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Volumetric ignition control for HCCI engines using nanostructured materials and light

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Use of the homogeneously-charged compression ignition (HCCI) mode of combustion and its varieties in reciprocating engines are very promising technologies with demonstrated potentials for simultaneous reduction of emission of harmful pollutants and significant improvements in fuel economy. However, the timing for the compression ignition, or "auto-ignition", of the fuel-air mixture must be precisely controlled to be of practical use in such engines. To date variety of techniques have been employed to achieve a limited range of controllability of the autoignition process, being at the heart of the practical operation. Ideally, by "controllability" we mean the timing when the autoignition occurs as well as the volume within which it takes place. It is argued here that the potential for the widest HCCI engine operating range can only be achieved if these two attributes of the "controllability" are satisfactorily achieved. The author's group has pioneered the use of nanostructured materials, specifically single-walled carbon nanotubes (SWCNTs) and graphene, for the pulsed-light-activated volumetrically-distributed (PLA-VS) ignition of fuels. Based on tests conducted so far, this new ignition method is considered as a potential enabling technology for volumetric and distributed ignition of liquid fuel sprays and gaseous fuel-air mixtures with the lowest incident power intensity possible. This means remote and spatial ignition within any desired region defined by the shape of the light from a pulsed light source. Averaged light intensities between 10 to 150 W/cm2 are required for distributed ignition of SWCNTs. This is a factor of 80 less than cases where lasers (pulsed or cw) are used in coal particles. A side-by-side comparison between a conventional spark plug and the PLA-VS ignition method showed a great potential application of this new nanotechnology-enabled approach for HCCI combustion mode in engines.

Keywords: HCCI, carbon-nanotube, ignition, engine