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ENAMEL PREPARATION AND TECHNOLOGY OF ART PRODUCTION

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The purpose of the study is to highlight the process of preparation and disclosure of the technology of making works of art in the technique of hot enamel, as the basis of enamel art. The process of development of artistic enamel in Ukraine in the first quarter of the XXI century was supplemented by technological innovations. On the basis of the experimental approach, the artists developed the latest technologies, which became the basis of new directions of artistic and plastic expression – easel, monumental and plastic forms, artistic relief enamel. Systematic and complex approaches, chemical-physical and technical-technological methods were used to reveal the purpose of the research. The application of technical and technological method of enamel art research allows to reveal the attributive properties of the work, to assess the quality of its performance, to supplement the results of art analysis by revealing the essence of hot enamel technique and its impact on the author's style. The scientific novelty of the obtained results lies in the formulation and development of a topical topic, which in the scientific dimension has received insufficient coverage. The combination of technological methods and academic art research methods creates a synergy of understanding the significance of enamel art. The study of the application of enamel technologies contributes to the disclosure of the process of development of enamel art. The technology of making a work of art in the technique of artistic hot enamel is a complex labor-intensive *process that requires not only the creative inspiration of the artist, but also the knowledge, skills and competencies associated with the technology of making the work. Enameling technology is divided into four stages: preparation of the work under the enamel, application of enamel, firing of enamel and processing of the work. Technical conditions affect the possibility of realization of the figurative and stylistic idea of the author. The results of understanding the essence of the process of technology and methods of enamel works can serve as an important component of the study of modern problems of art history and the development of enamel art.*

Key words: enamel art, technique, technology, hot enamel, cold enamel, artistic enamel.

Introduction. Historiographical research of the development of enamel art gave little attention to the enameling technique, its composite structural elements, experimental verification of enamel recipes and their modernization with due account for the enhancement of the color range and manufacturing technologies. When investigating the enamel art, the researchers mostly consider an issue of the artist's creative work, imagery and stylistic peculiarities of their artworks, as well as the history of enamel art based on the method of art analysis and historical approach (Kyiv, 2020) [1].

To confirm this assumption, we can cite the science opinions of such scientists as Y. Dovhan, L. Pasichnyk, R. Shmahalo and O. Barbalat, who conducted studies in the field of hot enamel technology. In particular, Yuliia Dovhan states, that when processing and analyzing the available literary sources, she found that in science terms the art of artistic enamel in Ukraine remains poorly studied, and comprehensive researches on this issue are close to nonexistent. Namely: «there are no works dedicated to the technology and methods of execution of enamel artworks by contemporary Ukrainian artists» (Kharkiv, 2009) [2, 16].

It is important to consider the technical characteristics of enamel and enameling technology based on the technical and technological methods. The application of technical and technological methods of research of the fundamental concepts of enamel art allows to supplement the results of art analysis by revealing the essence of the technique of hot enamel and its impact on the author's style.

Main part. Materials and methods. In the first half of the 19th century, Jules Labarte embarked on a study of the technique used to make transparent enamel. In 1847 his book was published, which dealt with the works of art from the collection Debruge-Duménil (Paris, 1847) [3]. In addition to the detailed description of art objects, Jules Labarte gave a detailed description of the types of artistic activities and identified three types of enamel: inlaid enamel, transparent enamel and painted enamel. He also enlarged upon the description of the technique used to make transparent enamel and the variety of its color gamma.

A similar work was published in 1875 by the German art expert B. Bucher, who published a two-volume «History of Technical Arts», in which he gave a brief overview of the manufacture of products using the technique of transparent enamel. (Stuttgart, 1886) [4] At the end of the 19th century, the French historian Émile Molinier published a book, which dealt with the origins of the technique of transparent enamel. (Paris, 1891) [5] In general, this art form became the subject of study at the close of the 20th century. Since then, the technology of manufacturing enamel products is considered as a subject of study in the vocational schools. (Moskva, 1986) [6] In Ukraine, Rostyslav Shmahalo (Lviv, 2015) [7] and Yuliia Borodai (Kyiv, 2013) [8] devoted their works to this issue.

Thus, it can be said that the historiography of the problem of research of artistic enamel technology in Ukrainian art history is represented by a few publications, which confirms the relevance of study of a problem concerning the method of making art objects in the technique of artistic enamel.

