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Design on Neural Network Controller of Engine-generator for Electro-thermal gun in the tracked Vehicle

Abstract: *In order to ensure the engine can always work in the optimal fuel states and supply for electro-thermal gun, neural network controller of engine is designed in the electric drive tracked vehicle. The identification model of engine of tracked vehicle based on network is set up by using the measured data of the engine as learning stylebook so that the optimal fuel curves can be got based on the model. Simulation results show it can always work in the optimal fuel states when the engine works based on the optimal fuel curves in stable state.*

Streszczenie. *Przedstawiono układ sterowania napędem elektrycznym z wykorzystaniem sieci neuronowych. Na podstawie analizy modelu opracowane dane do uczenia sieci. Uzyskano optymalne sterowanie pojazdem i optymalne zużycie paliwa. (**Projekt sterownika neuronowego dla pojazdu gąsienicowego z wtryskiem elektrotermicznym**)*

Keywords: engine-generator; neural Network; control
Słowa kluczowe: sterownik neuronowy, pojazd gąsienicowy.

Introduction

Electric drive system in the armoured vehicle mainly include control of the brushless direct current motor and control of engine, which can make energy match and shunting current for electro-thermal gun of the whole electric drive system succeed. Because classic and modern control theory is established in the foundation of accurate parameter model, we can only change control clew to intelligence control for the ECU output-engine-output revolution system failure to build up accurate parameter model. Application of neural network in the engine contro l will be introduced in this text.

1 Neural network

There is a variety of combining way for neural network design used for controling a system, which can produce various types [1,2]. There is not only method to completely escape from traditional design, but also combine together with traditional design. There are several type methods: neural network control system based on daptive mode, control system composed only by neural network, neural network control system based on general control principle, intelligent neural network control, optimizing neural network control. Concrete structure and principle of every neural network control are different according to specific characteristic of actual object and demand of practical application [5-8].

In this thesis, neural network is used for engine identification of armored vehicle and optimized illustration storage of engine of armored vehicle.

2 Control concept

Output rotary speed of engine does not impact rotary speed of output axis of the vehicle, so engine can be controlled optimizedly that its fuel consume is minimum and economic benefit is best.

Now, with a view to fuel economical efficiency and emission behavior, engine works based on the optimal fuel curves [9]. Rotary speed and load factor affect fuel rate of engine, so properly regulating rotary speed of engine can ensure it always works in the optimal fuel states when the engine works based on the optimal fuel curves in stable state. This method is used for the electric drive system whose engine is independent power source, but the optimal fuel curves of engine must be stored in control unit in advance in this work method. [10]. The optimal fuel curve of engine is shown in Fig.1 which is a nonlinear curve.

The curve is stored in the controller, control unit control oil supply of the engine according to difference value between generator output power and generator optimal output power. When the given power is more than stability point, engine increases distributive value (increases ratchet displacement) and engine rotary speed is increased. Then the output power corresponding to rotary speed compares continuously with the given power untile they are equal, and now engine works at another stable point. And distributive value is reduced according to opposite process. In transition process the output power does not proceed according to the optimal fuel curve. It can not only work in the optimal fuel states but also reach the optimal dynamic performance when the engine works based on the optimal fuel curves.

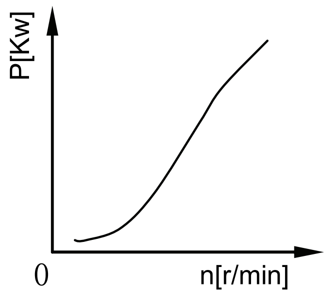

Fig.1. The optimal fuel curve

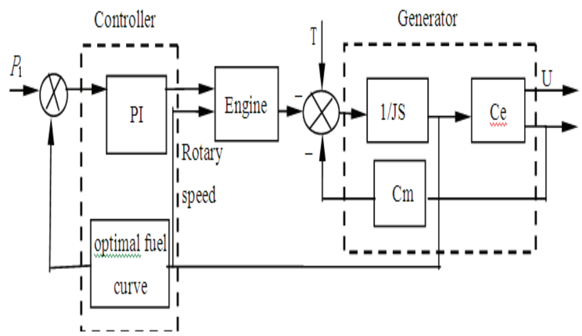

Fig.2. Control block diagram of engine and generator

3. Power control of the engine-generator

Power control block diagram of engine and generator is shown in Fig.2: In Fig.2, output of the controller is ratchet position and rotary speed, T is torsional moment of other load, and Generator is expressed in dashed line box. Thereinto key of control is determination and storage of optimal fuel curve.

4 Identification of the engine

Neural network control has been an important and effective form to realize intelligent control. Engine is multivariable, time varying and high nonlinear system whose dynamic process is concerned in ventilation, combustion and thermodynamics, so it is difficult to build exact mathematical model and realize quantitative analysis. But neural network control is nonlinear control which is just propitious to remember and learn characteristic curves of the engine so as to find optimum working point and realize optimum control. Identification principle of the engine model is shown in Fig.3.

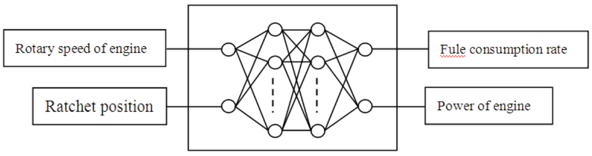

Fig.3. Identification principle of the engine

After characteristic of the engine has been tested, based on experiment data neural network can learn speed characteristic of the engine to get engine model which can represent stable characteristic of engine. Simulation results are shown in Fig 4.

