SECTION 7. POWER ENGINEERING

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IMPLEMENTATION OF ARTIFICIAL INTELLIGENCE FOR THE DEVELOPMENT OF INTERNAL COMBUSTION ENGINES

ПЕРСПЕКТИВИ ЗАСТОСУВАННЯ ШТУЧНОГО ІНТЕЛЕКТУ ДЛЯ РОЗРОБКИ ДВИГУНІВ ВНУТРІШНЬОГО ЗГОРЯННЯ

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Nowadays, the applications of Artificial Intelligence (AI) are noticeably extending in the wide range of research and industries. It seems that industrial products are competing in equipping themselves with artificial intelligence. Engines also use this concept to improve their performance, usability, and viability in this competition.

It could be asserted that the world is experiencing the midst of a new wave of artificial intelligence algorithm development. Besides the conventional ways to improve engine performance, its numerous challenges and the competition between the producers lead the researchers to develop artificial intelligence algorithms and apply them in the engine industry. Using conventional methods to regulate, anticipate, and optimize the hardly nonlinear and complex events of an ICE such as 2D and 3D mapping of the engine characteristics, large number of nonlinear combustion chemical reactions, pressure and temperature gradients, multi-phase flow interactions, and formation of particulate matters is a challenging issue. So, the models based on AI could estimate the engine performance ignoring such hard phenomena and just based on the experimental data [1].

Furthermore, there are some ignored issues in conventional ICE management systems such as regulating stochastic cyclic variability that brings insufficient performance for the engine management systems. More powerful and efficient control models are provided using artificial intelligent algorithms in various ICE combustion modes such as homogeneous charge compression ignition or reactivity-regulated compression ignition. The rapid rise of employing and applying big data, make us able to provide ever-more sufficient and smart management system using a large amount of details and countless information from the engine sensors such as speed, load, indicated torque, temperature, pressure, fuel injection, fuel consumption, etc. Figure 1 illustrates more clearly what is meant.

It is obvious that such an enormous amount of data needs a powerful analyzing tool, and artificial intelligence algorithms are the best choice considering efficiency, time consumption, errors, and cost for engine management. In addition, AI technology using the data adopted from noticeable comparable ICEs connected to a network could provide a real-time smart engine management system [2].

The ever-increasing growth of human societies, continuous change of customer desirers and the mechanization of traditional common methods besides fossil fuel resource limitations, environmental pollutants concerns, and design considerations lead researchers to have non-stop efforts developing the performance of internal combustion engines. Extended works have been carried out by researchers to have more efficient and cleaner engines These efforts contain a vast variety of approaches from engine design to fuel development and combustion control [3].

Among these extended subjects, applying AI to internal combustion engines is a new approach on which researchers are working. Although the most of efforts have been devoted to the control approaches [4], the range of employing AI in engine performance development is still wide from the optimized redesign to fuel/charge mixture and combustion characteristics [5].

Furthermore, due to the strong research background in this field, it can be asserted that AI technology is simultaneously applied to all known combustion modes, from spark ignition engines to diesel and low-temperature combustion ones [6].

