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Characterization of a plasma enhanced ignition system for modern combustion engines by optical methods

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The principle of the ignition technology of Otto engines has not changed since its invention of Nicolas August Otto in 1884. A very high voltage pulse is generated by an ignition coil. This pulse causes a spark discharge between the electrodes of a spark plug, igniting the petrol-air mixture inside of the engine. Since alternative ignition systems are believed to reduce petrol consumption at the same engine power compared to a conventional ignition system, there are many approaches to optimize ignition technology. To influence plasma chemical processes towards a more complete combustion, the plasma parameters, the plasma volume and the transient behavior of the spark discharge have to be evaluated. Usually, spark plugs work in a pressure range of up to 30 bars, which is close to the ignition point of a modern Otto engine. For the characterization of a spark discharge, a high pressure experimental setup is used to avoid measurements inside the cylinder of an Otto engine. A double-stage vacuum system allows evacuation of the discharge vessel. It is possible to investigate the spark discharge in a simplified atmosphere only consisting of a single gas or more complex gas mixtures. To further investigate spark ignitions in a realistic atmosphere, an Otto engine equipped with an optical entrance is built up. It is possible to operate this engine with gasoline or propane. The transient behavior is investigated by a PCO hsfc pro ICCD camera, which consist of four independent ICCD cameras with one optical entrance. This way it is possible to take 4 consecutive pictures with an exposure time of 250 µs to investigate the plasma on a suitable time scale. To optimize the ignition process, a standard ignition system (ignition coil and spark plug used for automotive applications) is investigated in a pure nitrogen atmosphere for different pressures at first. An echelle spectrometer (ESA 4000, LLA Instruments, Germany) is used to determine the gas temperature. The spectrometer provides a spectral resolution of 0.015–0.06 nm in the range of λ = 200 – 800 nm. The measured emission spectra of the applied echelle spectrometer are compared with spectra of molecular nitrogen which are simulated for different rotational temperatures. The resulting gas temperature is compared with the gas temperature of an alternative ignition system. In a second step the two different ignition systems are operated in an Otto engine. The angle of ignition spacing is investigated at the same center of energy-conversion mass. The influence of the gas temperature of the angle of ignition spacing will be discussed.