1 Seminar-5

1.1 Waterloo Tsutsui

Crash Energy Absorption of EV Battery Packs

The current state of the art in the field of the mechanical behavior of batteries is limited to quasi-static analysis. The lack of the fundamental understanding on the dynamic behavior of batteries prevents automotive engineers from exploring bold design concepts, such as multifunctional batteries used as both an electrochemical energy storage device for vehicle propulsion and a crash energy absorption device for vehicle impact. In order for the batteries to be used as the crash energy absorption device, cylindrical “18650” lithium-ion battery cells and surrounding structures were exploited for their structural application and utilized in our proposed system, Granular Battery Assembly (GBA). GBA deforms under impact loads, which is similar to the behavior of cellular solids. Then, the deformation forces the rearrangement of load chain, which is similar to the behavior of granular materials. Combining these mechanisms, the GBA structure reduces the maximum impact force for EVs getting into crash loading conditions, thereby mitigating the risk of bodily injury to the vehicle occupants. The research results are both transformational and translational; therefore, the battery scientists and engineers will be able to incorporate the outcome of our research in the development of the next-generation EV batteries.

195 words

1.2 Sayan Biswas

Ignition of Lean Premixed H2/Air Mixtures by a Hot Jet Generated by Prechamber Combustion

An experiment is developed to investigate the ignition characteristics of ultra lean premixed H2/air mixtures by a turbulent hot jet generated by prechamber combustion. Fundamental understanding of complex jet ignition mechanism at lean burn regime ($\phi=0.35-0.5$) is of substantial interest. Simultaneous high-speed Schlieren and OH* chemiluminescence are applied to visualize the jet penetration and the ignition process inside main combustion chamber. A thorough knowledge concerning the evolution of hot transient turbulent jet structure is essential to understand inherently complicated jet ignition physics. Hot wire pyrometry is used to measure temperature distribution of this transient hot jet. A novel velocity measurement technique is developed based on Schlieren measurements to characterize the local flow field. Effect of prechamber volume and geometry, orifice diameter and length, spark location, initial temperature and pressure are considered. Results evidently illustrate existence of two ignition mechanisms, namely jet ignition and flame ignition. The former produces a jet comprising of only hot combustion products (the flame of prechamber combustion is quenched when passing through the orifice). The latter produces a jet of wrinkled turbulent flame (the composition of the jet is incomplete combustion products containing flames). The physics of two different ignition mechanisms, occurrence of one mechanism over another and the ignition probability can well be attributed to the local Damköhler number, the ratio of the characteristic turbulent mixing timescale to the characteristic ignition timescale. The range of the local Damköhler number corresponding to unsuccessful ignition, flame ignition and jet ignition are plotted on turbulent combustion regime diagram for ultra lean H2/air mixtures. Such criteria can be used to guide future prechamber design, optimization and to control overall ignition behavior at lean limit.

275 words