявлення парів ацетону.

Щоб вивчити відтворюваність сенсора ацетону на основі тонкої плівки *ZnO*, реакцію зразка тестували на 100 ppm ацетону при робочій температурі 280 °C три рази поспіль. Результати цього тесту представлені на рис. 8 і показують хорошу відтворюваність зразка. Також була досліджена стабільність ацетонового сенсора на основі тонкої плівки *ZnO*. З цією метою проведено тестування реакції зразка на 100 ppm ацетону при робочій температурі 280 ° C в залежності від дня з кроком 3 дні протягом 21 дня (рис. 9). Можна бачити, що відгук зразка зменшується з проміжком часу з 30 до 26 (стабільність близько 87%), а потім встановлюється сталий стан. Зменшення відгуку може бути пов'язано з реакцією поверхні плівки з навколишнім середовищем між і під час вимірювань, особливо з вологістю [34]. Також варто відзначити, що вимірювання чутливості в цьому дослідженні проводилися в сухому повітрі, в той час як на чутливість датчика на основі *ZnO* може впливати відносна вологість. Про вплив відносної вологості на чутливість газового сенсора на основі *ZnO* можна також знайти в літературі [49-51].

Таблиця 3.

Детальна інформація про опубліковані роботи по чутливості до газу ацетону тонких плівок чистого ZnO, отриманих різними методами.

Метод підготовки (морфологія) (Товщина)	Електрод	Підкладка	Робоча температура	Межа виявлення (ppm)	Відгук	Час відгуку/відновлення (с)	Джерела
Піроліз розпиленням (гранульований) (250-300 нм)	Срібна паста (на плівці)	Скло	300	100 25	~46%[a] ~21%[a]	-	[38]
Гідротермальний (як квітка)	Au	керамічна трубка	300	100 50	18.6[b] ~4[b]	7/70 -	[28]
Гідротермальний (наностержень)	Pt (на підкладці)	SiO2/Si	300	100	30.4[b]	5/15	[39]
Гідротермальний (порожнисті мезопористі мікросфери)	Au	керамічна трубка	390	100 10	7.7[b] 2.6[b]	- 3/5	[40]
РЧ розпорошення (гранульоване) (250 нм)	Pt/Ti (на підкладці)	SiO2/Si	400	30	~10%[a]	-	[52]
Золь - гель центрифугування (гранульоване) (80 нм)	Ru (на плівці)	окис алюмінію	200	100	5.76[b]	30/72	[41]
Електроспіннінг (наночастинки)	Au	керамічна трубка	340	100 5	105[b] 36[b]	11/18 -	[35]
Електронний пучок і післявіджиг (100 нм)	Au	SiO2/Si	280	100 10	30[b] 2[b]	6/18 15/9	Ця робота

[a] $\frac{R_a - R_g}{R_a} \cdot 100$

[b] R_a/R_g, (~): значення, наведені в стовпці 6, були отримані з літературних кривих і можуть бути неточними.

Таблиця 4.

Детальна інформація про опубліковані роботи по чутливості до газу ацетону легованих тонких плівок ZnO та інших напівпровідників з оксидів металів.

Матеріал	Робоча температура	Межа виявлення (ppm)	Відгук	Res./Rec. час (с)	Джерела
WO_3	300	200	~108%[a]	237	[42]
Au-WO_3	300	200	~131%[a]	98	[42]
a-Fe_2O_3	300	100	10[b]	33	[43]
a-Fe_2O_3-Au	260	100	20[b]	26	[43]
$In2O_3$	400	25	7[b]	-	[44]
SnO_2	240	50	6.5[b]	-	[45]
Ce-легований Fe_2O_4	200	2000	~157%[a]	38	[46]
In-легований ZnO	300	100	96.8[c]	-	[38]
Sn-легований ZnO	300	400	~131%[a]	-	[47]
Co-легований ZnO	360	100	16[a]	-	[48]

[a] $R_a/R_g \cdot 100$

[b] R_a/R_g, (~)

[c] $\frac{R_a - R_g}{R_a} \cdot 100$: значення, наведені в стовпці 5, отримані з літературних кривих і можуть бути неточними.