However, the specificity of enamel as a form of fine art and applied art lies in the fact that it is intimately connected with a technology, which is the driving force of development of enamel art. As summarized by Yuliia Dovhan, the uniqueness of enamel artworks precludes the series production and mass production; unexpected results are the impetus for numerous experiments and innovative techniques; the range of color palette and the variety of textures, the ability to create volume and imitation of traditional art forms (painting in oil and water colors, art drawing, etc.) give grounds for the implementation of a much wider range of artistic conceptions. The main criteria that draw attention to the enamel art of monumentalists, easel painters, graphic artists and sculptors include versatility, uniqueness, three-dimensionality, polychrome and durability (Kyiv, 2015) [9, 17].

Technical characteristics of enamel. Enamel is a vitreous solid solution of silica, alumina and other oxides. This low–melting glass melts at a temperature lower than the melting point of metals, on which it is applied in powder form. It should be noted that the characteristics of enamel, in addition to decorative properties, also include protection properties and anticorrosion properties efficacious against both atmospheric action and effects of chemicals. This property allows the use of hot enamel technique in the architectural decoration of buildings, as well as in the industrial production.

The chemical composition of enamels is different and varies in a wide range depending on the purpose. D. I. Mendeleev considered enamel as a solution of more refractory glass-like compounds in low-melting materials.

The proportion of both substances should be selected in such a way that, during cooling and curing of the enamel, materials should not give off particulate matter in crystalline form resulting in defect precipitation. It may occur when the silicon oxide and other refractory compounds prevail in the enamel composition. On the other hand, the excessive low-melting compounds, such as sodium oxide and potassium oxides, make the enamel weak in consequence of which it easily corroded by acids, cracks and even dissolves in hot water (like soluble glass). Excessive lead oxide is also undesirable, because the enamel becomes soft, and a knife would leave scratches on it. However, when alloyed with other silicates and borates, the lead oxide forms a quite strong enamel, and beside that improves the luster, color, brightness and high fusibility. This accounts for the widespread use of lead oxide for the preparation of decorative enamels in the past. It should be noted that this fact is important for the art criticism and attribution of the works.

Lead oxide, potassium oxide and sodium oxide increase the fusibility of enamels, but at the same time make them less resistant to external conditions. Other compounds, such as silicon oxide, aluminum oxide and magnesium oxide, on the contrary, increase the strength of enamel and its refractory quality. For obtaining colored enamels, metal oxides (lead, cobalt, nickel, etc.) are also added, which act as pigments in the chemical composition of the enamel.

The salts and oxides of metals give color to enamel mixtures. The researcher Oleksandra Barbalat gives a sacred definition of colors. For example: a combination of silver, antimony oxide, titanium acid and uranium oxide are the foundation shades of yellow, which endue the product with a symbolic presence of the Holy Spirit, divine revelation and enlightenment. Iron oxide in combination with other compounds forms red color. Metallic copper, lead chromate, potassium dichromate and gold compounds provide the basis for transparent and opaque shades of red, which symbolizes the Blood of Christ shed for the salvation of people, and hence his love for mankind. The shades of brown, gray, black and similar colors appear through chromic iron. Thus, tin oxide produces white color, which represents an inviolable symbol of holiness, purity and spirituality. At the same time, manganese oxide and cobalt oxide provide the basis for violet color, which represents the sky or heaven for early Christians.

Today, it’s associated with the color of eternity, which symbolizes humility, piety and expresses the idea of self-sacrifice. Copper oxide and tin oxide with cupric phosphate create the range of blue-green and turquoise-azure colors that symbolize the earthly life, spring, nature's awakening and youth. Cobalt oxides create the varieties of blue and cyan, and as well as violet, represent the eternity and infinity of all things (NACAM, 2019) [10, 121].

In Ukraine, the artists adverted to the use of this ancient technique and independently conducted experiments in order to create enamel mass, more so because the technical difficulties encountered in the past, do not exist now. They try to combine and melt together low-melting enamels of various color gamma for their artworks.

There are three types of enamels: transparent enamel, opaque enamel and opal enamel. Transparent or vitreous enamels are used to cover gold and silverwares. When enameled smooth or engraved, areas of metal shine through the enamel, they are complemented by its luster and color. Transparent enamels have a bright luster and pure deep color; they play and shimmer on a carved metal background.

