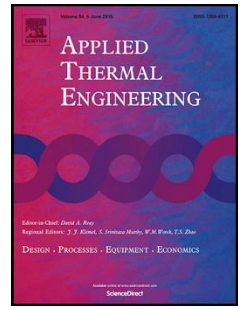


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# A NUMERICAL AND EXPERIMENTAL STUDY OF DUAL FUEL DIESEL ENGINE FOR DIFFERENT INJECTION TIMINGS

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**ABSTRACT**

The dual-fuel technology has the potential to offer significant improvements in the $CO_2$ emissions from light-duty compression ignition engines and, in this sense, such a concept represents a viable solution to reduce emissions from diesel engines by using natural gas as an alternative fuel. In light duty, high-speed engines, where the combustion event can be temporally shorter, the injection timing plays an important role on the performance and emissions. Following a methodology that has been proposed in previous authors' papers, this article summarizes the results of a combined numerical and experimental study on the effect of injection timing on performance and pollutant fractions of a common rail diesel engine supplied with natural gas and diesel oil. The study of dual-fuel engine carried out in this paper aims at the evaluation of the CFD potential to predict the main features of this particular technology. The experimental investigations allow the validation of the CFD modeling and at the same time, to highlight the major aspects that arise from the actual engine operation with different diesel injection advances. The fluid-dynamic calculations are extremely useful to put into evidence the key phenomena that take place during the dual-fuel operation, say the typical flame propagation throughout the premixed methane-air medium that is activated by the early self-ignition of the diesel fuel.

While previous papers have discussed the effect of the NG/ diesel fuel ratio, this paper focuses the attention on different conditions that have been induced by varying the injection timing at fixed brake torque and diesel amount. Actually, the start of injection timing can considerably influence the combustion development and therefore THC and NOx fractions production. Calculations making use of the Fluent code have been compared with the experimental data and a comparison between full diesel and dual fuel operation has been made, in terms of performance and pollutant levels.



**Keywords:** *CFD, Dual fuel engine, Injection timing, $CO_2$ reduction*

## INTRODUCTION AND STATE OF ART

Dual-fuel engine (diesel/NG) represents a possible solution to reduce emissions from diesel engine by using a natural gas mixture as an alternative fuel. The dual-fuel engines are supplied with both natural gas and diesel fuel simultaneously, but the most of fuel burned is natural gas. Diesel fuel acts essentially as a "spread spark plug" as it self-ignites after compression and then aids the ignition of the natural gas - air mixture, whose equivalence ratio is close to the lower flammability limits.
The idea of the Dual fuel mode is to exploit the favourable characteristics of natural gas by keeping the diesel engine compression ratio and its efficiency level. The NG could be responsible not only for lower $NO_x$ emissions but also for a reduction of $CO_2$ formation, since it is the fossil fuel with the lowest C/H ratio.
An improvement of the dual fuel engine performance can be obtained especially if the engine is equipped with an exhaust gas recirculation (EGR) system for aiding the development of a smoother process; actually if considering the high octane number of NG [1-2], in high pressure gradients due to a quick combustion with a high risk of knock due to end gas autoignition should be avoided in some operating conditions. In addition, at low loads the recirculation of part of the hot exhaust gas allows an improvement of the combustion due both to the presence of radicals and to the temperature increase [3].

Several authors are investigating on dual fuel mode in a Diesel engine, by assuming natural gas as main fuel and varying the chief engine parameters to define the best operating condition in terms of diesel injection law [4], diesel/NG ratio and many others. Some authors consider also other gaseous fuels as a primary premixed fuel, as described in [5].

Combined with an experimental activity, the numerical simulation can be helpful in understanding the complicated combustion phenomenon in a hybrid engine such as the dual-fuel one. In [6] the combustion process within the diesel and diesel/gas dual-fuel engine is investigated by means of a coupled 3D-CFD/chemical kinetics framework. In this study, methane and n-heptane are used as representatives of the natural gas and diesel fuels. The KIVA-3V code, with modified combustion and heat transfer models, incorporates a chemical kinetics mechanism for n-heptane and methane oxidation chemistry. A chemical kinetics mechanism of 42 species and 57 reactions is used for predicting the n-heptane oxidation chemistry. The results show that Zheng and Yao's n-heptane mechanism, which had been previously validated in their work, is able to model the diesel and dual-fuel combustion, where fuel-rich zones are present. Based on constant total mixture input energy in dual-fuel combustion, increasing pilot fuel