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Protection of the environment by using innovative greening technologies in land transport

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ABSTRACT

The continuous growth of population results in more consumption of energy. Moreover, land transport consumes about 35% of the total liquid fuel in most countries. The resulting pollutants cause a tremendous death toll. Hence, it is imperative to enhance the fuel efficiency in transport and protect our environment to make vehicles progressively greener. The engine is an important component for meeting this goal.

The spark ignition engine, by far, is the largest source of motive power in the world. Therefore, continuous endeavors to improve its performance are needed to save fuel, reduce cost and protect the environment.

In this article, nine research investigations carried out by the author and associates during the last few years are briefly reviewed. These researches cover major green tools and technologies which contribute directly in the advancement of land transport especially fuel saving, power boosting and emissions reduction.

This work comprises fundamental studies in modeling and simulation with spark ignition engines S.I.E. and compression ignition engine CIE; impact of alternative fuels with S.I.E.; combustion chamber design; heat transfer in ICE; gaseous pollutants and the environment; and the design of an innovative engine control. Moreover, fuel cells, electric vehicles and biofuels for sustainable future of transport are briefly discussed.

Engineering analysis covered alternative fuels, combustion chamber design, heat transfer, pollutant formation and neuro-fuzzy control.

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1. Introduction

Reserves of crude oil are continuously decreasing in parallel with growing population and increasing energy demand. Hence, it becomes necessary to enhance energy efficiency in different aspects especially transport, to make vehicles progressively greener. Thereby, the engine is expected to play a major role towards this goal.

Internal combustion engines of all types are, by far, the largest source of motive power in the world. Their many advantages have brought them to this position in spite of their shortcomings. Among the advantages which must be listed are high efficiency, low cost, low weight, long life, versatility and simplicity [1]. The relative importance of the advantages varies with engine type, power output, fuel consumption and application [2]. The trend toward high-performance automobiles made interest in these engines unsurpassed [3].

In the United States, the passenger car sector represents 80% of the total vehicles and uses 70% of the highway fuel. The spark-ignition engine dominates the light-duty vehicle market due to its low initial cost, good performance and good fuel economy [4].

Major changes in engine technology have emerged due to the need to reduce vehicle emissions, reduce fuel consumption, increase the engine specific power and improve vehicle drivability. For the spark-ignition engines, these improvements have come from areas such as development of more sophisticated engine designs with electronic engine control, and the development of the catalytic converter [5]. An energy balance through the engine cycle identifies where the potentially useful work is lost through irreversibilities such as friction, heat transfer and the exhaust-gas flow [6].

2. Systems analysis

This analysis focuses on several tools and technologies utilized by the author and associates in nine previous international publications. These technologies may boost power, reduce fuel consumption and save the environment from tons of gaseous pollutants emanating from land transport. They are briefly mentioned in the following sections.

2.1. Modeling and simulation [7,8]

Modeling is important because it saves time, effort and cost needed for engine development and prediction of performance. This could cover losses due to imperfect construction of the real engine including progressive combustion, valve timing, heat transfer and engine friction. Hence, it becomes possible to convert the output of the fuel–air cycle into net real performance. Simulation of engine performance is usually carried out by varying engine speed, compression ratio r_c, and the spark advance over wide range. Then it becomes possible to compare the results of modeling with those from experiment to explore the accuracy of modeling.

Impact of alternative fuels is important because it affects engine performance and the resulting pollutants. The increased use of automobiles and the rapid rate of industrial development in the world made petroleum supplies unable to keep up with the demands. Petroleum fuels usually pollute the environment with their combustion products. Control devices are used to reduce pollution but they also reduce vehicle mileage [9]. Alternative fuels cover wide variety, mainly alcoholic fuels and gaseous fuel produced from renewable resources, and produce less exhaust pollutants. Gaseous fuels offer cleaner combustion due to their better fuel–air mixture preparation and higher H/C ratios than in the conventional liquid fuels [10].

2.2. Combustion chamber design

The internal combustion engine (ICE) has been continuously developed by carrying out research in different aspects. When gasoline engines are tested using different speeds, combustion appears to be the major contributor to the system inefficiency and all performance parameters were affected by engine speed [11].

The compact chamber spark-ignition engine is one of the methods used to improve the performance of the spark-ignition engines. In this design, the chamber is a bowl-in-piston or in the cylinder head itself. This design will cause swirling of air–fuel mixture, which means better mixing of air–fuel mixture, so the specific fuel consumption will decrease due to leaner mixture and reduction in pumping work. The brake power and efficiency will increase [12,13]. These improvements in performance parameters make it worth using the compact S.I. engine instead of the conventional one.

In the direct-injection stratified (DISC) engine fuel is injected into the engine cylinder just before top–center (like diesel); a spark discharge is then used to initiate the combustion process. At high load, the inlet pressure is boosted by a compressor to above atmospheric pressure. The compressor is geared directly to the engine drive shaft. The exhaust pressure is 1 atm. This DISC engine is suggested to replace an equal displacement conventional naturally aspirated spark-ignition (SI) engine, which has a compression ratio of 8 [14,15].