It is common practice to prepare the base alloy, so called flux, then add different dyes to this colorless alloy and re-melt again in order to obtain colored transparent enamel and opaque enamel. For transparent and the most fusible enamels the flux of the following structure (mass fraction, %)

shall be used: silicon oxide – 21.8; barium oxide – 5.5; sodium oxide – 8.8; titanium oxide – 2.4; lead oxide – 61.5 [6, 19]

The composition of the fluxes includes the following components: white siliceous sand crushed to a powder, ordinary clear colorless glass crushed to a powder and borax (sodium salt of boric acid) calcified on the iron sheet in order to remove water. The introduction of borax facilitates and accelerates the boiling of the mass, increases the fusibility without strength reduction and when using in large quantities it throws a peculiar greasy luster on the enamel, which is appropriate for the early Venetian enameled wares and low-melting enamels. Besides, borax promotes a stronger connection of the enamel with the metal after simmering on the finished product. The flux also consists of potash, which contains potassium oxide (up to 68%). Potash additives not only add fusibility, but also color purity, strength and luster to the flux. The flux contains a boric acid (in crystals or powder), which increases the fusibility and clarification of the enamel during melting, baking soda pre–calcined on the iron sheet (contains sodium oxide up to 58%), table salt crushed to a fine powder and red lead paint (heavy red powder) or lead monoxide (heavy grayish-yellow powder). It was experimentally proved that the better and more thoroughly powders are mixed during the preparation of fluxes, the faster their alloy age and more homogeneous their composition.

The fluxes differ according to purpose and they are designated by numbers, Their composition depends on the metal. The formula of ancient fluxes, which are simpler in composition, are given in the Table below. For example, numbers 12 and 13 are used for enameling using low carbon steel.

Composition of flux (%, mass percentage)	**Numbering of fluxes in composition**												
										0	1	2	3
quartz		2								0	0		8
glass									50			1	
borax													
potash										0	6		
boric acid													0
baking soda												,7	0
table salt													
red lead paint		0				5	0		50	0	5		0

The flux should be melted in graphite crucibles or ceramic crucibles. The crucible is preheated in the muffle, and the mixture is poured in small portions to avoid cooling of the heated crucible. The experience of melting flux in the workshop of the Museum of painted enamel (in Dnipro) shows that it is better to make two backfills: immediately after melting of the first batch, the second batch is made. First, the composition turns into a granular mass, which then melts and begins to boil with the release of gases. The degree of readiness can be determined by sampling. For this purpose, a long burning hot steel hook is immersed into the melted solution and removed. If the flux is stretched in the form of smooth, thin hair, the flux is ready for use. For cooling and clarification of the flux, it is poured from the crucible into the water. The resulting flux shall be pounded with a pestle, crushed to a fine powder and dried.

Crude mixtures are fused at a higher temperature than ready-made alloys of the same composition, so the temperature in the muffle must be high. Multicomponent mixtures are melted more easily than pure materials taken apart. There are other more complex recipes for fluxes. Ready-mixed and well-dried fluxes shall be stored in a tightly closed glass container carefully protected from dust and other contaminants.

However, it is very difficult to fuse the flux by yourself following old recipes. It is very important to know the melting conditions and sequence, but this data are usually not available. In order to distill the lost secret and achieve success, you have to conduct multiple studies and carry out experiments with options for mixing and melting the components specified in the recipes.

When preparing easily-fusible enamels, which can be simmered on the alloys with a melting point below 800°C (for example, low-grade alloys of gold, silver and brass), the flux of the following composition can be used. First of all, the following mixture shall be fused in a crucible: quartz (powder) – 10 parts, red lead oxide (powder) – 10 parts and baking soda – 3 parts. After fusing, the mixture shall be crushed to a fine powder. You should take 125 parts of this mixture and add baking soda – 20 parts and boric acid – 12 parts. Once this is done, the mixture shall be fused in a crucible and after melting poured on a stone slab. After cooling the mixture shall be crushed to a fine powder.

To obtain colored enamels the dyes shall be added to the base (flux) in different proportions.

Pigments	Enamel color
Iron oxide (*depending on the combination with other elements*)	Yellow, red, brown, gray and black of different shades
Manganese oxide	Violet, brown, gray, black
Copper oxide	Blue, green and their shades
Copper oxide	Copper ruby with transition to pink, purple, gray and turquoise
Cobalt oxide	Blue and shades of blue, cyan
Cobalt oxide in a mixture with other oxides	Violet, gray and black
Chromium oxide	Green
Lead chromate and potassium dichromate	Pink, bright red and brown
Chromic iron	Black and brown
Combination of oxides: chromium, cobalt, tin and potassium	Lilac and carnation
Uranium oxide	Yellow and red-orange
Titanic acid	Yellow
Antimony oxide III	Yellow and orange tones
Nickel oxide	Gray and brown
Iridium oxide	Black
Gold compounds	Gold ruby-shades of red from pink to purple
Tin oxide	Milky white, opaque
Tin oxide with cupric phosphate	Turquoise and azure

Silver compounds	Yellow
Aqueous iron oxide	Ocher

Other dyes are also used. The density and intensity of tones, depends on the amount of oxide: the more oxide, the more intense and bright the color of enamel. Flux plays the same role as water in the watercolor painting. For example, by «diluting» the blue enamel with flux, you can get any number of gradations of light blue and cyan. Mixing of enamels in a powdery condition produces additional tones, but it should be noted that not all enamels can be mixed.

