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Cold start characteristics of an ethanol-fuelled engine with heated intake air and fuel

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ABSTRACT

The conventional cold start system of flexible fuel engines introduces gasoline in the intake system when the vehicle is fuelled with hydrous ethanol or with high ethanol content gasoline-ethanol blends. The system is necessary to allow for ignition of the fuel-air mixture under low temperatures due to the high ethanol evaporation temperature, in comparison with gasoline. This works presents a new cold start system for flexible fuel engines with heating of intake air and ethanol injector. The removal of the gasoline reservoir for cold start is the main benefit of the new system, and it is an awaited evolution of flexible fuel engines. The experimental results demonstrate that the new system provides hydrous ethanol-fuelled engine start in less than 2 s under temperatures as low as 0 °C.

1. Introduction

The physical–chemical properties of ethanol directly influence engine cold start. While gasoline-fuelled engines can start at ambient temperatures as low as −40 °C, ethanol-fuelled engines can only start at temperatures over 13 °C without the need of a cold start system [1,2]. Ethanol evaporation temperature is 78 °C, while the light hydrocarbon compounds of gasoline start to evaporate at 40 °C. Table 1 shows the main properties of hydrous ethanol (6.8% wt/wt water) and a blend of 22% anhydrous ethanol (0.7% wt/wt water) and 78% gasoline.

To overcome the ethanol cold start difficulties, ethanol-fuelled vehicles are equipped with an auxiliary gasoline injection system. Gasoline is injected during the cold start and warm-up period. Although this system reduces cold start problems, it is desirable to eliminate the system to reduce costs, to free car owners from the need to use a secondary fuel when fuelling with ethanol, and to reduce cold start emissions [3].

The conventional cold start system is constituted by a small gasoline reservoir, an electronic fuel pump and an electronic valve [2]. The addition of gasoline to the intake pipe is done through a pipe with calibrated holes. Gasoline is added to the intake pipe during cold start and warm-up period. The amount of gasoline added to the intake pipe is controlled by the engine electronic control unit that actuates on the electronic fuel pump and on the electronic valve.

Further developments on the conventional cold start system include the substitution of the pipe with calibrated holes by one or more electronic fuel injectors [4]. Nevertheless, it still requires the use of gasoline as an auxiliary fuel for cold start of ethanol-fuelled vehicles. An evolution of the cold start system with an electronic fuel injector for gasoline injection is the use of a fuel distributor at the injector inlet [5]. This system allows for more accurate control of the gasoline amount injected.

Recent attempts try to eliminate the use of gasoline and all components of conventional cold start systems through ethanol heating [6–11]. In some cases, the time required to fully heat the injected ethanol can be very long for acceptable cold start standards. Depending on the ambient conditions, the heated fuel amount may not be enough to promote engine start. If heated ethanol is introduced in the intake pipe in a point far from the intake valve, excessive heat loss to the cold intake air may prevent ethanol to reach the combustion chamber with an adequate temperature for vaporization.

Heating of the fuel line was an alternative presented by Boyle et al. [6] for cold start of E85 fuel (85% ethanol and 15% gasoline). The authors used 950 W electric resistances to warm the fuel line. Heating of E85 allowed for cold start and operation of a converted vehicle with similar performance as when it used gasoline as the original fuel.

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