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NEURAL NETWORKS FOR INTERNAL COMBUSTION ENGINES

Increasing demands to the engine exhaust gases composition based on new emission standards as well as necessity of the fuel consumption economy are main reasons for the development of new approaches for the control of combustion processes in internal combustion engines. A popular way is the transition to combustion of lean or ultra-lean fuel-air mixtures. For engines equipped by the standard spark ignition systems main problems appeared in this case are connected with the decreased probability of ignition and increased misfires combined with the unstable character of the combustion process. Different types of alternative ignition systems based on the laser, microwave, nanosecond discharges have become very popular to get a reliable ignition with the low fuel consumption and low toxicity of exhaust gases [1]. Any step ahead on the way of getting a new design of the lean burn engine and adaptation of the new ignition system includes many experimental tests and as a consequence a lot of data. At the same time changes in the operation conditions, mixture composition, ignition timing, torch and so on, especially taking into account vehicles variability as well as variability of parameters between cylinders leads to the necessity of new experiments.

An artificial neural network can be used as a mathematical tool for the non-linear data analysis as well as for the prediction of new information based on preliminary training. So having the initial experimental data or data from different sensors as training arrays the contribution of artificial networks is the accurate prediction of the engine performance under different conditions. Last decades the use of neural networks for application in internal combustion engines attracts lots of attention. Neural networks have been used for misfire detection [1], for engine sensing [2], diagnostic and on board monitoring [3], for the analysis of ionic-current data, pressure and air-fuel ratio control [4]. The advanced strategy of controllable combustion process in engines operating lean mixtures with the alternative ignition system can also be developed using neural networks. A first step in this direction is training a neural network based on the measured indicator diagrams. A multi layer perceptron with one hidden layer and radial basis activation functions and training by the back propagation error algorithm can be used. Input parameters for the perpeptron are as follows: engine speed, torque, mixture equivalence ratio, engine load and electrical parameters of the alternative ignition system. For a case of the nanosecond pulse discharge additional parameters for the training process are the pulse width, signal frequency, diameter of the electrode and the interelectrode gap. A second step is the estimation of the peak pressure value, the location of the peak pressure, misfire events for the different mixture composition and engine operation conditions. All that will help to design next experiments as well as to understand main characteristics of the combustion process and engine response. Furthermore, having as training data for the neural network the exhaust gases composition it is possible to predict a content of toxic components such as NOx at different operation conditions with a good accuracy. It should be noted that an accurate prediction of the peak pressure value can be useful for a closed -loop combustion process control system and to balance the cylinder pressure for different ignition systems depending on operation conditions. The MATLAB function newrb trained on the experimental data of pressure measurements has been used. The normalized peak pressure dependence on the nanosecond discharge energy normalized on the energy of the standard ignition system (66 mJ) is presented in Fig.1.

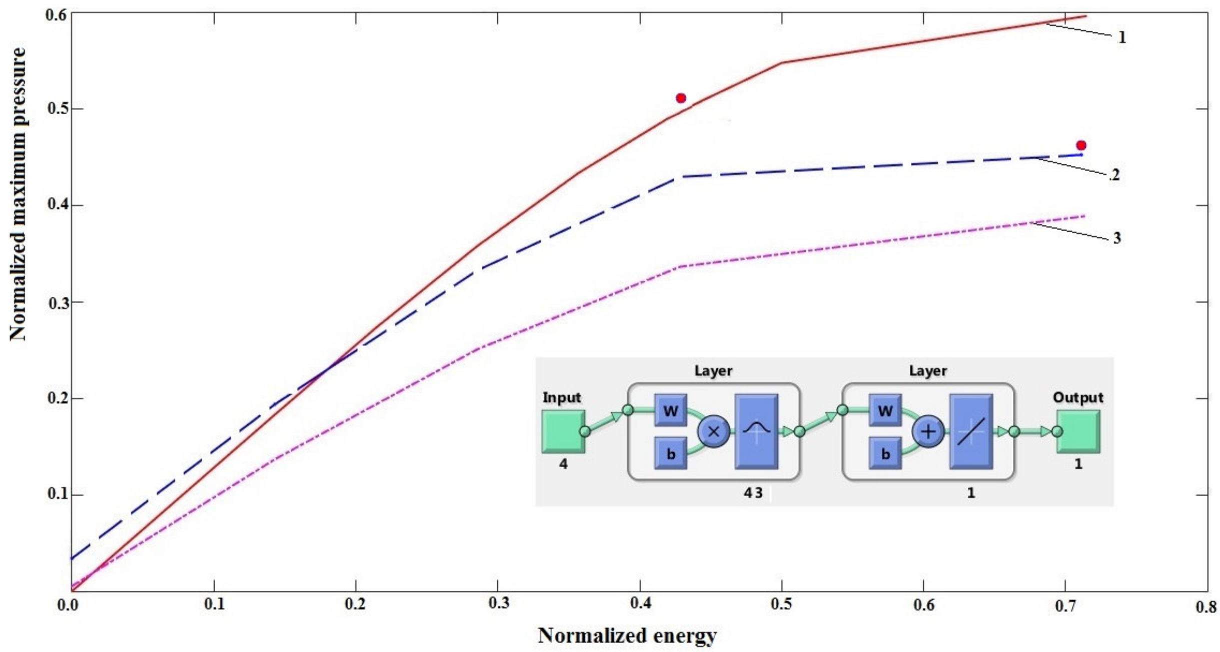

Figure 1 – Normalized peak pressure dependence on the discharge energy at the different engine speed: 1 - 3500 RPM, 2 - 2500 RPM, 3 - 4200 RPM. Red circles are the experimental data.

Literature

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