Dyes have different coloring ability. For example, the coloring ability of silver is very high, so 0.1% of silver chloride gives a fairly intense yellow color to the alloy, but you need 7–10% of antimony oxide to get a sufficient yellow color. Coloring ability of gold is especially high. In this respect its surpasses all other substances: 0.04% of gold is enough to receive intensely colored red transparent enamel, so-called «gold ruby».

Flat or opaque enamels are used on copper, as well as on other metals. These enamels are mainly used for the manufacture of enamel works of monumental or easel art. The advantages involve the color brightness, which exceeds the transparent enamels, gloss and richness of colors, as well as the contrasts of exposed surface of metal with the color of enamel. These enamels are obtained by introducing into their composition such substances that are opaque of itself and insoluble in the smelting process (tin oxide, antimony oxide, gypsum). Even if these substances are soluble at high temperatures of heating, they are again released as deposits during cooling of the alloy.

It includes arsenic anhydride (white arsenic), phosphorus compounds, fluorine compounds and copper oxide. During melting, these substances form a homogeneous transparent mass, and during cooling and curing, opaque elements are released and enamel becomes flat. If these additives (such as copper oxide) are introduced into the alloy in large quantities, it immediately turns into a flat red enamel, but if the quantity of additives was minimal, the composition during the first melting can be kept in a transparent state, which disappears upon the prolonged reheating (already in the process of simmering of enamel on the workpiece), and transparent red enamel turns into a flat enamel.

Some artists conduct experiments with the use of colored glass instead of enamel, by melting its crumb directly on the surface of copper-red or steel decorative elements. Besides, they use cold nitro enamels, epoxy resins with hardener, painting them in different colors. This enamel technique should be distinguished during the attribution and expert evaluation of artworks.

Transparent or opal enamels combine to some extent the quality of the first two types. Depending on the light incidence angle, such enamel can look either transparent or opaque with a variety of colors and gradients resembling a thick opal.

In the enamel art the acids and salts are used in addition to enamel in the process of preparation and manufacture of art objects. Nitric acid is used for etching silver blanks, as well as for etching copper and copper alloys for adding a glossy look. Sulfuric acid, which dissolves almost all metals when hot, is used to bleach blanks and finished products. Hydrochloric acid is used to bleach blanks before application of enamel. Boric acid is used for pickling silver blanks before application of enamel and in the manufacture of fluxes. Citric acid and oxalic acid are used to bleach products covered with enamel having low acid resistance. In some cases, a mixture of acids in the following ratio is used for etching: one part of nitric acid, one part of sulfuric acid and 0.02 part of hydrochloric acid.

In the enamel art the borax is used as a stand–alone flux or as a base for all fluxes, and potassium carbonate (potash) is used for oxidation of silver and copper workpieces, as well as for the preparation of degreasing solutions.

From ancient times such metals as pure gold and high carat gold, pure silver and high carat silver, varieties of copper (red copper, pure copper and copper alloys) were used in the enamel art: red brass (alloy of copper with zinc 7–12%) and very rarely bronze, from the middle of the 19th century the use of iron alloys (mild steel and cast iron) for enameling became customary. In the twentieth century aluminum came into common use.

The suitability of any metal for enameling is determined by a number of properties and primarily by softening temperature and deformation temperature preceding the melting point of the metal. This temperature must be above 800°C, i.e. above the temperature of enamel roasting or melting.

In addition to the melting temperature of metal the ability of metals to sustain color and luster, as well as to shine through the transparent enamel after roasting plays an essential role for enamel work. Only precious metals (gold, silver and platinum) have this ability, because oxide films are not formed in the process of roasting and gloss remains under an enamel layer.

