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Color characteristics evaluation of ceramic brick made of coaly argillites

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Abstract. It have been presented the study results of the ash content and mineral composition of the waste from the enrichment of carbonaceous argillites by thermal and X-ray phase analyzes. It has been shown using of coal waste as the main raw material for the production of building ceramics. Problems are noted in assessing and choosing the name of the color of ceramic bricks based on industrial wastes. A method for determining and adjusting color using a synthesized digital palette is described. The proposed use of search engines and digital color databases to determine the names of the colors of building ceramic materials.

1. Introduction

Researchers have been interested of using of coal preparation waste in the manufacture of ceramic products for many decades [1, 2]. There is a positive experience of brick factories which used coal waste as the main ceramic raw material [3]. Along with the CHP ashes, coal waste is included in the composition of potential ceramic technogenic raw materials in GOST (USSR Standard-Setting Authority) 530-2012 "Ceramic brick and stone. General technical conditions". Advantages and disadvantages of coal waste are well studied and published [4-10]. Their description and analysis can make a separate article. Studies of the decorative properties of building ceramics from the beneficiation of coaly argillites are considered in the current paper.

Compared to rock refuse of coal mines, this waste is characterized by a higher content of coal, an unstable material composition and a lower content of the sand fraction. For the developed ceramic composition materials of matrix structure based on coally argillites enrichment, the main obstacle is the increased carbon content in them, which can lead to the destruction of contacts at the granule boundaries in the firing process [11]. However, the outstanding issues of improving the product appearance are especially important for the production of face and decorative bricks.

An objective color assessment is very important to characterize the decorative properties of ceramic bricks. From the point of view of building physics, the color perception of an object by a human eye depends on the absorption by the material surface of the spectrum part of visible white light falling on it (electromagnetic oscillations with a wavelength of 380-780 nm). Thus, many objective and subjective factors will influence the color of ceramic products. For example, lighting conditions, the number of light sources, its amplitude and spectral characteristic, optically active centers on the surface of ceramics, etc.

An atlas of architectural colors is commonly used during architectural and finishing works for color identification and selection of color schemes in Russian Federation. It consists of 96 dyestuff test paper sheet, prepared mainly from two types of pigments [13]. In Western Europe the German color standard "RAL Classic" catalog has been distributed, it developed in the first half of the 20th century

by the State Committee on terms of supply and quality assurance [14]. The classic RAL color collection has become the standard for choosing colors, includes 213 colors and has four-digit numeration of shades in 9 basic directions.

Nowadays, these and other color systems are actively used for the correct understanding and color assessment in construction practice. Unfortunately, numbered color palettes which are demand in paint and varnish production, architecture and design (graphic, industrial, interior, etc.), have hardly ever used in assessing the color characteristics of decorative ceramics. As a result, there is no generally accepted system and color characteristic on the market of volume-colored ceramic products. Typically, a brick color line has three basic color directions: standard brick-red, light white or deep brown. In industrial slang, brick is often called the name of products or products with a characteristic color: "orange", "apricot", "straw", "peach", "ivory", "chocolate", etc. [15].

Sometimes, this leads to confusion in assessing the color of bricks and can confuse the consumer. For example, the color of the brick "ivory" can vary considerably in color depending on the manufacturer.

In addition, there is no regulation of the names of these colors. As a result, different manufacturers call the same basic color direction differently: "straw-colored", "yellow", "sand", etc.

There are also problems with the name and understanding of the base colors shades. For example, the color named "chocolate" of the same name can have a whole range of shades from "dark" to "light-milk".

Thus, it is necessary to create a system for accurately determining and evaluating colored bricks in the production and on the consumer market of decorative ceramic building materials.

The aim of the study was to develop a methodology for assessing the color characteristics of ceramic materials using the example of a brick made of clay and enrichment wastes of coaly argillites.

2. Methods and objects of study

Standard and precision methods of modern building materials science were used for the study of raw materials and ceramic samples: methods of physical and mechanical tests; methods of thermal analysis, X-ray diffractometry, laser granulometry, optical and electron microscopy.

For developing the methodology for determining the color characteristics of ceramic samples, the following were used: SONY digital camera (Cyber-shot DSC-RX 100); Hewlett-Packard color inkjet or laser printer (HP Photosmart 8153); computer with raster and vector graphics applications "Adobe" or "Corel".

