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Experimental Aspects of the Hydrogen Use at Diesel Engine

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Abstract

In the global content regarding the impact on the environmental of the gases emissions resulted from the fossil fuels combustion, aspect discussed on the 2015 Paris Climate Conference**,** contribute to the necessity of searching of alternative energy from durable and renewable resources. The purpose of the paper is the use of hydrogen fuelling at truck diesel engine in order to improves engine efficiency and pollutant performance, hydrogen being injected into the inlet manifold. Experimental results show better energetic and pollution performance of the dual fuelled engine due to the improvement of the combustion process and reduction of carbon content.

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Keywords: diesel engine; hydrogen; substitute ratio; combustion; pollutant emission.

1. Introduction

In the global content regarding the impact on the environmental of the gases emissions resulted from the fossil fuels combustion, an interest aspect discussed also on the 21st Session of the Conference of the Parties (COP21) from the 2015 Paris Climate Conference in November 2015, and the gradual diminution of the worldwide oil reserves contribute to the necessity of searching of alternative energy from durable and renewable resources. The replacement of the classic fuels of oil origin by alternative fuels was initiated many decades ago and represents one of the most actual preoccupations linked by the possibility of pollutant emissions decrease and efficiency increase of the diesel engine and necessity of fossil fuel saving. These issues impulse the research's for developing and using

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new fuel sources which will allow the substitution, even a partial one, of the classic fuels. Many specialists consider hydrogen a future fuel for the automotive industry due to its properties which define it as the cleanest fuel and due to the unlimited sources of manufacturing, [1], [2], [3], [4], [5]. The purpose of the paper is the use of hydrogen fuelling at diesel engine in order to improves engine performance and pollutant emissions. The use of hydrogen as fuel for diesel engines is a high complexity aspect because of some hydrogen particularities, such as: very wide flammability limits, very high combustion velocity, lower minimum ignition energy, lower caloric power per volume unit, higher diffusivity coefficient versus diesel fuel. These properties lead to specific issues of the hydrogen use at diesel engine: tendency of uncontrolled ignition with inlet backfire, in-cylinder combustion with higher heat release rates and even knock (higher maximum pressure rise rate, brutal engine running) and with high NO_X level, tendency of power per litre decreasing, storage difficulties [1], [2], [3], [4], [5], [6], [7]. The most critical issue is related to the difficulty of the autoignition without require major design modification of the standard engine, hydrogen having a higher autoignition resistance defined by a lower cetane number. At the use of hydrogen as addition in air to diesel engine, the level of CO, HC and smoke from the exhaust gases will decrease due to the improvement of the combustion process [2], [3], [4], [5]. At low and medium partial loads (often used in exploitation) and low hydrogen energetic ratios used the NO_X emission level can decrease comparative to classic diesel engine. The hydrogen use as fuel for diesel engine leads to the improving of the energetic and emissions performance of the engine due to combustion improvement and reduction of carbon content [3], [4], [5]. At engine running at the fuelling with hydrogen and diesel fuel, the CO, HC and smoke emissions has a much lower level comparative to diesel engine fuelled with diesel fuel due to improvement of the combustion, a lower carbon content in air-fuel mixture and a higher homogeneity of air-hydrogen mixture [1], [2], [3]; slightly increase of the CO_2 emission level [3]. The level of the NO_X emission increases at the rise of the hydrogen addition, especially at large engine load because the in-cylinder gases temperature is much higher comparative to the NO_X formation temperature [3], [4]. N. Saravanan [5], Younkins M. [3] and Tomita [6] show that the NO_X emissions level decreases with almost 14% at hydrogen fuelling in relative low additions (up till 15% energetically substitution of diesel fuel) at small engine loads, due to a shorter duration in which the high temperature reached inside the engine cylinder exists, the NO_X emissions forming being avoided. At big hydrogen additions, the level of NO_X emissions increases, comparative to the emissions level of a standard engine, because of the duration of maintaining high temperatures inside the cylinder [6], [4]. Talibi et. al. [7] show that at use of the hydrogen in addition with diesel fuel, CO, HC and smoke emissions level decreases due to improvement of the combustion, but CO_2 emission slight increases [7]. The NO_X emissions increase with hydrogen addition percent at higher engine loads only when the gas temperature is over the temperature for NO_X formation, by Santoso [8]. Researchers highlight the decrease of brake specific fuel consumption (BSFC) at the hydrogen amount increase which replaces the diesel fuel due to the increase in brake thermal efficiency [3], [4], [9], [10]. Pollutant emissions are dependent on engine operating conditions (engine load, engine speed etc), fuel composition, air/fuel equivalence ratio, oxygen content. At use of the hydrogen as addition in air, hydrocarbons and smoke emissions level decreases due to improvement of the combustion and due to lower carbon content in air-fuel mixture [7]. For used small hydrogen quantities, CO emission level decreases but if the percent of substitute of diesel fuel with hydrogen is greater then CO emission level increases, in special at engine great loads, due to lower oxygen content in air-fuel mixture [4]. The NO_X emissions level increases with hydrogen addition percent at high engine loads only when the gas temperature is over the temperature of NO_X formation [10], [11]. Some authors, Lambe, Talibi, Pechlivanoglou, show that the NO_X emissions level decreases at the engine operation with small hydrogen quantities in addition in air (for engine partial loads) [7], [11], [12]. The research work has been carried out on automotive truck diesel engine firstly fuelled with diesel fuel and in the secondly dual fuelled with diesel fuel and hydrogen at different rates up till 40 L/min. The paper presents, in a comparative way, results of the experimental researches carried on a truck diesel engine fuelled with diesel fuel and with diesel fuel and hydrogen as addition in air, the results obtained during experimental investigations showing better energetic and pollution performance of the engine fuelled with hydrogen as addition in air comparative to classic engine. The influences of hydrogen addition are analyzed and shown and by this the authors bring an important contribution in the knowledge field of hydrogen use at diesel engines, the professional literature offering extremely few information's at the present time. The main advantages are represented by the optimal correlation between engine parameters at dual fuelling for which the combustion process control is efficient and the best energetic and pollution engine performance are achieved.