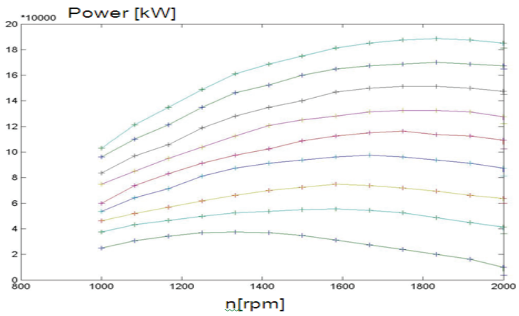

Fig.4. Stable characteristic of the engine

Obtain of optimal fuel curve is virtue of optimal power point of speed characteristic figure when fule consumption rate is lowest and speed value is constant. Namely corresponding power points at relevant opening when fule consumption rate is lowest are used to neural network learn so as to get optimal fuel curve.

5 Storage of optimal fuel curve

Radial basis function (RBF) neural network is used to store optimal fuel curve. RBF neural network is three-level forward network whose input layer is composed by signal source and the second level is hidden layer and the third level is output layer. Transformation fuction from input layer to hidden layer is RBF and that from hidden layer to output layer is linear function. RBF selected in this thesis is gaussian function:

$$\varphi(v)=\exp\left(-v^2/2\sigma^2\right) \quad (\sigma>0, v\geq 0)$$

Action function (basis function) in hidden layer node responds to input signal locally. Namely when input signals near the center of basis function, hidden layer node will generate major output, hence this network is equipped forlocal approach. Programme is as follows:

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net=newrb(p,t);
a=sim(net,p) ;
gensim(net,-1);
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Optimal fuel curve trained by neural network is shown in fig.5

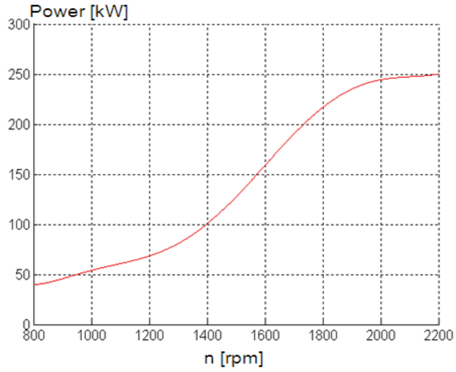

Fig.5. Optimal fuel curve trained by neural network

The engine model generated by neural network trained can be added into controller so that optimal fuel curve of the engine is stored in the controller. Now controller design of the engine is completed. The engine can work along lowest fuel consumption curve according to control block diagram in Fig2. Simulation results according to lowest fuel consumption control are as follows.

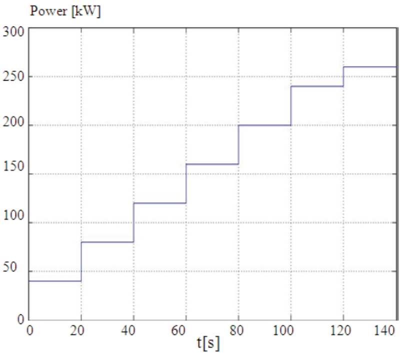

Fig.6. The given anticipant output power of the engine

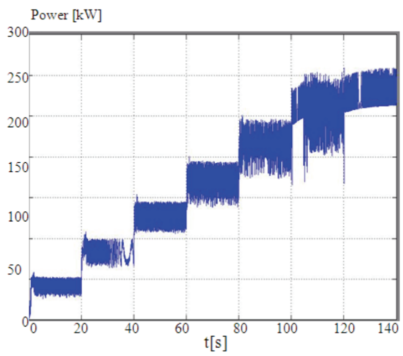

Fig 7 Output power of the engine

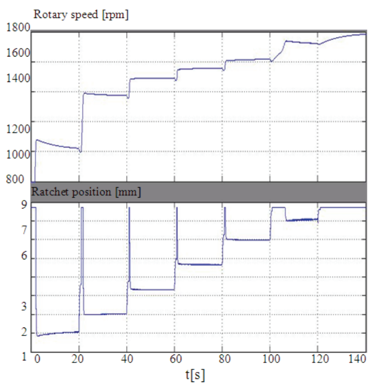

Fig.8. Rotary speed and ratchet position of the engine

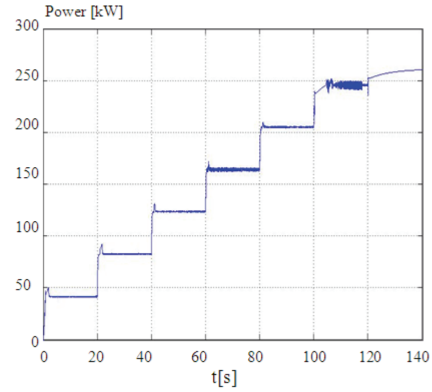

Fig.9. Power commuted of the generator

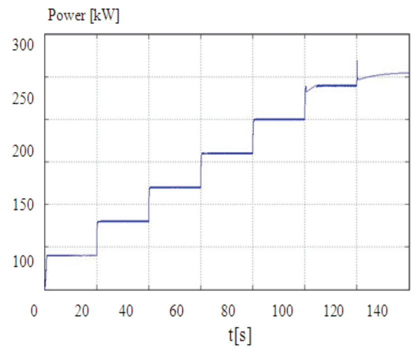

Fig.10. Load power

6. Conclusions

From identification results, identification format and network structure are reasonable, and learning algorithm is better because neural network can reflect speed characteristic of the engine by little learn frequency. neural network is adopted to train and study the optimal fuel curves which will be saved in the controller of the engine. the engine with optimum illustration trained by neural network can always work in the optimal fuel curve by simulation.

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