For current research were used ceramic samples and bricks from the dry enrichment of coal from the Korkinsky coal deposit (KCD) and clay raw materials. A low-dispersed, moderately-plastic, low-melting loam of the Novokuznetsk deposit (Kemerovo Region) was used to manufacture cylinder samples using the semi-dry pressing technology. The study results of particle size, chemical and mineralogical compositions and ceramic-technological properties of raw materials are given in the previous journal issue (2018) [16].

At present, the problem of the effective use of KCD coal waste products for the Chelyabinsk region is particularly relevant, since the volume of accumulated workings, according to various estimates, is about 1 billion cubic meters [17]. Dry enrichment at the field is also used, which consists in crushing and classifying coaly argillites to obtain various classes by fineness. The content of coal in them can reach up to 20-22 %. Coal enrichment wastes are represented by three size classes: 0-13 mm; 13-40 mm and 40-80 mm. The content of coaly particles in each class is significantly different (Table 1).

Table 1. Ash content of coaly argillites enrichment wastes of KCD depending on the fineness.

Wastes fineness, mm						
0-1	1-3	3-6	6-13	13-25	25-50	More than 50
72-74	76-78	82-83	85-88	80-82	75-78	85-92

With an increase of waste fineness, their ash content increases and the fuel potential decreases [18, 19]. The ash content of the rock with a particle size of less than 1 mm varies from 55 to 73 %, the ash content of large fractions (more than 50 mm) reaches 85-92 %. This indicator is important when choosing the method of mass preparation of the ceramic charge and ultimately affects the performance and decorative properties of ceramic brick [20]. The best results were obtained from coal waste with a particle size of 40-80 mm.

Method of X-ray phase and thermal studies of the crushed raw materials were carried out to specify the mineral composition of the enrichment waste of coaly argillites with a particle size of 40-80 mm (figures 1 and 2).
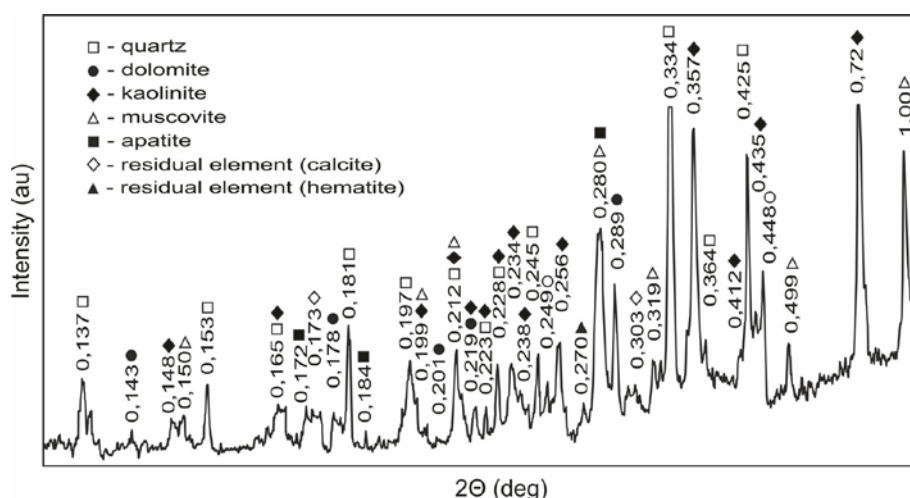

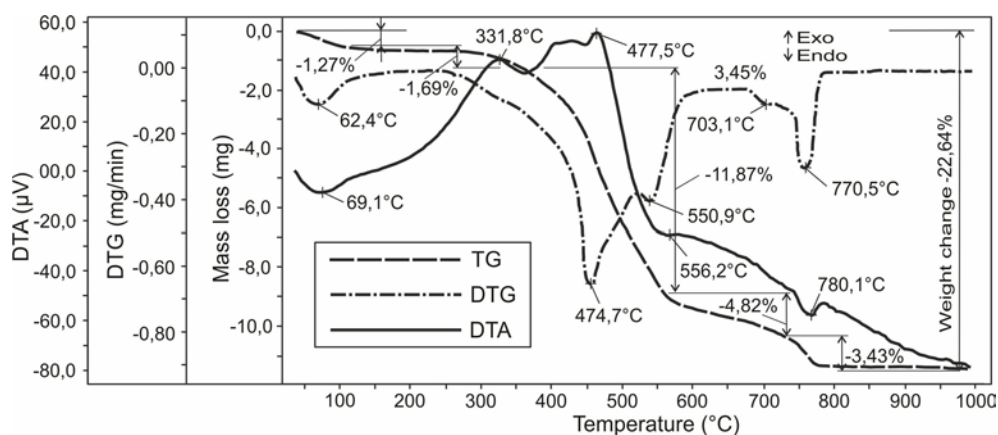**Figure 1.** X-ray diffractogram of enrichment wastes of KCD class 40-80 mm coaly argillites.

