NCKU-YAGEO Research Collaboration

The fabrication of MLCCs involves several ceramic powder processing including the addition of polymeric binders that enhances the strength of formed ceramic powder. As these polymers can give defects in the final ceramic product, they are then removed in later processing steps by decomposing them at elevated temperature into gas-phase products (1, 2). MLCC binder burnout typically occurs by initially raising the temperature quickly to a level where binder burnout starts and is subsequently programmed at a very low constant rate up to a level where burnout is almost complete (3). The binder burnout is a process that takes a long time and plays an important role in the defect formation of the ceramic body during the ceramic manufacturing process (4).

From the perspective of environmental load reduction, it was stated that industries which involve ceramic industry produce about 40% of the greenhouse gas generated by energy consumption. The changes of energy consumption in ceramic industry is also higher than those iron and steel, paper and pulp, and chemical industries (5). Heat is necessary for the removal of the organic binder in the green body, the conversion of exhaust gas to vapor or carbon dioxide, and for the ceramic firing. Moreover, the energy efficiency is low. Therefore, optimizing the heating strategy is necessary to obtain better quality and a higher yield of the product.

Superheated steam has been recognized as one method in heating and drying the ceramic materials. During the whole process, the steam stays above its condensation temperature (6). The superheated system is enclosed and reuses the same steam and heat to dry the part. Superheated steam has some advantages over drying the ceramics with hot air. Superheated steam has a higher capacity and much higher heat transfer quotient. The ceramics can also be dried more evenly throughout its volume at the same rate. Drying with superheated steam is also more efficient in usage of energy and time. Less enthalpy is lost with superheated steam since a new air supply is not continuously heated as with a hot air dryer. The drying cycle is also shorter for superheated steam, thereby requiring less energy. Possible emissions from the drying process, presented in the drying medium, can be effectively removed by condensation.

1. Feng ZC, He B, Lombardo SJ. Stress Distribution in Porous Ceramic Bodies During Binder Burnout. Journal of Applied Mechanics. 2002;69(4):497-501.

2. Incledon ML. Modeling binder removal in ceramic compacts. 2013.

3. Verweij H, Bruggink WHM. Reaction-Controlled Binder Burnout of Ceramic Multilayer Capacitors. Journal of the American Ceramic Society. 1990;73(2):226-31.

4. Liau LC-K, Chiu C-C. Optimal Heating Strategies of Polymer Binder Burnout Process Using Dynamic Optimization Scheme. Industrial & Engineering Chemistry Research. 2005;44(13):4586-93.

5. Watari K, Nagaoka T, Sato K, Hotta Y. A strategy to reduce energy usage in ceramic fabrication. Synthesiology English edition. 2009;2(2):132-41.

6. van Deventer HC, Heijmans RMH. DRYING WITH SUPERHEATED STEAM. Drying Technology. 2001;19(8):2033-45.