INVESTIGATIONS ON THE RHEOLOGY OF CERAMIC INKS, DROP FORMATION AND DESIGN OF NOZZLE FOR DIRECT CERAMIC INKJET PRINTING

ABSTRACT

Recently, there is an increased interest to use ceramic containing inks to develop ceramic components for several strategic applications like sensors and fuel cells by depositing the ceramic ink using direct ceramic inkjet printing technology (DCIJP), a free form fabrication process. DCIJP uses a suspension containing ceramic particles, which is deposited using a delivery system actuated by a piezoelectric device. As there is not much literature reported for the design of a nozzle for DCIJP based on experiments and simulation studies, a systematic study as presented in this report is taken up.

Success of this technology lies in the use of ceramic inks with optimum rheological properties that can produce the best sediment packing density and the availability of an appropriate actuation mechanism to deposit the ink. In this research work, studies were made on the systematic preparation of ceramic inks with (i) 7.5%–17.5% alumina by volume and ethyl alcohol with varying dispersant content (0-3%) and (ii) 7.5%–15% zirconia by volume and ethyl alcohol with varying dispersant content (0-3%). Viscosities of the suspensions were measured with Brookefield viscometer (Model: DV–E, U.K), which is suitable for measuring the viscosities of suspensions accurately.

Viscosities of the suspensions were determined at various shear rates. The packing densities of the resulting suspensions were calculated which can be related to the density that can be achieved in the final product. It is observed that the sediment packing density and the apparent viscosities are decreasing when the shear rate is increasing at a particular solid concentration and increasing when the percentage of ceramic content is increased for a given shear rate. The spreading of the solid ink droplets, deposited from a burette was observed photographically for understanding several stages of drop formation, impact and spread.

In an attempt to develop a ceramic inkjet printer for the manufacture of ceramic components with their sizes in micro scale, the formation of ceramic ink droplet and its spread from a reservoir using piezoelectric actuation are simulated. The properties of the ceramic ink are taken from the data reported in literature. The simulations were performed with computational fluid dynamics software with multi-physics capabilities (CFD-ACE+), CFDRC. This study gives details of the interaction among different physical phenomena that contribute to the droplet formation and ejection process. The results from this study are used for a preliminary design of nozzle. A prototype of the nozzle is made for understanding the working of such a system. Displacement-voltage relationships are used to calculate the voltage needed to produce a given displacement of the piezoelectric diaphragm. Integrating these with the X-Y table and servomotors through a computer is also carried out for controlling the motion of the X-Y table. Thus this work is a systematic approach which provides researchers with initial data and methods to develop a device for DCIJP.