Figure 2. Derivatogram of enrichment waste of coaly argillites class 40-80 mm.

Differential-thermal analysis of the wastes enrichment of coaly argillites confirmed the presence of kaolinite by a characteristic endothermic peak at 550 °C (figure 2). The presence of this peak is due to the dehydration of the clay mineral. During heatinf of wastes, adsorption moisture is removed first (exothermic peak at 69 °C), then destruction (331 °C) and oxidation (477 °C) of organic matter, at which the mass loss was 11.87 %. Calcite and dolomite are diagnosed by the endothermic dissociation of carbonates with a maximum at 780 °C.

The radiograph shows diffraction peaks (figure 1). Wastes are diagnosed with kaolinite (d/n = 0.712; 0.45 nm), quartz (d/n = 0.405; 0.314; 0.212 nm), muscovite and chlorite. Calcite, siderite, apatite and hematite are identified as impurities. A characteristic amorphous halo appears, which confirms the presence of organic matter (brown coal).

Figure 3. Ceramic brick on the basis of KCD class 40-80 mm enrichment waste of coaly argillites (sample of pilot lot produced at the Berdsky semi-dry pressing brick plant).

Studies have shown that the enrichment wastes of coaly argillites KCD are poor, aluminosilicate raw materials with a high content of coal. According to the content of clay minerals, they belong to the hydromica-kaolinite group and can be used as technogenic raw materials for the production of ceramic bricks (figure 3).

3. Results and discussion

In accordance with the work aim, the authors developed a method of digital analysis of the color characteristics of ceramic material based on the enrichment of coaly argillites. To precise determine the color of the ceramic samples, taking into account the brightness, it have been used their shooting and digital processing.

The technique consisted in determining color using digital software, using the correction for light conditions, features of the light-sensitive matrix of a digital camera, design and ink (color toner) of the printing device. The whole process of determining the color characteristics of the object under study consisted of several stages.

3.1. The first stage

A palette, containing 8 colors to determine the coefficients of color change in real conditions as compared with the reference one was created (figure 4).

Two color synthesis systems based on the additive color models RGB and CMYK were used in developing the color palette. White color was additionally synthesized by adding three RGB color channels. Characteristic colors are presented in table 2.

Table 2. Characteristics of the color palette depending on the method of color synthesis.

Name of the color	Additive color model						
	RGB			CMYK			
	R	G	B	C	M	Y	K
Cyan	0	183	244	94	7	4	0
Magenta	246	85	160	5	95	7	0
Yellow	255	243	36	8	0	87	0
Key color (black)	0	0	0	58	46	41	95
Red	255	0	0	0	100	97	0
Green	0	255	0	91	0	100	0
Blue	0	0	255	83	72	0	0
White	255	255	255	0	0	0	0

3.2. The second stage

At this stage of the research, an original color palette was developed on a color laser printer. Then, at the same time, a digital camera was taken of a printed color palette, laboratory ceramic samples and

ceramic bricks from the enrichment of carbonaceous mudstones under the same light conditions (figure 5).
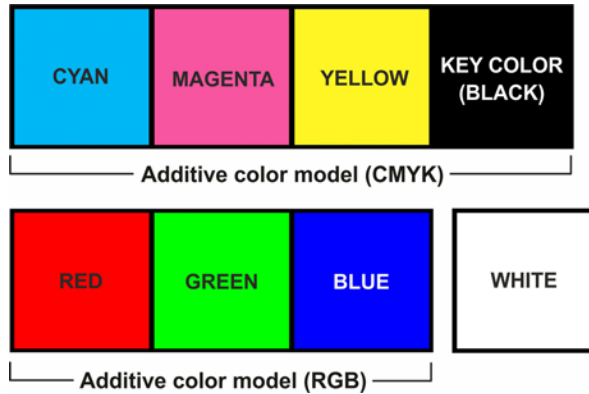

