ISSN: 2664-9640

Rongchang clay ingredient principle and characteristic analysis of red clay

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Abstract

Looking at the existing research results, the vast majority of researchers' research on laterite mines is mostly related to the coastal areas along the river, and the research on rongchang clay related topics does not give too many conclusions. In order to scientifically develop and utilize the clay resources in Rongchang area, relevant studies show that the basic properties of various raw ores of Rongchang clay were tested by using analytical techniques such as XRD and XRF flake analysis, and were compared with the clay raw materials in other regions. The results show that the main chemical components of clay in Rongchang area are SiO2, Al2O3 and Fe2O3, of which SiO2 is SiO2 The content is high, and the basic formula pottery test reflects that the molding performance is good; the crystal phase of Rongchang clay ore is dominated by quartz, followed by kaolinite and muscovite; the sintering temperature range of single clay raw materials is 1080~1150 °C; the water absorption rate of ancient Foshan shale, Rongchang white sand, Rongchang red clay, and Taodu Er Mine No. 3 clay is close to 0%, which is porcelainized or overburned, with certain fustenability; Guangfu Yellow Sand, Taodu No. 2 Mine No. 1, Taodu No. 2 Clay has a high water absorption rate, mostly sandy clay The plasticity of clay in Rongchang area is slightly lower than that of purple sand raw materials in Yixing; in addition, the heavy metal content in Rongchang clay is small, which is not enough to cause the heavy metal dissolution hazard in ceramic products.

Keywords

Rongchang clay; ingredient principle; red clay; mineral properties.

1. Introduction

China is rich in purple sand resources, in Jiangsu, Jiangxi, Shanxi, Guangxi, Yunnan, Hunan and other places are rich in purple sand resources, yixing Jiangsu purple sand is more famous. Purple sand resources in different regions have their own characteristics, but all of them can be used for purple sand production. Anfu Town in Rongchang, Chongqing is one of the three major pottery capitals in China. The antao produced in this area is known as the "Four Ceramics of China" along with Zishai Pottery in Yixing, Jiangsu province, Jianshui Pottery in Yunnan Province and Qinzhou pottery in Guangxi Province. Rongchang pottery has a wide variety of types, mainly in the production of arts and crafts pottery, garden art pottery and daily pottery, mainly because of the use of local red clay. It is characterized by fine clay, strong viscous plasticity and good firing performance. Therefore, the ceramic body is glazed with rich glaze color, smooth glaze, no natural glaze color, giving people a sense of simplicity, crisp and pleasant tapping sound, and the existence of trace elements that are impervious, good preservation and beneficial to human body [1]. The pottery manufacturing in Rongchang area flourished from the Song Dynasty and became famous throughout the country during the Ming and Qing dynasties. Since 1950s, Rongchang pottery has gradually transformed from traditional production technology to modern production technology. In May 2011, rongchang's pottery making skills were included in the third batch of national intangible cultural Heritage expansion project list, attracting the attention of the local government and all walks of life. Rongchang county is extremel

y rich in clay resources, there are many pottery. The clay is mainly red clay with high iron cont ent, and white clay with low iron content. The pottery color is mainly red and brown. Relying on the advantage of ceramic resources, Rongchang regards the development of cultural and cr eative industries based on pottery as a strategic decision to build an innovative city. The autho r of rongchang produced clay mining area with the team through the site investigation and ex ploration sampling, combined with the comprehensive analysis of the sample test, process ex periment research and the feasibility of the product formula, the regularity of rongchang regio n clay resources characteristics and industrial applicability has carried on the exploration, for large scale high level development of rongchang pottery handicraft industry to provide techni cal support.

2. The design principles of the blank

2.1. Analysis of raw materials

After the selection of raw materials for the blank formula, it is a key task to determine the amount of various raw materials used in the blank and glaze, because it is directly related to the quality of the product and the formulation of the process system. The design of the blank formulation is a heavy and complex task. At present, the rapid development of ceramic products, the performance requirements of ceramic products are ever-changing, and there are many kinds of raw materials used in the production of ceramics, and there are great differences in the chemical composition of mineral composition and their process properties, and the standardization of raw materials cannot be achieved. The technology, equipment, management level of enterprises around the world, as well as the performance indicators of ceramic products are affected by a variety of factors, so in the design of the billet formula, can not rely only on theoretical calculations, otherwise, it is difficult to get satisfactory results.