Copper and iron alloys do not have this ability. They are oxidized quickly and become dull and dark. In connection with this, these metals are used for flat, opaque enamels. This circumstance necessitated the invention of the method of application of transparent enamels on copper. If it is still desirable to have sites with transparent enamel when enameling copper products, gold or silver foil should be put under enamel on these sites. Blue, cyan and green enamels shine especially brightly on the silver foil, and red and yellow enamels glare on the gold foil. Another way to use transparent enamels on copper is to put transparent enamels not on copper directly, but on the layer of white enamel. It is possible to put both opaque and transparent enamels on a copper zinc alloy, because its gloss remains under a layer of enamel, though its reflective power is far below the brightness of precious metals. In this case, it is possible to put transparent enamel on the layer of white enamel.

Another property of metal that should be considered when using in enamel art involves the thermal coefficient of linear expansion during heating and subsequent cooling. The coefficient of linear expansion of the enamel must correspond to the coefficient of linear expansion of the metal or alloy, on which the enamel is applied, otherwise the enamel will scale off under cooling, despite the scrupulous observance of the technological process. It is desirable to make the base surface rough, because this increases the adhesion of metal to enamels.

The choice of a given metal as a basis for enamel largely determines the parameters of manufacture of the artwork. In majority of cases, this applies to the artworks with transparent, translucent enamels. The luster and color of the base metal shining through a thin layer of transparent enamel gives a special strength and brightness. For the most part, this provision applies to gold. Gold (both pure gold and high carat gold) is a particularly good base. It is slightly deformed when heated and gives brightness and luster to the enamel. In contrast to gold, silver loses shape and retains enamel less well. Copper is an excellent base for enamel, because it has a high melting point. However, transparent enamels, which shine very brightly on gold or silver, look dark on copper, but shine satisfactorily on red brass. Bronze is not considered as a good material for enameling, because adhesion of enamel to bronze is fragile and the enamel crumbles easily. Enamels with a low melting point are used for application on aluminum. Most commonly enamels with a melting point close to 800°C, are not suitable for application, because aluminum melts at 660°C.

Enameling technology. Enameling technology can be divided into four stages: preparation of the workpiece for enameling, application of enamel, enamel roasting and processing of the artwork. When preparing the metal base of the artwork for enamel coating, the surface should be decontaminated, degreased and etched in nitric acid or bleached in a weak solution of sulfuric acid.

When enameling copper or red brass bases, the workpiece should be heated in the furnace until the thinnest oxide film appears on the metal surface due to the contact of hot metal with oxygen. This film is very firmly connected with metal and promotes strong adhesion of enamel to metal. Before application of enamel the treated base shall be cooled. When enameling precious metal wares, it is necessary to perform the procedure for increasing the percentage of precious metals in the surface layer. Depending on the fineness of metal, from 2 to 5 annealing cycles (583 gold) are performed for the gold base and from 2 to 6 annealing cycles (875 silver) are performed for the silver base.

It was proved by experimenting, that the high content of copper in the surface layer of silver wares complicates the use of red enamel «gold ruby», because it turns black. One of the characteristic features of enamel products lies in the fact that low-grade gold and silver alloys are not suitable for enameling.

There are several ways to apply enamel. In the method of bulk enamel, the application of enamel to the base of the artwork is carried out in powder form with a fraction up to 0.01 mm. Opaque enamel shall be crushed to a homogeneous fine powder, and transparent enamel shall be crushed to a powder fine grains, because it affects the glow of enamel. However, a very fine powder after roasting forms milky spots, which are especially evident in transparent enamels. The homogeneity of the enamel powder mass is important because the small grains melt much faster and have time to burn out before the largest grains begin to melt. As a result, the color of enamel becomes dull and sometimes dirty. The powder shall be flushed with water to remove finely powdered particles formed during grinding. In any case, the enamel must be flushed until the water becomes clean. When preparing opaque enamel, the water may become little cloudy. Small porcelain cups shall be filled with enamel mass with an indication of the enamel number.

The milled enamel is then mixed with water and applied in the form of slurry on the prepared base of the workpiece with a brush or a narrow metal spatula. To even out the enamel layer, shake the product before use. It is necessary to put enamel on the reverse side of the thin plate. In other words, at first you should apply counter enamel, allow it to dry out a little, carefully turn the workpiece and do the same on the front.

Septate or champlevé enamels do not fill the hollows completely, because some kinds of enamel become cloudy and dull when applying a layer too thick.

The full height of the enamel layer should be achieved by means of gradual filling and sometimes requires two or four consecutive roasts.