Figure 4. Original color palette, digitally synthesized.
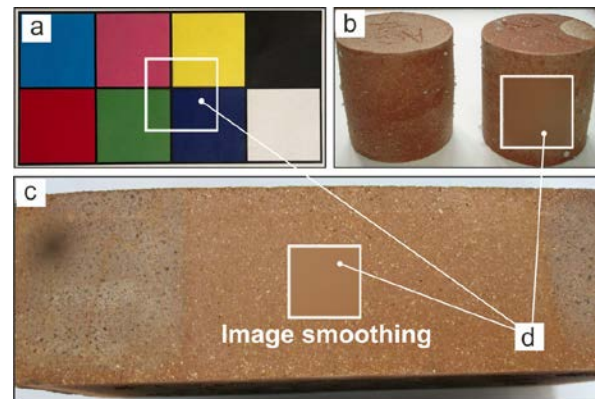

Figure 5. Digital images of the printed color palette (a), ceramic samples (b), bricks based on the enrichment of coaly argillites (c), photographed under the same conditions, and smoothed surface areas of objects (d).

3.3. The third stage

At this stage of the study, smoothing of photographic images was carried out in order to eliminate possible distortions associated with microdefects in the samples, as well as reduce errors in the digital identification of color channels (Fig. 5, d). Each area of a particular color palette and the characteristic surfaces of ceramic samples were processed in the editor "Corel PHOTO-PAINT" using the "Blur" tool (the "Effects" tab in the top menu bar).

3.4. The fourth stage

At the fourth stage of the work, a comparison was made between the original and the photographed color palette. The obtained values of the color channels of the RGB and CMYK additive system were compared with the original ones by calculating correction factors determined by the "synthesized original" / "digitized photo" ratio. The results are shown in table 3.

Table 3. Comparison of the original and pictures of the color palette.

Color name	Original			Photography			Coefficient			The average coefficient for each color
	R	G	B	R	G	B	R	G	B	
Cyan	0	183	244	1	87	141	0	2.10	1.73	1.28
Magenta	246	85	160	176	58	84	1.40	1.46	1.90	1.59
Yellow	255	243	36	230	203	53	1.11	1.20	0.68	1.00
Key color	0	0	0	32	31	27	0	0	0	0
Red	255	0	0	149	0	19	1.71	0	0	1.71
Green	0	255	0	62	110	53	0	2,32	0	2.32
Blue	0	0	255	29	37	77	0	0	3.31	3.31
White	255	255	255	228	219	208	1.12	1.16	1.22	1.17

The obtained correction coefficients of the color channels made it possible to reduce inaccuracies and errors due to the light conditions when determining the color of the samples. The subjectivity of assessing the color characteristics of decorative ceramic materials has decreased. According to the

corrected parameters of the RGB-model color channels, it was obtained an "objective" color of ceramics from coaly argillites: R = 165-168, G = 122-124, B = 76-81. Based on the entered RGB values (figure 6), the name of the color of the ceramic brick was determined in a search system of a digital color database (for example, Yandex RGB). In the considered example, in the absence of an exact match, the closest color with the name "Chamois" was chosen.
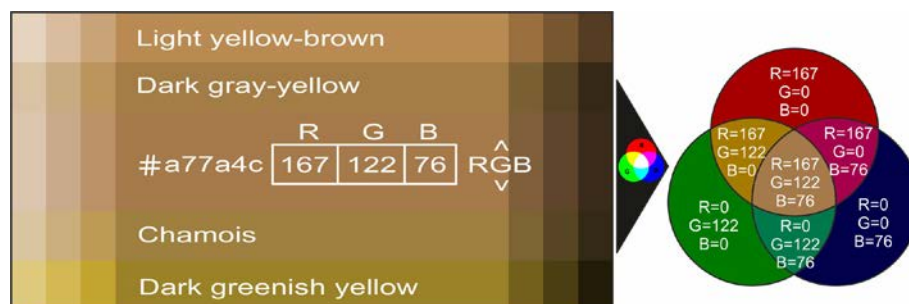

Figure 6. RGB Color Database Search Color Detection System.

4. Conclusion

An assessment of the color characteristics of ceramic materials based on the enrichment of carbonaceous mudstones was carried out using the developed color correction method using a synthesized digital palette. The proposed use of digital color database to determine the names of colors. It have been determined the directions for further research of the objective assessment of the building materials color.

Acknowledgments

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