2.2. Formulation design principles

The following basic principles should be followed when designing the formula: (1) The chemical composition should meet the performance requirements of ceramic products. The raw materials should be fully analyzed and compared from the chemical composition, and the performance characteristics of each raw material should be found out, depending on whether they have or are close to the required properties of the product. (2) The performance and ratio of the raw materials used should be able to meet the final physical performance requirements of the production process and products. The purity, forming properties, firing properties, color after firing and the strength and transparency and thermal stability of the raw materials after firing should be considered, and sometimes certain changes should be made in the chemical composition of the blank to meet the physical performance requirements of the product. (3) The scale of existing plants and specific production conditions should be fully considered. The use of formulas cannot be used to change the existing production process parameters in large quantities and invest a lot of money to purchase equipment and technological modifications. When the blank formula is designed, its process parameters should be examined from the aspects of raw material preparation, forming and firing, and take this as the fundamental condition, only such a formula has practical and scientific value. (4) Economic rationality should be considered. Raw materials should be used locally, measured materials should be used, rather than far away, and make the best use of materials. Blank preparation of daily ceramic blanks usually refers to the formation of ceramic raw materials after the batching and processing, the formation of forming properties meet the quality requirements of the multi-component mixture for forming.

2.3. The importance of raw material rationing to the process

According to the forming method of the product, different blanks have different characteristics, respectively, made of 19% to 26% of the water content of the plastic forming of the mud, the moisture content of 30% ~ 35% of the slurry for slurry molding with a moisture content of 4% ~ 7% of the dry pressing forming powder and the hot pressure injection molding of the slurry or dry powder and wax after the uniform mixing of wax cake and other blanks have different preparation processes, should be based on the characteristics of the raw materials used, equipment conditions, production scale, Factors such as the quality requirements of the product and the technical and economic indicators of the preparation process itself are selected. Improper processing methods or process control of bad materials will not only reduce production efficiency and increase production costs, but also affect the process performance of the blank and the performance of the product. The forming of formed ceramic products is to use different methods to make the blank into a blank with a certain shape and size. According to the difference in moisture content and properties of the blank, the forming method of pottery is divided into plastic method, grouting method and pressing method.

2.3.1 Plasticized forming

Plastic forming is a method of making a blank under the action of external force, so that the plastic deformity of the blank and make the billet. Due to the different external forces and operating methods, the plastic forming method of the purpose pottery can be divided into two major categories of sculpture, hand forming and mechanical forming, printing blank, drawing blank, hand kneading, etc. Belong to hand forming, these forming methods are relatively old, mostly used in the manufacture of artistic pottery. Spinning and rolling forming are the mechanical forming methods widely used in factories at present, which can be used for the production of plates, bowls, cups and saucers and other products. In addition, plastic forming methods such as extrusion, blanking, pressing, and rolling film are also used in other pottery industries.

2.3.2 Grouting molding

Grouting is the use of porous model water absorption, the mud into it to form the method, this forming method is adaptable, all complex shapes, irregular thin walls, thick tires, large volume and loose size requirements of the product can be formed by grouting method. For example, soup bowls, oval plates, teapot handles, etc. in daily pottery can be formed by grouting. The structure of the blank after grouting is uniform, but its moisture content is large and uneven, and the drying shrinkage and firing shrinkage are large. In addition, from the production process, its production cycle is long, manual operation, labor intensity, large footprint, model consumption. With the continuous progress of the production process and the continuous development of grouting and forming machinery, these problems will be improved and solved, so that grouting is more suitable for modern ceramic production.

2.3.3 Compression molding

Compression molding is the use of pressure to press the powder placed in the mold to a tight structure, becoming a forming method with a certain shape and size of the blank. According to the moisture content of the powder, it can be divided into dry compression molding (moisture content less than 6%) and semi-dry compression molding (moisture content 6% 14%) pressed forming body low moisture content, dense body, small drying shrinkage, accurate shape and size of the product, high quality. In addition, the simple forming process and large production volume facilitate mechanized large-scale production, ~which reduces time, cost, and improves considerable efficiency for the production of flat pottery with regular geometry.