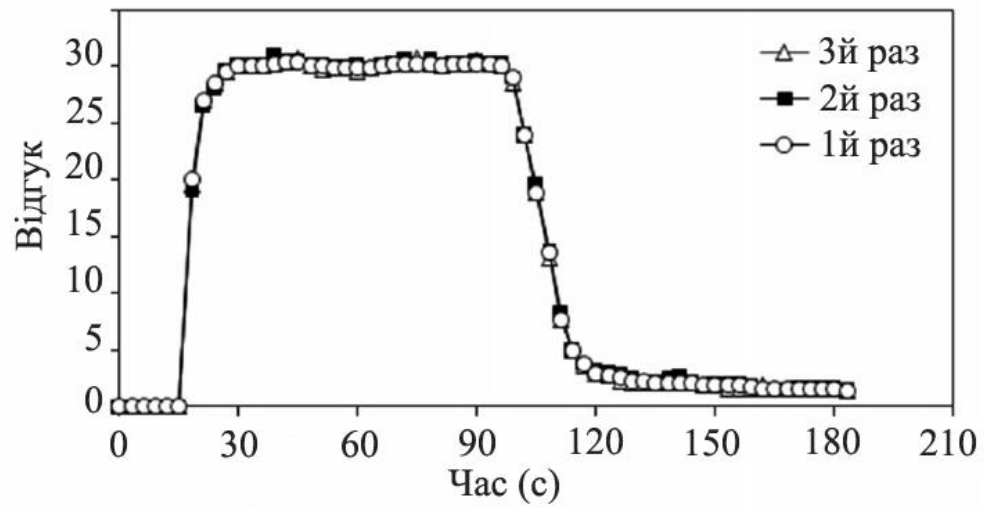

Рис.8. Динамічний відгук тонкої плівки ZnO, отриманої в цій роботі, на ацетон з концентрацією 100 ppm при робочій температурі 280 °C протягом трьох раз, тест відтворюваності датчика

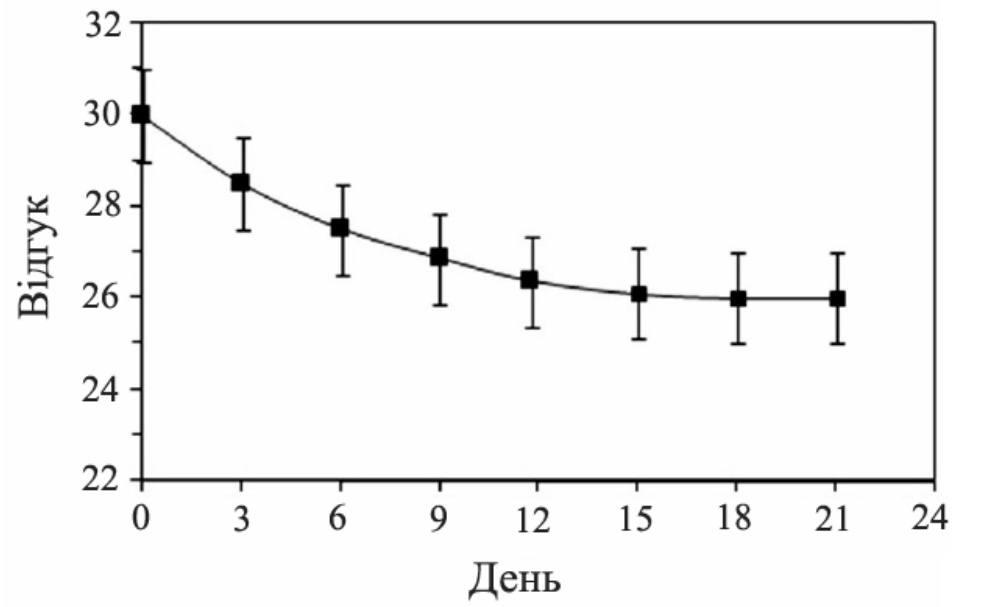

Рис.9. Електричний відгук ацетонового сенсора на основі тонкої плівки ZnO, підготовлений в даній роботі в якості тесту стабільності сенсора.

Висновки

Тонкі плівки *ZnO* товщиною 100 нм з гексагональною кристалографічною структурою вюрцита і кращою орієнтацією (002) були проаналізовані відповідно до знань, отриманими в ході попередніх досліджень, а саме осадженням методом випаровування електронним пучком на підкладку SiO_2 / *Si* та подальшою обробкою. Віджиг при 500 °C з потоком кисню 200 sccm протягом 60 хв. Чутливість і селективність зразка були оптимізовані по відношенню до різних парів ЛОС і робочій температурі. Межа виявлення зразка також досліжувалася в діапазоні 5-400 ppm. Зразок показав кращу чутливість, селективність, а також межу виявлення до парів ацетону в порівнянні з іншими парами в діапазоні температур 200-400 °C, тоді як зазначені параметри були оптимальними при робочій температурі 280 °C. Ацетоновий сенсор на основі тонкої плівки *ZnO* також показав чудову відтворюваність і стабільність близько 87% при робочій температурі 280 ° C.

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