Applications of Carboxymethyl Cellulose Sodium in the Ceramic Glaze Slurry

Sodium Carboxymethyl cellulose (referred to CMC) is white or yellowish powder, granular or fibrous solid, tasteless, non-toxic, and water soluble. CMC is chosen as the electrolyte in the production of sanitary ceramics, due to its good adhesion, suspension, deagglomeration, and water retention effects. The application aim is to:

① act as the binder and play a bonding role. It can increase the strength of raw glaze, reduce the drying shrinkage of glaze, make the green body and the glaze firmly combined and not easy to fall off, be easy for process operation, and prevent such defects as rolling and missing of glaze. While playing the role of suspension, it makes the ceramic slurry suspended and prevents precipitation.
② play its role of water retention, so that the glaze slurry has a certain water retention and the glaze layer are uniform drying, forming a flat, dense glazed surface and the glazed surface is flat and smooth after firing.
③ use the deagglomeration effects of CMC (of medium and low viscosity) to improve the liquidity of glaze slurry and facilitate the spraying operation of glaze. To achieve the above purposes, it is very important to give full play to the effects of CMC, grasp the properties of CMC and the effects of temperature and time on it, and properly select and apply CMC.

Selection Principle of CMC for Sanitary Ceramic Glaze

1.1 Determine the Viscosity of CMC used According to Glaze Formulations

The raw materials used in the glaze are mainly feldspar, quartz, dolomite, calcium carbonate, aluminum hydroxide, zircon powder, zinc oxide and kaolin, etc., and there is a slight change in the use of raw materials depending on the shades of color. But they are mainly lean materials and the amount of plastic materials is less than 10%; some formulations do not use plastic kaolin raw materials. In this way, the viscosity and adhesion of glaze slurry mainly depend on the addition of CMC to adjust, and in sanitary ceramic glaze, CMC of medium or high viscosity is usually selected.

1.2 Selection of Degree of Substitution (Degree of Etherification) of CMC

The production plants of sanitary ceramics have always attached great importance to the viscosity of CMC. And the CMC for the ceramic industry sold on the market is mostly divided

according to the viscosity into low, medium and high viscosity, while the degree of substitution of CMC are often overlooked. However, in the production of glaze, a phenomenon can be noted: in detecting the fineness of glaze, “CMC particles” can be visible in the oversize products, and the performance of glaze is greatly affected. This is related to ignoring the degree of substitution of CMC or inappropriate degree of substitution.

The degree of substitution refers to the average number of H substituted by CH2COONa in the CMC structure “-OH”. This indicator is a key factor in determining the water solubility of CMC. With the rise of the degree of substitution, the water solubility of CMC is enhanced. In the sanitary ceramic glaze, CMC tends to be smaller in the amount, but requires good solubility properties and it is appropriate to choose CMC with the degree of substitution more than 0.7. In addition, the selected CMC must be high in the purity, does not contain colored impurities, and can burn out, in order to ensure the clean glazed surface for products after firing. The ceramic production plant can use the method of quality assessment to ensure the quality of the CMC used.

2. Storage and Detection of CMC

2.1 Storage

CMC should be stored in the dry environment, which is determined by the hygroscopicity of CMC. The equilibrium moisture content of CMC increases with the increase of air humidity, but decreases with the increase of temperature, and the moisture content is approximately 10% in the product. As is reported in the literature, stored under the condition that the room temperature and the average humidity are both 80% to 85%, the equilibrium moisture content can be up to 26%; when the moisture content is more than 20%, the mutual adhesion of part of particles can be seen, and the higher the viscosity of CMC is, the more significant it will be. Preventing the moisture absorption is to ensure the accuracy of addition amount.

2.2 Detection of CMC

Since CMC has a small amount in the glaze and a great effect on the quality of the glazed surface, it is necessary for ceramic production plants to detect the physical properties. According to the detection methods, detect the moisture content, viscosity, and degree of substitution of the CMC into the plant in batches to ensure the stability of its quality. During the use process,

make timing detection of the moisture content and timely adjustment of the addition amount.

