Advances in Automobile Engineering

Extended Abstract

Diagnosis of hydrous ethanol combustion in a spark-ignition engine

Caio H Rufino[1], Waldyr LR Gallo and Janito V Ferreira

[1]University of Campinas, Brazil

Abstract

By evaluating combustion duration and flame development, it is possible to evaluate the effects of utilizing a new type of fuel. This allows for optimization of the operational parameters such as the ignition timing, air–fuel ratio, and throttle opening with respect to efficiency, knock, emissions, and performance. In this work, the combustion of a Brazilian hydrous ethanol fuel was evaluated in a commercial flexfuel engine. Investigations were conducted by performing a heat release analysis of the experimental data and providing combustion characteristics. The experimental design comprised of variations in engine speed, load, ignition timing, and air–fuel ratio under lean condition. The results indicated the relationship between the engine parameters and combustion characteristics under a wide range of operational conditions, and identified the relationship between the physical characteristics of the fuels and their combustion in the commercial engine. For high engine speed, lean combustion presented a similar duration to the stoichiometric combustion duration. When comparing the combustion characteristics obtained for the hydrous ethanol with gasoline combustion, the main differences noted were reduced sensitivity to detonation and a shorter duration of combustion, although the temperature at the start of combustion was lower for ethanol. In addition to shorter combustion duration, ethanol presented a lower value for the Wiebe exponent. The results obtained from the combustion duration values and Wiebe function parameters enable the composition of a set of data required for a simplified combustion simulation. Combustion diagnosis is a powerful tool employed in internal combustion engines, and it provides information regarding combustion characteristics using a thermodynamic approach. It is performed using the measured in-cylinder pressure, as it is the most accessible thermodynamic property in the cylinder.1 The combustion effect on the in-cylinder pressure can be isolated from other phenomena such as blow-by, heat transfer, internal energy change, and work.2 The outputs of the procedure are known as the apparent heat release (AHR) and the heat release rate (HRR) profiles. The start of combustion (SOC), end of combustion (EOC), and other secondary parameters such as the combustion duration, ignition delay, and form of combustion can be deduced from the AHR profile.

Therefore, it is possible to perform this analysis to determine the effect on combustion from engine design parameters such as piston geometry, compression ratio, and valve timing, as well as operational parameter, which are constantly adjusted by an electronic control unit (ECU) during the operation of the engine, such as air–fuel ratio, spark timing and load. From the HRR profile, it is also possible to understand the effect of each tested parameter on the phases of combustion, specifically the flame development phase (usually the phase until 10% of the fuel is burnt), fast burn phase (burnt fuel is from 10% to 90%), and quenching phase.3 Much research has been conducted on spark ignition engines (SIs), and it is possible to derive the mass fraction burned (MFB) from the AHR profile by knowing the trapped mass in the cylinder and the energetic content of the fuel, thereby providing a value for the fraction of burned fuel along the engine cycle. Other methods can characterize combustion from a more detailed and microscopic approach. For example, the flame growth, structure, and speed can be measured in optical engines or closed vessels to obtain the effects of specific parameters on

combustion, for example, the air–fuel ratio, 5 diluent concentration 6 and temperature.7 Such analyses can also be used to present comparisons between different types of fuels 8,9 However, determining the effect of the combined variation of many parameters within the wide operational conditions of an engine can be a difficult task. Thus, combustion diagnosis is still a reliable tool for characterizing combustion, and can be used in parallel to those methods, based on a more theoretical approach. Moreover, combustion diagnosis can provide data for data-based MFB models for engine simulation. The most frequently used correlation that describes the MFB profile is the Wiebe function.10 consequently, several studies in combustion diagnosis have evaluated combustion characteristics by fitting the parameters of the Wiebe function to the studied case.

Caio H Rufino,
University of Campinas, Brazil Email: rufino119186@gmail.com