Abstract

Particles acquire electrostatic charges due to repeated collisions with other surfaces: a phenomenon termed as tribocharging. This results in the generation of electric field, which, beyond a threshold value, causes propagating brush discharge (PBD) to take place. Contamination particles in an unclean oxygen system, particularly in bends, valves and regulators, make it more vulnerable to fire hazard when PBD acts as an ignition source. The present work evaluates the possibility for such a hazard, through determination of effects of various parameters. Dust particles with low auto-ignition temperature, particularly in dispersed state, may help in initiating the fire.

The phenomenon of electrostatic charge generation during impact between dust particles and pipe wall is investigated experimentally and theoretically. The experimentation and simulations are performed with mild steel particles. The effects of air velocity, pipe diameter and pipe length on tribocharging of particles have been determined. The velocity profiles of dust particles have been determined utilizing the FLUENT 6.3.26 code and the charges generated are calculated. CFD simulations of the study of dispersion and settling of dust particles in flow restrictors like regulators, valves, bends, etc. in oxygen systems have been performed. Calculations have been performed to predict the vulnerability of regulator for ignition due to PBD in simultaneous presence of both charged dust particle layer and dispersed dust particles.

Numerical results for tribocharging of dust particles have been validated with the experimental ones. In the present study it has been found experimentally that addition of 10 % to the charge value of metallic dust particles obtained from relations available in literature gives actual charge generation. Tribocharging of non-metallic dust particles also may be calculated using the relations given in literature. CFD analyses show valve seats and some other spots to be possible locations for accumulation of dust particles. An appropriate configuration may help to avoid the onset of PBD due to accumulation of charged dust particles on the regulator diaphragm. From the CFD analyses of dust particle settlement and dispersion, it is proposed that the reopening of the valve/regulator may be avoided up to 6 minutes plus of its closure to prevent the electrostatically charged dust particle layer causing the PBD and ignition of the dispersed dust particle.

Keywords: Oxygen, ignition mechanism, tribocharging, propagating brush discharge, dust particle layer, two-phase flow, dispersion, settling, valve, pressure regulator.