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Identification of a charge formation and combustion with a direct injection dual-fuel supply system

The doctoral thesis takes up the issue of direct, high-pressure injection of two different liquid fuels to the combustion chamber of a spark-ignition (SI) internal combustion engine. Its scope covers the simulative research concerning spray, combustion and exhaust emission processes, and the experimental research of processes of spray and combustion.

The direct fuel injection becomes the main method of mixture formation in SI engines, on the other hand, the direct supplying two fuels to the combustion chamber is an actual research direction on lowering the harmfulness of transport on the environment. As a method of charge formation in the combustion chamber, the novel dual direct fuel injection was applied.

The research was conducted using gasoline, ethanol, n-heptane and n-butanol. The choice of fuels was motivated by the trends in the newest scientific research, focused on the described issues.

In the thesis, the simulative research method was utilized, with the use of the AVL Fire software. This work concerned the determination of the geometrical position of injectors in the cylinder head of the modeled engine. The methodology of maximizing the spray, combustion, and exhaust emission processes' indicators were used for three variants of injectors' position in the combustion chamber. The following research – the experimental one – concerned the analysis of spray and combustion processes of fuel mixtures formed directly in the combustion chamber. Four fuel mixtures: gasoline + gasoline, gasoline + ethanol, gasoline + n-heptane, and gasoline + n-butanol were subjected to the analysis.

The above research on the fuel spray was conducted using the constant volume chamber. Utilizing the high speed camera, the geometrical spray development was recorded, and the selected geometrical spray indicators were analyzed: the range, the width, the speed and the area. In the optical research, two spray lighting sorts were used: LED light and the oriented laser light, to eliminate the dependency of research results on the lighting sort.

The experimental research of the combustion process was conducted using the rapid combustion machine. Simultaneously, the optical and indicator research was conducted. The analyzed indicators of the combustion process were the cylinder pressure, the pressure rate, the heat release rate, and the heat release value itself. The optical research of the combustion process enabled the analysis of the flame development in the recorded area of the combustion chamber.

As a result of the conducted research and analysis, it was stated, that it is possible to control the excess air ratio directly in the vicinity of the spark plug right before the ignition. This possibility is achieved by the injected fuels' properties, which mainly include the diverse value of the stoichiometric air-fuel ratio to combust these fuels. Additionally, in the spray research, it was stated, that the sort of fuel has a negligible impact on the geometrical properties of the spray formed with direct injection.

In the research of the combustion process, it was proven, that the charges composed of the gasoline and a different fuel are characterized with the greater combustion efficiency than the charges composed of only one fuel, and the impact of the sort of the used fuel is significant for the combustion process and the values of the process indicators.

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