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NUMERICAL INVESTIGATION OF EMISSIONS IN A COMPRESSION IGNITION ENGINE

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INTRODUCTION

The effects of technological advances are also seen in the automotive world. Many studies on vehicle structure, vehicle control systems, powertrain and vehicle engines are being carried out and new R & D investments are being made in the automotive sector.

Experimental research on internal combustion engines, one of the most important research areas of the automotive field, requires high costs and time-consuming. The importance of numerical modeling studies for internal combustion engine is increasing day by day and numerical modeling studies save time and reduce costs.

The R & D done on the engines focuses on engine performance and engine emissions and continues with increasing momentum every day. All working conditions of the engine are examined in detail by experimental and numerical analysis methods and optimum working parameters are tried to be determined and controlled.

The effect of many parameters on engine performance and exhaust emissions can be examined ultimately with the modeling software. Examples of these parameters are: loading conditions, compression ratio, combustion mechanisms, alternative fuel additives, alternative fuel usage, combustion chamber geometry, etc.

Engine modeling studies are carried out through 1-D modeling and 3-D modeling methods. In this context, many software are used such as Ricardo-Wave and STAR-CD/es-ice, AVL-Fire, GT-Power etc. Through the studies carried out in these software, many results can be obtained about the actual engine behavior.

It was conducted several studies on the engine modelling by this time. Hooper, P. R. et al.[1], modelling engine as 1-D for multi-fuel operation via using Ricardo-Wave software. Results of computational modelling of a stepped piston engine using one dimensional CFD code. In their work, the engine has set specific fuel consumption values for different fuels. Malaguti and Fontanesi [2], investigated the formation of liquid film and the development of spraying in a commercial-engineered combustion chamber with spark ignition by means of computational fluid dynamics at low temperature operating conditions with STAR-CD software. Aydın and Soruşbay [3], numerically modeled the effects of CNG-air mixtures delivered to an internal combustion engine in the AVL-Fire program on engine performance.

In this study, a commercially compression ignition engine was 1-D modelled and the emission values were analyzed.

MATERIALS AND METHODS

As a result of numerical modeling of compression ignition engines, the performance and emission values can be obtained more quickly and economically than the test devices. It is difficult for engine manufacturers to respond to the Euro Norms and the Driving Cycle's emission values. Hence, it has become inevitable for producers and users to turn to numerical analyzes instead of costly and time-consuming engine tests.

In this study, a compression ignition engine was modeled as 1-D with all the elements. Engine parts with specific geometric measurements are created individually with representative elements.

The engine 1-D model is built including the entire engine from the beginning of the intake line to the end of the exhaust line as plotted in Figure 1.

