ETHANOL DEFLAGRATION TO DETONATION TRANSITION

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Abstract

The present work-in Progress aims to determine the transition from deflagration to detonation of ethanol – air mixtures at different reduced pressures and 60°C. This temperature was needed in order to avoid ethanol condensation inside the tube. Different equivalence ratios were tested. The experimental work was conducted in the Explosion Physics and Prevention Laboratory at Queen's University.

The experimental apparatus consists of a detonation tube 6.2 m long, 0.1 m diameter and 1.91 cm of wall thickness. The flame was accelerated by placing orifice plates with 10 cm outer diameter and 7.55 cm of inner diameter. The plates spacing was 10 cm and they filled half of the tube. The detonation tube was wrapped with ceramic bead electrical heaters which were used to attain the desired 60°C temperature. An automobile spark plug system was used to ignited the mixture at one end of the tube few centimeters before the first obstacle.

The mixtures were prepared at 280 kPa in a separate mixing chamber provided with an electrical heater to attain the desired temperature. The mixture chamber is a cylinder with 25 cm diameter and 50 cm height. An impeller is located inside the chamber in order to ensure homogeneity of the mixture. The mixtures were prepared by the partial pressures method, using a pressure transducer.

The ethanol – air mixture was admitted into the detonation tube up to the test pressures of 60, 80 and 100 kPa. The initial pressure was measured by a pressure transducer. The flame speeds were determined by using ion probes. The ion probes detect when a flame passes by them and the corresponding time is registered. Afterwards, the flame speed is determined by using the spacing between two consecutive ion probes and the registered arrival times. In total 7 ion probes were placed, the first one was placed 60.96 cm from the ignition source, the distance between the second and third ion probes was also 60.96 cm, while, the spacing between any other consecutive ion probes was 30.48 cm.

The results obtained so far correspond to equivalence ratios ranging from 0.9 to 1.5 for 100 kPa, from 1.0 to 1.5 for 80 kPa and 60 kPa. In all cases the wave speed reached values above the speed of sound of the products. However, the velocities did not reach the Shapman – Jouguet velocity. All experiments were repeated at least 3 times.

As an example, the maximum wave speed at 100 kPa were 1084.7 m/s for ER=0.9; 1331.0 m/s for ER=1.0; 1437.7 m/s for ER=1.1; 1472.5 m/s for ER=1.2; 1404.6 m/s for ER=1.3; 1234.0 m/s for ER=1.4; and, 1088.6 m/s for ER=1.5.

More experiments will be performed by considering different inner diameters of the orifice plates.