Collage of Engineering

Materials Department

Third Class

Course 2 / Lecture (5)

GLASS

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GLAZE

1- Introduction

Glaze is a thin layer of glass that adheres to the surface of the clay body. It provides a smooth, non-absorbent surface that can be colored and textured in a manner not possible on the clay body itself. Glazes are composed of various oxides combined in proportions that will yield the desired properties. Silica (SiO_2), and boric oxide (B_2O_3), are the glass formers, but oxides such as Na_2O, K_2O, CaO, PbO and Al_2O_3 must be present in the stoichiometric sense to give the desired properties. These include, for example, lowering the viscosity of the molten glass so that the glaze will flow smoothly over the surface of the clay body at the temperature at which the glaze is fired.

2-Composition of glaze

A glaze is usually formulated by mixing together the appropriate amounts of finely-ground potter's flint (SiO2), boric acid, feldspar (a source of K2O, Na2O, CaO and Al2O3) and whiting (CaCO3) plus, if required, a colouring agent. An appropriate mixture of these components, when made into slurry with water, can be painted onto the clay body and fired.

3-COLORS OF GLAZES

Some of the substances commonly used in forming glazes are listed below in Table 1.

Table (1): Glaze colors

Colour	Chemical(s)
Blue	Glaze contain Cobalt a blue colour results. In Matte blue, cobalt is present as a cobalt aluminate. Royal blue, when Cobalt in silica glazes.
Green	Many green glazes contain Cr_2O_3. As Cr_2O_3 is not soluble in most glazes, the glazes are opaque. Compounds of Cu^{2+} are blue or green. CuO (green) dissolves in boric oxide (B_2O_3) glaze, giving transparent green shades. If SnO_2 is added to this glaze it becomes opaque and if alkalis, e.g. Na_2O or K_2O, are added, a blue colour may be produced
black	A combination of CoO (blue), Cr_2O_3 (green) and MnO (black).
Yellow	Lead chromate, $PbCrO_4$
red	Many red coloured glazes contain the red oxide Fe_2O_3. If Fe_2O_3 is dissolved directly into a silica containing glaze, the red colour is lost because the two components react to give an iron silicate that is brown.

4- WAYS TO APPLY GLAZE

1- Brush

Many ready-to-use glazes are formulated to work well when applied with a brush. These glazes tend to be much thicker in consistency than dipping and pouring glazes. Some are a little less fluid than heavy cream, while others are so thick as to be pudding-like. Make sure you read the instructions carefully, as they will tell you how many coats to use for your desired color. You still need to make sure that the glazes have been stirred well before use. Always wash your brushes fully after use.

2 - Dipping

Dipping wares into pots or buckets of glaze is probably the most common glaze application method. It's fast, easy, and generally gives a coating of even thickness. Dipping is the most useful glazing process for production work, where speed and efficiency are important. If the glaze runs during application, it can be removed with a knife, if necessary, to ensure a smooth coating for any further painting. Touch up the unglazed spots (from where you hold the piece) with a brush or your fingers.

3 - Spraying

It is a good application method, although it usually takes quite a lot of experience to achieve even coatings and to learn to judge the thickness necessary for an adequate covering. It can be used for glazing the whole piece, or for glazing small areas. Equipment varies from simple to very sophisticated. The simplest is the atomizer, Garden sprayers can be used. There are a wide variety of spray guns requiring compressors for air control. There are also miniature spray guns, called airbrushes, which also need a compressor to function. These units are comparatively expensive but are irreplaceable for fine and detailed work.

5-DEFECTS OF GLAZING

1. Pinholes can be caused by over firing, impurities in the glaze, or contaminants in the body. Closed setters can be used to protect the ware from flame impingement during firing.

2. Crazing Cause by a glaze / body mismatch where the coefficient of expansion of the glaze is higher than that of the body. Addition of silica or a low-expansion frit usually corrects the problem.

3. Crawling: Crawling is a glaze defect in which the glaze separates, leaving portions of bare clay exposed. These can be a few tiny areas, or it can extend across the surface of a sample. Extreme cases may result in the glaze leaving the surface of the sample completely. Droplets or even puddles of glaze may end up on the kiln shelf.

Crawling occurs when the glaze has not properly adhered to the bisque clay. The most frequent cause is that the glaze was applied to dirty, dusty or greasy pots.

4. Blisters fast firing or incomplete firing. Non oxidation of carbon compounds from organic binders due to too little heat in the preheat zone and impurities such as limestone from grinding or clay storage operations.

5. Shivering is a glaze defect in which slivers or flakes of glaze detach themselves from a pot. When shivering occurs, it is most frequently seen on thin edges. Shivering is usually due to the glaze coat is too large (having too small coefficient of thermal expansion) for the sample.

6- Firing Conditions of Glazing

The firing curve naturally has heat up and cools down periods. In between these slopes is a flat or modified soaking time/temperature. During heat up, the binders are removed from the glaze. They must be completely removed and they must not be reduced to carbon during heat up (preheat). This does not mean that you can't approach reducing conditions. Some compounds like MnO and FeO can greatly improve melting although they are often in the glaze only in tiny amounts as impurities. These compounds do not form under oxidizing conditions.

7- Cooling Conditions of Glazing

Cooling is important to both the glaze and ceramic ware. You can cool quickly to just above the silica phase transition and then cool slowly through the transitions. This may not be good for the glaze which is trying to get rid of the bubbles created after the glaze melted. This can put you between a rock and a hard place. You have to be able to control the whole cooling zone of a tunnel kiln from the minute the ware comes out of the hot zone.

8- Notes on Glaze Formulation

1- It is interesting that silica can raise the thermal expansion of a body and lower the thermal expansion of the glaze.

2- For all practical purposes the thermal expansion coefficient of the glaze must be lower than that of the body. This keeps the glaze in compression after firing. Glazes always fail in tension. Keeping the compressive forces higher than the tensile forces.

3-Kiln contamination can be a problem in some operations. Pits, pin holes, and pocks caused by impurities dropping on the glaze during firing can be removed by grinding. The ware is res-prayed with a thin coat of glaze and then refired.

4- If body impurities are still releasing gases on refiring.

5- Every element you add to a glaze impacts the final-glaze properties.

For example, too much alkali content will increase the solubility of a glaze, raise its thermal expansion, and in general raise havoc. A minimum amount of alkali content will give the glaze fusibility. Also, individual alkalis act differently in extent. Therefore one would use more than one alkali and the minimum amount of each that yields the best balance in properties.