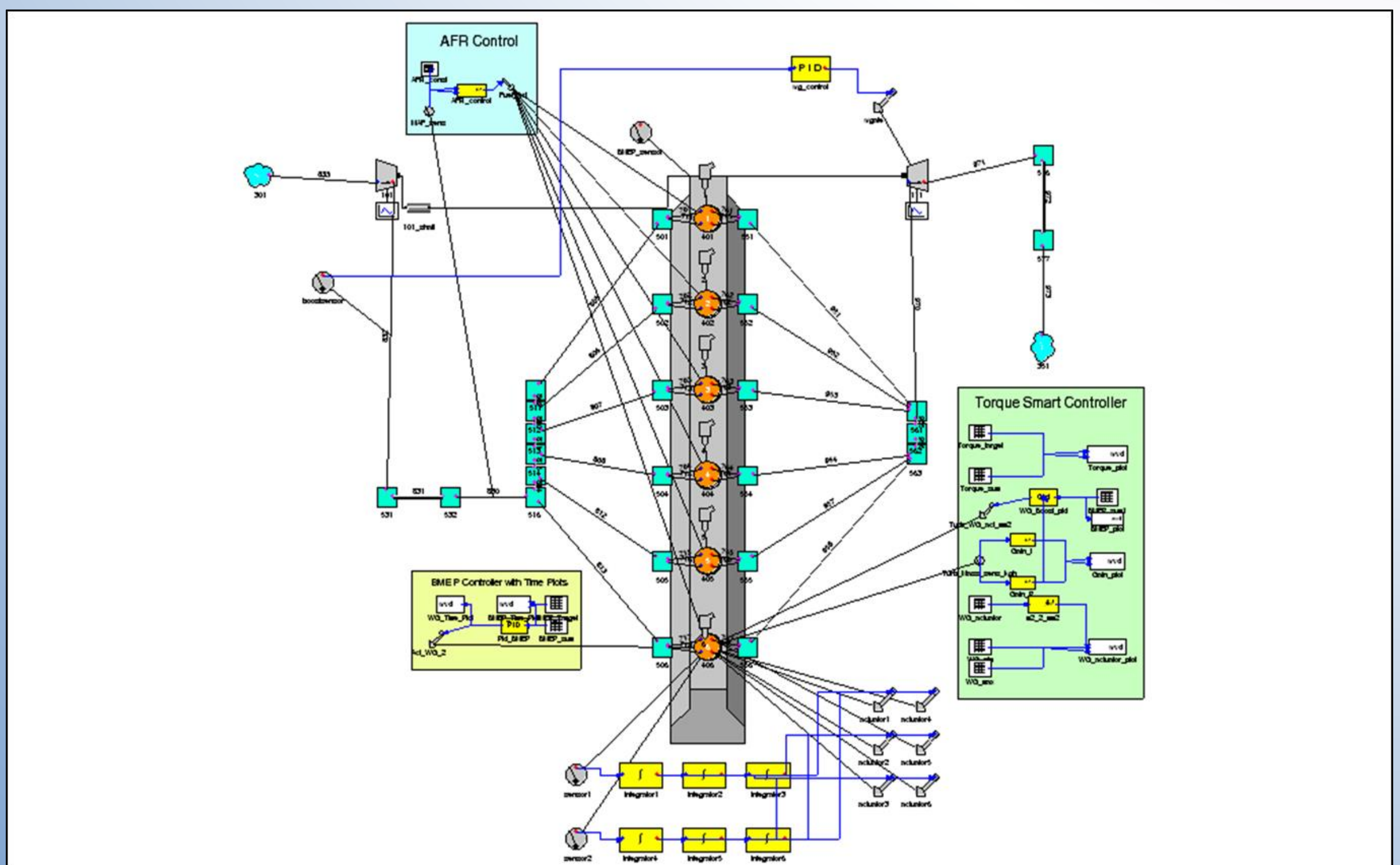

Figure 1 : 1-D Compression ignition engine model

At the beginning of the engine modelling phase, each engine components (pistons, injectors, cylinders, valves, ports, engine blocks, intake and exhaust manifolds, fuel line, exhaust line, etc.) are separately formed by defining their properties in Ricardo-Wave. Then, they are connected to each other by defining the relevant relations and boundary conditions.

The model created engine has the following features: 2.8 liters stroke volume, 6 cylinders, 420 Nm torque and 130 kW power. During the 1-D modeling, Wiebe was used as the combustion model and Woschni was used as the heat transfer model.

For read engine data on the 1-D engine model, many sensors, actuators and signal processor are located at certain points on the model.

The analyses were run for 250 engine cycles in order to ensure fully developed steady conditions before reading the data.

RESULTS AND DISCUSSIONS

The results obtained from the 1-D model was compared with the motor test results and the results are shown graphically in Figure 2. The results of the study are listed below:

- CO emission increases with speed. The emission of CO_2 decreases with increasing speed. Combustion efficiency decreases at high speed and the partial products of incomplete combustion increases as a result of this CO formation increase.
- The formation of HC in engines depends on many factors. As the main causes of hydrocarbon (HC) formation; the fuel vapor, the blowing gases formed in the combustion chamber, the lubricating layer on the piston-cylinder contact surface, the areas in which the flame can not reach the piston-cylinder connections, the high-level aromatics and olefins contained in the fuels, etc. As can be seen in the graphic, the HC emission decreases as the engine speed increases.
- The formation of soot is always contrary to the formation of nitrogen oxides. NO_x is observed in poor mixtures and at high temperatures. Whereas the formation of soot is a powerful function of the rich mixture.
- NO_x with speed increases by making some fluctuations. NO_x formation depends on the air-fuel ratio and in-cylinder temperature because nitrogen and oxygen enter the reaction at high temperatures and NO_x are formed. Exhaust gas temperature values support NO_x trends.
- The 1-D numerical model and the test results were obtained in the near-realistic trends.