You can use an aerograph to apply enamel on the large flat surfaces. According to Yuliia Borodai, this method of enamel coating is the most popular. Through the use of stencils, you can perform the most complex enamel works using the spraying technique [8, 51]. The technology of enamel coating is somewhat different in this case. Milled and well screened out enamel shall be miscible with water, to which dextrin or urea is added calculated as 2–2.5 gram per liter of enamel solution (casting slip) for fixing. Once this is done, you can apply enamel on the surface making sure that the layer is homogeneous and not thick.

When applying enamel on flat surfaces, it should be applied simultaneously on both sides of the plate. In that case, the counter enamel applied to the reverse side is designed to prevent distortion of the base of the workpiece, which is inevitable due to the different coefficients of linear expansion of enamel and metal. After applying the enamel, the product shall be thoroughly dried. First of all, you should remove water by applying a piece of paper to the edge of the workpiece and dry it by placing on top of the heated muffle until the powder becomes dry and no more steam is released.

Roasting of enamel is carried out at the temperature of 600–800°C. Each item fired in the furnace must be placed on a special stand, because successful roasting depends largely on its quality. The stand must hold shape when heated and neither come into contact with molten enamel, nor stick to enamel or raise the scale on its surface. Products made of nickel or nickel alloys, as well as chromium-nickel steel are best suited for the stand, because they are less deformed and oxidized when heated. If the stand is made of common steel, it should be chalked to prevent formation of scale. The shape of the stand is determined by the shape of the workpiece.

Different enamels have different melting points, so before proceeding with application of enamel on the workpiece, it is necessary to check the melting temperature range of the most fusible and refractory enamels. For this purpose, the enamel shall be tested on another metal plate the same as the workpiece itself. All the enamels shall be placed on this plate and heated. In case of small melting temperature range of enamels, the results are positive and you are ready for application of enamel on the main workpiece. If as a result of the test it has been established that low-melting enamels burn out at the melting temperature for refractory enamels, they are either completely excluded, or applied and roasted after firing refractory enamels. When heated, the surface of enamel becomes leveled. When the surface becomes red and acquires a glassy luster, the workpiece can be removed from the furnace for gradual cooling.

If after removal from the furnace the flat plate becomes distorted, it is subject to hot straightening. If after the first application and firing of enamel, minor defects (cracks, bubbles, exposed surface of metal) appear on the surface, they are corrected by reapplication of enamel, drying and roasting. Then the workpiece is subject to final processing: bleach of the metal parts of the workpiece free from the enamel layer, which are covered with an oxide film as a result of enamel roasting. Bleaching is performed in a weak solution of sulfuric acid (15%), because enamels that are not resistant to acids can fade and lose brightness and luster.

There is another technique of enamel coating with arbitrary color mixing, but it is rarely used because of its complexity and unpredictability of the result. In a given setting, the pattern emerges during roasting. It is important to select enamel according to melting point and compatibility of enamels by their physical properties. However, this method attracts artists, because due to the mixture of transparent, opaque and translucent enamels, the pattern becomes unexpected and inimitable in its color gamma, which is the essence of painted enamel.

For art analysis of the artworks made in the technique of hot enamel, it is important to consider the techniques used by artists for enamel processing in order to give texture to the artworks. In particular, according to Yuliia Borodai, this refers to crackle (scratch), scratching, overlays, enamel frit and application of enamel to an embossed relief [8, 51].

Crackle is obtained by applying refractory enamel on fusible enamel, which at different melting temperatures results in the rupture of fusible enamel and the appearance of texture. Scratching is carried out by running a sharp engraving tool over dark opaque enamel laid on a light tone, or vice versa. This results in a graphic drawing. Overlays may be various. Most commonly they are used in the decoration of an enamel product. Enamel frit in in different variations is developed by Oleksandr Borodai to the fullest extent possible. The essence of this technique is to mix enamels or fluxes having different fractions. Frit particles are melted only partially, because they have a higher melting point. Application of enamel to an embossed relief involves preliminary preparation of the base in the technique of embossing and application of enamel.

Conclusion. Technology for the production of the artwork in the technique of artistic hot enamel is a complex and time–consuming process, which requires not only the creative inspiration of the artist, but also the knowledge of the properties of enamel, skills and competences associated with the technology of production of the artwork. Enameling technology can be divided into four stages: preparation of the workpiece for enameling, application of enamel, enamel roasting and processing of the artwork. Technical conditions affect the ability to put into practice the figurative and stylistic ideas of the author. The application of technical and technological method of research of enamel art allows to reveal the attributive properties of the artwork, evaluate the quality of performance and supplement the results of art analysis by revealing the essence of the technique of hot enamel and its impact on the author's style.

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