Iron Based Earthenware In A Forced Reduction Atmosphere

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Abstract. Iron is a strong flux in ceramic glazes when fired in an oxygen-starved atmosphere (reduction), resulting in a CO rich atmosphere. The carbon monoxide (CO) robs the iron (Fe2o3) of two oxygen molecules, thus transforming the iron into FeO. It is when iron is in the FeO state that it becomes an active flux and it is this state of flux that I am interested in. Earthenware clay is an iron rich clay that is typically fired in an oxygen rich atmosphere where the iron in the clay maintains it's maximum amount of oxygen. This results in a porous and non-vitreous clay, which typically requires the application of glaze or a vitreous surface to allow for safe utilitarian usage.

I intend to research and develop a low-fire earthenware clay body that becomes vitreous due to the forced reduction atmosphere in which it will be fired. The intention is to develop a low-temperature food safe clay body that doesn't require glaze for utilitarian applications. This will result in aesthetic alternatives to surface treatment and finishes.

In this research I will formulate two different clay bodies, each varying in the amount of iron. Both of the clays will be fired in both oxidized and reduction atmospheres, allowing for comparable data from which saturation of carbon and vitrification can be tested. One set will be fired to 1954 ºF in an oxidation atmosphere, which will be used as the control. The reduction firings will also reach 1954 ºF in oxidation and then cooled in a reduction atmosphere down to 1500 ºF. It is in the cooling cycle that I anticipate the vitrification to occur.

1.Introduction

Due to the extensive history of ceramics as a tool for communication, self-expression, and the role it plays in cultures as art and utilitarian objects, it becomes easy to recycle ideas and techniques from the past coincidently, there is rarity in revolutionary movements within the ceramic medium in present day. As a graduate student, I feel it is my responsibility to bring new information and research to the field of ceramics. My research focuses on the technical side of ceramics but will also lend itself to expressive applications to assist in the conveying of ideas. The utilitarian aspect of this research will allow for the use of materials in a manner never before used. This research can be used as a vehicle to express ideas in a manner in which exposed clay remains safe for utilitarian use.

2.Experiment, Results, Discussion, and Significance

In the research, two iron-rich clay bodies were fired to 1954 ºF in three different atmospheres. The two clay bodies differed in iron content by 16.6%. The source of iron came from two commercially reliable resources. Red Art, a commercially produced earthenware clay, is the source of iron in clay body 1, which consisted of 7.04% Fe2O3 and Laterite, a commercially processed, Iron-rich kaolin clay, is the source of iron in clay body 2, which consisted of 24% Fe2O3. The three firing methods consisted of: Firing 1, (control firing), Oxygen-rich atmosphere in an electric kiln. Firing 2, Reduction cooled atmosphere in a gas kiln. Firing 3, Re-firing a number of the results from the reduction cooled firing in an oxygen rich atmosphere in an electric kiln.

Control: An electric kiln was used for the control firing. Electricity becomes the source of heat where there is no combustible fuel to change the internal atmosphere in the kiln. This firing method assures a uniform atmosphere containing an ample amount of oxygen. Both of the clay bodies acted as expected from the control firing. The color varied slightly. Clay 1 being a very bright brick red and clay 2 darker and muted. At this temperature the clay has not become vitreous in the oxidized atmosphere. Both clay bodies were porous and leached water. This shows that the iron in the clay didn't reach it's melting temperature even with the typical addition of fluxes inherent in clay bodies.

Reduction Cooled: By forcing the kiln into a heavy reduction atmosphere, the increased amount of Co2 in the kiln robs the iron (Fe2O3) of two Oxygen molecules and turns the oxidized iron into black iron (FeO). The loss of two oxygen molecules lowers the melting temperature of the iron and increases the vitrification (water tightness). Due to the lack of control or inability to see inside the kiln during a firing, it is difficult to know whether good oxygen reduction is achieved, because of the odorless tasteless characteristics of carbon monoxide. The most reliable way of getting reduction is to reduce the amount of available oxygen going into the kiln and close the damper, which reduces the amount of air and fuel to be released from the kiln. By decreasing available oxygen, the ratio of gas in the kiln is increased. The increase of gas inhibits the combustion of fuel, which results in increased amounts of CO. Not only does it lower the melting temperature of the iron but it also cools the kiln quickly. Forcing the kiln to cool in reduction ensures that the iron cannot re-oxidize, as long as cooling continues down to 1500ºF. Cooling down to such a temperature assures that it has dropped below the melting point of iron and by doing so; iron is kept in the state of FeO.

Re-fired in oxidation: This set was comprised of tests from the reduction cooled firings and re-fired in an oxygen rich firing with an electric kiln. The purpose of this test was to see how much if the FeO could be re-oxidized back to the state of Fe2O3. For the most part, the iron in the clay was returned back to its original state. There are areas that show that the black iron was strong enough that it was unable to become re-oxidized. The interesting thing about this test is that if the red color of the clay body is desired for the final look of the piece, the clay remains water-tight and safe for utilitarian use, even though it has been re-oxidized.

3.Conclusion

This research shows that vitrification of iron based earthenware is achievable at a lower temperature if the iron is reduced from Fe2O3 to FeO. The pure oxidized firing showed that the clay remained porous or non-vitreous and would allow for water and bacteria to be pulled into the clay. The re-oxidized firing showed that as long as the iron has been reduced the clay remains vitreous and water-tight. This information is valuable on a few levels.

For people who are concerned with producing wares out of earthenware, there is now evidence that shows the application of glazes are no longer necessary on the surfaces where food comes in contact. Not only are there utilitarian applications, but a broader palette is also created from which artist can may draw for aesthetic purposes.

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