Abstract

The effect of an applied electric potential on the dynamics of bubble formation from a single nozzle was studied experimentally. Bubbling of dry nitrogen into glycerol through a nozzle having an electrified tip was examined by pressure measurements upstream of the nozzle. As the applied electric potential is increased from zero, the bubble size is reduced and the bubbling frequency is increased. It has been found that, at constant flow rate, bubble-formation dynamics exhibit the classic signs of a period-doubling bifurcation to chaos with increasing applied potential. The behavior is similar to that for increasing flow rate of the well-studied dripping faucet and of bubble formation in liquids. A three-dimensional bifurcation map was determined as a function of gas flow rate and electrostatic potential. The data indicate that although bifurcation route is similar for applied voltage and flow, the effect on bubbling for applied voltage is significantly smaller than that for flow as measured by dimensionless variables. Electrostatic potential was successfully harnessed as the manipulated variable to track a set-point of a constant average bubbling frequency with disturbances dues to flow-rate. It was found that an increase/decrease in electrostatic potential can be used to compensate a 50% change in the flow rate. A control scheme suggested by Ott, Grebogi and Yorke was implemented to tame the chaos of bubbles with partial success. Software tools namely the Bubble Toolbox for Chaotic Analysis and the Automation Workbench for LabView were developed in conjunction with this experiment.