Bloating and Black Coring

[A brief analysis of a complicated problem]

Bloating occurs when the firing cycle does not match the clay being fired. The symptom is a void created in the walls of the pot, but the remedy does not lie with the clay: it is the firing that needs to be adjusted. We can generate some guidelines for adjusting the firing based on an understanding of the chemical processes that lead to bloating.

Why do pots bloat? In the simplest terms, it is because gases are formed in the body that cannot escape. With no place to go, they expand while still inside the pot and generate the voids called bloats. So where do these gases come from, and why can't they escape?

The gases are generated from carbon and sulfur in the clay components of the body. As a natural part of the weathering and deposit of clay particles, organic materials containing carbon and sulfur settle throughout the clays we mine and use for modern ceramics. When these organic materials reach temperatures ranging from 1290° to 1650° Fahrenheit, they combine with oxygen, form gases, escape the clay body through the pores, and exhaust from the kiln. Under optimal conditions, all of the organics will be expelled from the clay through this process during the bisque firing. However, it is possible to leave carbon and sulfur in the clay under the following two circumstances.

First, the bisque firing can be too fast. Not only must the firing go to or beyond 1650°, but it must allow enough time for the maximum quantity of carbon to burn out. The process is not instantaneous; it takes time for all the carbons and sulfurs to combine with oxygen, and it takes time for the subsequent gases to work their way out of the body.

Second, the atmosphere in the bisque kiln can be oxygen poor. If this is the case, some of the organics will remain in the body because they can find no oxygen with which to combine. We see this phenomenon in both gas and electric kilns. In electric kilns with poor ventilation and tightly packed ware, the organics in the clay quickly combine with what little oxygen is available, and there is no means for new oxygen to get to the pots. Gas kilns have good ventilation, but that does not mean that oxygen is available. If too much reduction is used in the 1290° to 1650° range, the atmosphere will be oxygen poor and carbon and sulfur will be left behind.

Once the organics have been left in the body, they are likely to bloat in the glaze firing. As the glaze begins to melt, and the clay-glaze interface becomes vitreous, it forms a barrier. The left-over carbon and sulfur combine with the oxygen in the kiln, but the now non-porous surface prevents the escape of these gases. With nowhere to go, the gases form "bubbles" or bloating within the walls of the fired objects.

These problems are compounded in iron-bearing clay bodies. In low-iron bodies, gases contend only with the clay-glaze interface. In iron-bearing bodies, early reduction causes the formation of "black glass" (reduced iron and silicate) within the body. This black glass is a powerful flux which becomes active at 1650° F. As temperatures rise, the black glass throughout the body gets softer. The net effect is that the body becomes better at trapping the gases at the same time that its softness makes it less capable to resist the expansion of the gases! This sequence of events results in bloating as the body reaches its normal maturing temperature.

Unfortunately, we may not know that the carbon or sulfur remain in the body after glaze or bisque firing. Sometimes, improperly, fast-fired bisque may exhibit a pink cast on the surface, which, if broken open will often reveal black coring. Black coring is the evidence of trapped organics in the form of a layer of black visible just beneath the surface of the piece. The layer of black may be in a "bloat" in a glaze-fired piece, or it may just be a black layer beneath the surface of the glaze. It is even possible for the black coring to exist throughout the fired clay body. Black coring will be present in glaze fired pieces where organics have been trapped. Black coring can explain existing bloats, or it can warn us that the firing process is prone to create bloats even if none have yet appeared.

With this understanding of the bloating phenomenon, how can it be prevented? It is as simple as eliminating the causes:

1. Fire slowly enough 1290° to 1650° F to give the carbon and sulfur in the body time to combine with oxygen and work its way out of the clay body. The burnout process must be done slowly and completely before the glaze begins to melt.
2. Provide an oxygen rich atmosphere. In electric kilns, use plenty of ventilation in the bisque fire. If your kilns are densely loaded, use a downdraft kiln vent. In gas kilns, keep the kiln in oxidation from 1290° to 1650° F.
3. When using iron-bearing clay bodies, fire up to 1950° F in complete oxidation to allow for proper and complete burn-out of the organics; then, if desired, begin the reduction process.

The above information offers a brief sketch of how to prevent bloating. Different clay bodies require different treatment as clays vary in their organic content. The following are a few of the many sources for additional information on bloating and proper firing. Time spent improving firing techniques is money in the bank!

- ***The Potter's Dictionary of Materials & Techniques*** by Frank and Janet Hamer
- ***Ceramic Science for the Potter*** by W. G. Lawrence
- ***Ceramic Faults & Their Remedies*** by Harry Fraser
- ***The Art of Firing*** by Nils Lou

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