Neural Predictive Controller Based Diesel Injection Management System for Emission Minimisation

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ABSTRACT

Rapid growth in production of automobiles has increased emissions. Automotive control engineers use innovative control techniques to meet the upcoming emission standards. This paper proposes a novel method of employing artificial neural network (ANN) based predictive controller design. The controller predicts the injection duration based on the inputs from various sensors. The results are then evaluated over a simulated engine model developed in AMESim (Advanced Modelling Environment for Simulation), which ensures a green design process with almost negligible carbon footprint. The results obtained are encouraging and promotes the use of neural predictive control. Implementation of the controller will lead to emission reduction.

Keywords: Artificial Neural Network (ANN), Control System Simulation, Common Rail System (CRS), Emission Minimisation, Fuel Injection System, Green System Design, Green Technology

INTRODUCTION

The rapidly developing economies of the BRIC nations have resulted in unprecedented growth of automobiles, thereby increasing the emissions over a period of time which form a major constituent of environmental pollution. The four wheelers have sophisticated control techniques to meet the Euro-IV emission norms, whereas light commercial vehicles with single cylinder design lack in efficient control techniques to meet the emission standards. These vehicles are mostly used in semi-urban and rural areas where growth is rapidly increasing. The permissible limits of exhaust emission from three wheeler diesel engines in g/Km are CO (0.50), HC +
NOx (0.50), PM(0.05) (Wikipedia, 2011). This paper focuses on designing a new age control technique for the above intended applications that assist in minimising emissions and contributes to a greener environment.

Earlier, diesel engines were less sought due to its noise, lower efficiency, higher fuel consumption and increased emissions. It is impossible to meet the above mentioned emission standards with complete mechanically controlled system. This made the advent of embedding electronic control in automobiles that made them cleaner, quieter, highly efficient and acceptable engines. With the advanced common rail fuel injection system, diesel engines are widely used in heavy goods vehicles, construction, agricultural machinery, railway locomotive and ships.

Besides the gain acquired from diesel engines, their complexity lies in control technique employed to satisfy the imposed demands. Increase in parameters to be controlled, increases the intricacies of existing map based technique. A novel and an alternative technique to map based technique is the neural network based controller proposed in this work.

LITERATURE REVIEW

The approach of employing neural networks for engine control applications for diesel powered vehicles was proposed earlier by Howlett et al. (1999). Neural network can control complex non-linear systems with little priori theoretical knowledge. The operating conditions of diesel engines are highly non-linear, due to rapid acceleration and deceleration. This requires quick and accurate control on fuel injection parameters such as injection duration, pressure and start of injection in a continuously varying manner, over a very short period of time. Use of neural networks for engine modelling and control was supported by Ouladsine et al. (2005) despite their strong dynamics and nonlinearities. A practical control technique based on neural network which is applied in online to engine was proposed by Omran et al. (2009).

Neural networks have wide applications in system identification and non-linear control applications. De Jesus et al. (2001) proposed a comparison of different neural network control algorithms like model predictive control, NARMA-L2 control, model reference control etc. An application for diesel engine speed control by varying fuel parameters was discussed. It shows that model predictive control is better to predict the behaviour of systems with variable time delay.

Artificial Neural Network (ANN) using Multi Layer Perceptron (MLP) network was proposed by Desantes et al. (2005) which has noticeable features to cope with problem of predicting emissions. As proposed by Obodeh and Ajuwa (2009) ANN based modelling does not require equations governing the engine performance but, the conventional map-based technique require. The above works illustrates that neural network is an effective tool for controlling emissions in diesel engine.

To minimise the emissions, it is required to try various options like control exhaust gas recirculation (EGR) and variable geometry of the turbocharger (VGT). In addition to these a possibility of water injection into the intake manifold of the diesel engines have also been reported by Tauzia et al. (2010) and Subramanian (2011) but the technology is yet to mature for commercial implementation, hence various other techniques need to be evaluated. To regulate the air-fuel ratio, the use of proportional-integral-derivative (PID) controller was proposed by Wahlstrom (2006). The shortcoming of PID controllers is that its control actions strive to achieve only short term goals, which can be overcome by Model Predictive Control (MPC) since it controls the system by forecasting future.

Model Predictive Control (MPC) is an advanced control technique which considers the non-linear characteristics of diesel engine and allows the system to operate closer to constraints so that reduced emissions and high fuel efficiency are achieved. MPC for diesel engines to control load, combustion phasing,
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