3. Applications of CMC in the Ceramic Glaze

3.1 Addition Amount

The addition amount of CMC affects its concentration in the glaze. Whether using the high, medium or low viscosity CMC, the viscosity of glaze rises with the increase in the addition amount of CMC. The principles to determine the addition amount are:

① according to the glaze formulations to determine the addition amount of CMC. If the content of plastic materials in the glaze is high, the addition amount of CMC is small. Whereas, the addition amount of CMC is large.

② according to the glaze process parameters to determine. For the glaze with strong adhesion and slow drying speed, the addition amount of CMC is higher, whereas smaller.

③ according to the viscosity of the CMC used to determine. When the viscosity of CMC is high, the addition amount is small; while the viscosity is low, the addition amount is large.

④ according to the experimental results to determine the appropriate addition amount. In general, the addition amount of low-viscosity CMC is 0.2%— 0.5%, while the addition amount of medium or high viscosity CMC is 0.1%— 0.3%. It is noteworthy that the addition amount of CMC will change with the change of seasons. When the summer temperature is high, the viscosity of CMC solution decreases with increasing temperatures, so the addition amount of CMC in summer should be appropriately raised than in other seasons. During the rainy season, the air humidity is high and the surface of green body is relatively wet and dries slowly, so the drying speed of glaze should be increased and the addition amount of CMC should also be appropriately reduced. The addition amount of CMC should be changed according to seasonal changes especially changes in temperature and humidity.

3.2 Adding Methods

3.2.1 Directly-Into-Mill Method

Most sanitary ceramics production plants use this method. There are two drawbacks of directly-into-mill method. One is not conducive to the dissolution of CMC. During the dissolution of CMC, it first generates swelling phenomenon and then gradually gets dissolved. Due to the swelling effects, the CMC ions are mutually adhered to form very strong film or micelle, making CMC particles not easy to disperse, resulting in the difficulty in dissolution, thereby affecting the role of CMC. The second is affected by temperature and time,reducing the role of CMC. During grinding, due to the mutual collision and grinding of grinding media and glazes, the glaze slurry can generate a lot of heat, raising the temperature of glaze. Especially in summer, the temperature of glaze slurry after grinding can reach up to 50℃. Literature introduction: When the temperature rises to a certain extent, permanent viscosity reduction will occur. It is generally believed that this temperature limit is 50 ℃, while the grinding time of glaze is more than 20 h. At a certain temperature, the viscosity of CMC decreases with the prolongation of heating time, so the directly-into-mill method of CMC should be changed.

3.2.2 Pre-dissolution of CMC in Warm Water

To prevent CMC from forming the film or micelle, it is necessary to increase its solubility and use the method of pre-dissolution in warm water. First, use the container to dissolve CMC into

the solution of a certain concentration, then grind after into the mill or add in the late stage, but the introduction of water should be considered and the amount of water added should be adjusted when grinding.

3.2.3 Phased Adding Method

Using this method can give better play to the role of CMC. Divide the total amount of CMC added into two parts and add into the glaze slurry in twice (using the warm water pre-dissolution method). A part of CMC is first into the mill for grinding and plays a deagglomeration role; the other part of can be added before the use of glaze to adjust the glaze and meet the bonding effects of glaze. But the CMC for adjusting the glaze in the late stage must be high solubility, and the addition amount is generally 0.05% -O.1%. Some enterprises have used imported CMC for adjusting glaze in the late stage and achieved very good results.

3.3 Storage Time of Glaze Slurry

In order to ensure continuous production and the requirements on the performance of glaze itself, a certain reserve of glaze slurry is necessary, and generally it is OK to meet the amount of 2d. 1-2d glaze banality can make the performance of glaze slurry uniform. If the glaze slurry is placed for too long, the viscosity of CMC solution will decline with the extension of time, resulting in the faster drying speed of glaze slurry, cracking on the glazed surface after glazing, and decline in the adhesion of glaze, not conducive to the process operation in the late stage and causing defects on the glaze surface.

3.4 Combined Use of CMC with Other Electrolytes

Since CMC is applicable to the deagglomeration of materials without (or with very little) clay---lean slurry, for the deagglomeration of clay materials, other electrolytes (such as sodium carbonate, sodium silicate, etc.) should be added to use together, and its glaze performance will be better.