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Operation of a Spark-Ignition Engine on Mixtures of Petrol and N-Butanol

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Abstract

The Article analyses the use of n-butanol (biobutanol) in mixtures with petrol in spark-ignition (SI) internal combustion engines (ICE). Analysis of the scientific literature allowed determining that n-butanol content had a different effect on the same engine parameters in different tests, thus a decision was made to conduct additional research, where, having assembled the necessary equipment and conducted experimental planning, experimental studies of n-butanol (with its volumetric content being 0%, 20% and 40%) and petrol blends in a SI engine were carried out. Regression analysis of research results was conducted and regression dependences were formed allowing evaluating the impact of the key variables (δ and θ) on engine parameters (M_e, P_e and b_e). The research results have shown that without changing the ignition advance angle θ, petrol blend with 10% n-butanol has essentially no adverse effect on engine power P_e, engine torque M_e and specific fuel consumption b_e. Increasing n-butanol concentration δ, the maximum engine torque M_e and effective power P_e decrease, while the specific fuel consumption b_e increases. Energy engine indicators decline as a result of a lower calorific capacity of n-butanol compared to that of petrol and lower combustion rate of n-butanol. Increasing n-butanol concentration δ in fuel mixture, engine parameters can be improved by advancing the ignition angle θ.

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Keywords: n-butanol, spark-ignition, fuel mixtures, power, torque, fuel consumption

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1. Introduction

Nomenclature

SI	spark-ignition
ICE	internal combustion engines
P_e	engine power
M_e	engine torque
b_e	specific fuel consumption
n	crankshaft rotational frequency
δ	n-butanol concentration in fuel mixture
θ	ignition advance angle
RON	research octane number
MON	motor octane number
TDC	top dead center
λ	excess air factor

At present, the most topical transport problem worldwide is environmental pollution by exhaust gas and reckless waste of non-renewable energy resources, so abundant scientific research works on investigation of fuels of the new generation, modification of internal combustion engines of usual types or creation of new ones upon striving to reduce the environmental pollution caused by them, to use renewable energy resources and to win the economic benefit are carried out.

Recently, a particular attention is paid to reduction of greenhouse gas emissions. Statutory regulation of them began as early as in 1992, after signing the United Nations Framework Convention on Climate; in addition, Kyoto Protocol on reduction of greenhouse gas emissions was signed in 1997. The major sources of atmosphere pollution include transport and energy sectors that use fossil fuels, so EU encourages to replace resources of mineral fuels by renewable energy resources and extend use of the latter in various sectors of economy [1].

Road transport and the exhaust gas generated by it affect considerably the air quality and the human health. In EU Member States, regulations for road transport exhaust pollutants are being applied. The said regulations provide a serious challenge to manufacturers of vehicles and fuels. In the document of the European Commission, no specific technologies that would enable satisfying the requirements of “Euro 6” are pointed out; however, it is emphasized that this task may be accomplished by improving engines and their exhaust gas systems as well as by searching for opportunities of using alternative fuels.

Use of alternative fuels in internal combustion engines applied for operation on oil-based fuels causes a number of various problems. If only an alternative fuel is used, an expensive and complicated alteration of the structure of the engine and its control systems is required. Upon striving to pare down the said expenses and to simplify the vehicle use, it is confined only to a partial replacement of usual fuel with an alternative fuel; in the case under discussion, the alternative fuel is biobutanol.

Butanol (also called butyl alcohol) is a four-carbon alcohol with a formula of C_4H_9OH, which occurs in five structures, from a straight-chain primary alcohol to a branched-chain tertiary alcohol; all are a butyl or isobutyl group linked to a hydroxyl group (sometimes represented as BuOH, n-BuOH, and i-BuOH). These are n-butanol, 2 stereoisomers of 2-butanol, tert-butanol, and isobutanol. Butanol is primarily used as a solvent, as an intermediate in chemical synthesis, and as a fuel. It is sometimes also called biobutanol when produced biologically.

It is notable that until quite recently, butanol was not known to be an alternative fuel, because its production never was considered economically viable.

However, new high-efficiency butanol production technologies appear at present, so it, as a fuel for road transport, attracts an increasingly growing attention of professionals and it is not improbable that ethanol will loss a priority in future. At present, butanol is considered one of the advanced types of motor fuels.

Today, organization of butanol production is one of the most perspective directions of development of biofuel based energy sector worldwidely.