ISSN: 2664-9640

3. Clay composition and its firing

3.1. Soil

Rongchang is located in the west of Chongqing, located in the subtropical humid monsoon climate zone, and the humid climate in the south makes it abundant precipitation, soil leaching effect is strong, Rongchang pottery raw materials taken from the local Yayu Mountain, along the Anfu Yayu Mountain Range there is a 15 km long, 2.5-4.5 km wide terracotta ore belt, there are red and white colors, red mud mostly, accounting for about 80%. Another reason for its formation is that the silicate minerals containing potassium sodium change in mineral structure under external action, and some or all of the potassium and sodium ions in the structural formula are lost, thus evolving into the original clay ore. Clay includes two types of plastic raw materials and barren raw materials, the former is preferred. Plasticity is the key to molding, the so-called plasticity refers to the mud under the action of external force deformation without breaking and losing the external force to maintain its shape. As we all know, red mud because of its red appearance, it is mostly iron content, and iron minerals play an important role in the process of blastoplasticity. Of course, red clay as a kind of clay, it itself has a certain plasticity, there are studies have shown that laterite, sedimentary soil, black soil and some other strong plasticity of the soil, the production of pottery is more ideal, strong plasticity, easy to form.

3.2. Iron in the raw material of pottery affects the firing atmosphere

The color of the pottery and the clay are necessarily related to the atmosphere of firing. Clay generally contains a certain amount of iron compounds, this compound plays a role in confluence, it can make the firing temperature of the pottery not too high, can also achieve the expected effect, can make the pottery in different atmospheres to present a variety of colors, usually in the kiln, the kiln needs to have sufficient air supply, fuel can be completely burned, in this case a flame atmosphere is the oxidation atmosphere. It appears to be characterized by smokeless transparency, with the main components of combustion being carbon dioxide and excess oxygen, without combustible substances or too little content. In addition, according to the amount of excess oxygen content in the combustion products, they can also be divided into strong oxidation atmosphere and weak oxidation atmosphere. The excess oxygen content of the strong oxidation atmosphere is 8% 10%, the excess oxygen content of the weak oxidation atmosphere is 2%~~ 5%, and the excess air coefficient of the oxidation atmosphere is greater than 1.

In addition, there is also a kind of firing atmosphere that is a restorative atmosphere. In the kiln, the kiln air supply is not sufficient, combustion is not thorough, a flame atmosphere produced under this condition is the reduction atmosphere, the reduction atmosphere is characterized by smoke, turbidity, combustion substances there are still some combustible substances, these gases can reduce the glaze iron oxide to ferrous oxide, copper oxide reduced to cuprous oxide. According to the amount of carbon monoxide content in the kiln, the reduction atmosphere can also be divided into a strong reduction atmosphere and a weak reduction atmosphere. The strong reducing atmosphere content is 5% 7%, and the weak reducing atmosphere content is 2% 5%. Its air excess coefficient should be less than 1, and the content of excess oxygen should be below 1%. There is also a neutral atmosphere between the oxidation atmosphere and the reducing atmosphere, which is generally produced at a peroxygen content of 1% and 1.5~~~%. Below is an in-depth analysis of the effects of laterite chemicals, an important component of raw materials, on pottery.

ISSN: 2664-9640

3.3. Analysis of laterite ore survey results

3.3.1 Rongchang clay advantages

From the perspective of pottery in previous generations, most of the clay contains more iron oxide components, taking the pottery of the new era of the Yellow River Basin, it contains more iron than loess, but the calcium oxide content is lower than it. Usually there are more iron compounds in pottery, and this iron compound can reduce the firing temperature of the ceramic billet. The clay composition can also affect the color of the pottery, if the potassium, calcium, magnesium content in the utensils is high, so that the solvent effect is increased, the pottery after firing will become orange-yellow, and the pottery fired in the upper reaches of the Yellow River has this characteristic. Early pottery is mostly mixed in the soil with sand grains, grass scraps, mussel shell fragments, chaff shells, crushed pottery, etc., the purpose of which is to make the body loose, easy to escape the moisture when firing, reduce the clay viscosity so that the semi-finished products will not crack or deform during the drying or firing process, improve the heat-resistant emergency performance, and avoid sintering is rupture. The chemical composition in Rongchang clay happens to be the opposite, which is also the unique advantage of Rongchang pottery.

3.3.2 Analysis of the chemical composition of red mud

Preliminary investigation found that the soil color in the area is mostly red, iron, aluminum and silicon oxides are more abundant, while potassium, sodium, calcium and magnesium are less accumulated, so the soil is more sticky and acidic. Table 1 shows the chemical composition of laterite.