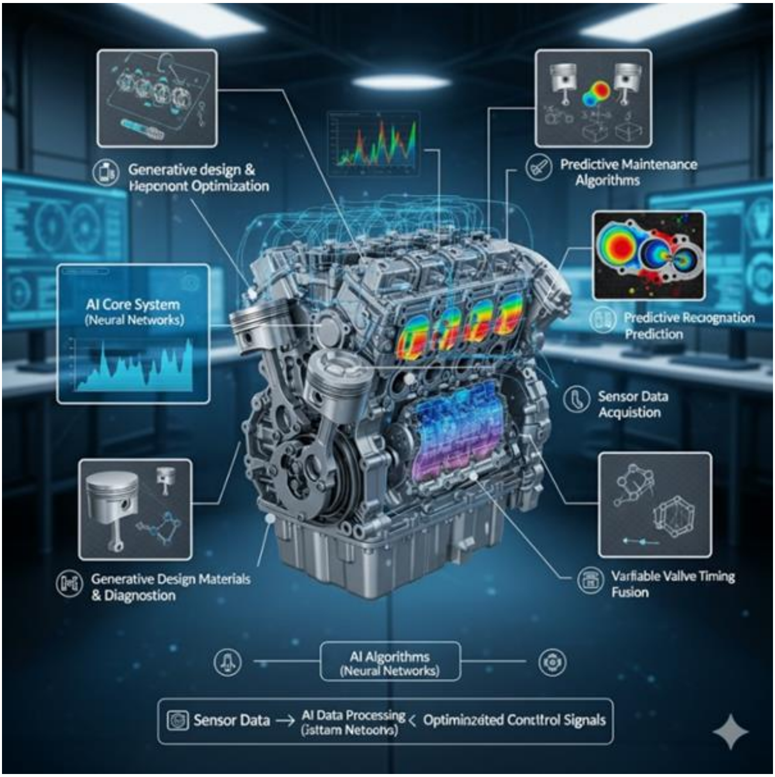

Fig. 1. Main initial data used for designing internal combustion engines

Most of the efforts are based on the Artificial Neural Network (ANN) to simulate the engine performance and then use such a model for control approaches or optimization. Indeed, engine general performance such as power, torque, and emission based on its operating conditions and input parameters such as valve timing, ambient pressure/temperature, and equivalence ratio could be estimated using machine learning and deep learning techniques (Figure 2). In such models, based on the engine data set, some predictive correlations will be produced and used to estimate the target values based on the input ones.

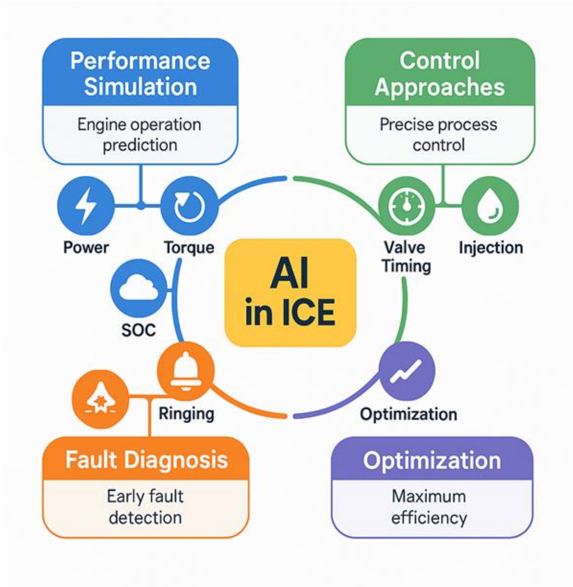

Fig. 2. Parametric model of AI processes in internal combustion engines

Conclusions. Algorithms and neural networks enable optimization in the design of internal combustion engines at an unprecedented level. Design optimization is achieved through the analysis of data obtained during testing and simulation. AI enables predictive modeling, predicting efficiency and performance. AI can help develop safer and cleaner engines that meet the most stringent requirements. Modeling and simulation allow you to assess the environmental impact of the engine and conduct multi-parameter optimization to reduce emissions.

Looking at more details on the engine control unit, we are able to find some primary levels of intelligence. There are lots of calibration tables for operating ranges of the engine that the engine control unit uses to calculate the needed, for example, fuel to be injected based on the working condition and driver request. Based on the data adopted from the sensors (engine speed, manifold pressure and temperature, the angle of throttle, etc.) the coefficients of fuel mass flow rate correlation is found from the related calibration tables, and after applying the modification coefficients (liquid film loss) the demanded fuel mass flow rate to be injected and will be calculated. There are some other correlations and modifications based on the voltage of the battery to convert the demanded mass flow rate to the millisecond needed to open the injector. Finally, the feedback of such a process can be achieved using oxygen sensor by calculating the equivalence ratio.

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