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Physics of the after-spark channel decay in dense gas

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Considerable experimental data on the dynamics of cooling of a post-discharge channel formed by high-power spark discharges, pulsed arcs, and laser sparks have been accumulated. Cooling of the hot post-discharge channel is a problem of major practical importance. The cooling rate determines the dielectric strength recovery rate. There is a regime when the turbulent gas motion develops in a decaying post-discharge channel, dramatically enhancing heat transfer compared with molecular heat conduction. Such turbulent motion arising in the after-spark channel can substantially enhance the rate of fuel-gas mixing, which may control the mixing rate in ramjet or scramjet engines. A known experimental results and simple theoretical models for self-consistent calculations of the entire evolution of a spark discharge and the subsequent cooling of the post-discharge channel, taking into account the generation and dissipation of turbulent motion of the gas are presented. Classical cascade and non-cascade mechanisms of a turbulence dissipation are discussed. The stabilizing effect of the continuous residual electric current on the plasma cooling in the channel is analyzed. This effect cannot be explained merely by Joule heating but is largely governed by the fact that the turbulent heat transport is substantially suppressed. The results for computed rate of restoration of dielectric strength are compared with known experiments.