Table 1 Chemical composition of laterite ore

Element	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	K2O	Na2O
content	68.87%	14.06%	7.09%	0.7%	0.68%	1.06%	1.64%	1.17%

According to the chemical composition characteristics of Rongchang clay raw materials, classified from the process point of view: (1) High silicon raw materials, SiO2 in laterite ore is the skeleton of pottery, which has the effect of reducing shrinkage and preventing deformation. (2) Aluminum raw materials are scarce, Al2O3 in laterite mines can improve fire resistance, but also to provide conditions for the formation of mullite, Al2O3 is mainly derived from kaolinite, kaolinite can improve plasticity, is conducive to molding processing, it can be seen through Table 1, The Al2O3 content in Rongchang clay raw materials is generally low, and cannot be used as an aluminum-rich raw material. (3) Flux raw materials, K2O, Na2O can reduce the firing temperature, the total content of K2O and Na2O in laterite ore is about 3%, which is a high-quality low-temperature fast firing raw material, which can be used as a suitable flux raw material. However, in special firing, another additive is needed. (4) High-speed rail raw materials, Fe2O3 content can change the color of raw materials after firing, with the increase of iron content, the color will gradually become darker after firing, and the firing temperature is different, the porcelain billet will also show different colors, the iron content of laterite ore is relatively high compared to the ore raw materials of Yixing purple sand pottery, Qinzhou Xiaoxing pottery, yunnan Jianshui pottery. This is also one of the reasons why Rongchang uses red mud as the main raw material. The basic formula pottery test of Rongchang clay is carried out, the ingredients are mainly laterite ore, the dosage reaches 75% 85% (mass fraction), followed by the addition of Rongchang white clay with good plasticity, the dosage is about 20% (mass fraction), plus a small amount of bentonite, which can be made into pottery with good molding performance. Figure 1 shows the pottery vessels made in the team's investigation experiments. (5) low iron raw materials, some products have strict requirements for chemical

composition, sometimes need to use iron, titanium content of raw materials to improve whiteness, at this time optional raw materials, after further iron removal treatment, can be used as low iron raw materials, used for the production of high-grade daily pottery and other products.

Figure 1 Pottery utensils made by research practice

3.3.3 Plasticity

Plasticity is an important indicator to judge the molding performance of mud. The greater the plasticity and the better the molding stability of the mud, the easier it is for the mud to be molded into various shapes without cracking. Plasticity is affected by many factors, such as moisture content, solid phase particle shape, etc. The plasticity of the clay can be judged by the plasticity index, the plasticity index is greater than 3.6 is high plasticity clay, and between 2.53.6 ~is medium plastic clay, Below 2.5 is low plasticity clay. From the plasticity test results of Table 2, the drying shrinkage rate is positively correlated with the plasticity of the raw material, and the greater the drying shrinkage rate, the better the molding performance On the whole, the plasticity is better, which can give purple sand good molding conditions. The specimen belongs to the medium plastic clay, indicating that their water molecule affinity is good, the viscosity is high, and it is easy to form. The plasticity index of Jingdezhen purple sand ore mud is between ~2.763.75, and the plasticity index of Yixing purple sand is between ~2.803.81. The plasticity of clay in Rongchang area is slightly lower than that in Jingdezhen and Yixing areas, which may be due to the high content of quartz sand in the clay in Rongchang area.

Table 4 Physical properties and sintering properties of Rongchang clay

Number	Drying shrinkage/%	Firing shrinkage/%			Water absorption/%			Plastic index
		1 100 ℃	1 150 ℃	1 200 ℃	1 100 ℃	1 150 ℃	1 200 ℃	
1#	5.91	10.91	—	—	0.03	—	—	1.78
2#	4.73	12.04	8.39	—	0.06	0.03	—	1.21
3#	5.50	7.14	9.37	9.89	9.60	0.80	0.04	2.47
4#	2.16	6.46	10.39	6.76	1.35	0.57	0.18	1.41
5#	3.35	4.29	7.37	6.73	14.04	8.63	5.85	1.41
6#	5.34	7.40	10.81	11.37	12.36	9.40	1.75	3.40
7#	5.81	2.67	5.94	8.19	16.42	8.24	4.12	1.67
8#	4.89	7.53	10.05	8.74	5.55	0.04	0.02	2.55
9#	6.28	6.71	10.07	10.10	7.15	0.18	0.16	2.63

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