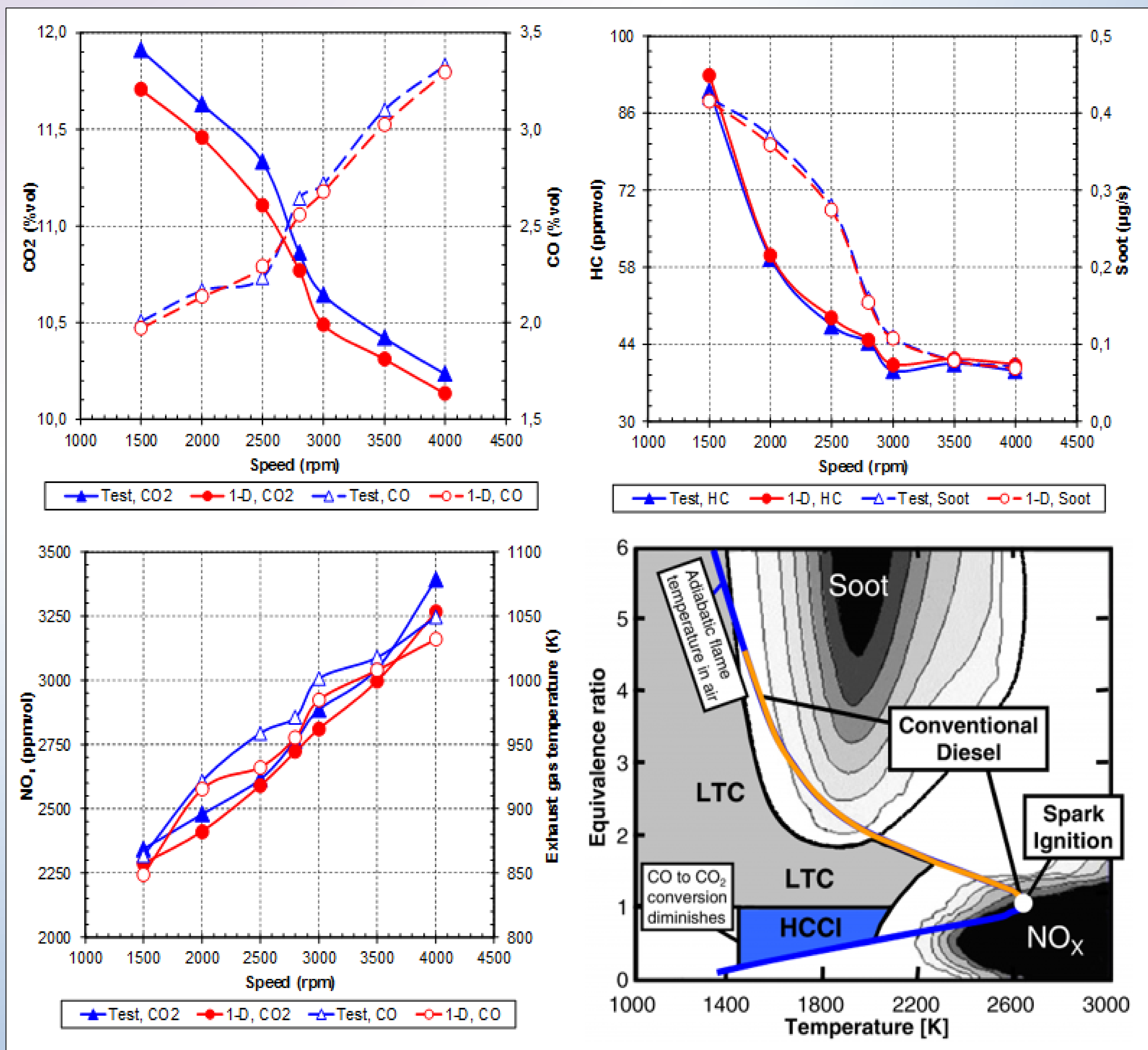

Figure 2 : Trends of emissions characteristics

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