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CHIP-TUNING METHOD OF ELECTRONIC CONTROL SYSTEMS OF THE AUTOMOTIVE INTERNAL COMBUSTION ENGINE

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The software and hardware packages for the electronic chip tuning of the internal combustion engine control has been analyzed. In this work the technique of carrying out of chip-tuning of an automotive internal combustion engine with the use of indicative efficiency of the engine from the change in load and rotational speed of the crankshaft of the engine has been suggested, as well as the coefficient of excess air from the moment of engine power and fuel consumption. The suggested method is used in the educational process for the training of chip-tuning specialists at the Department of Computerized Automation Systems at the Lviv Polytechnic National University.

Keywords: *chip-tuning, electronic control unit, read only memory, correction coefficients, calibration tables, software and hardware package, optimization.*

Formulation of the problem. Despite the constant improvement of internal combustion engines, the problem of saving traditional petroleum fuels in transport remains one of the hottest not only in Ukraine, but also for the whole world. Increased consumption of liquid fuels is accompanied by the exhaustion of existing oil fields, resulting in the development of new deposits located in hard-to-reach areas. This, in turn, leads to higher prices for both oil and petroleum products. In addition, according to scientists, world oil reserves at its present level of consumption will last about 40 years and humanity will face the fuel crisis if it does not find alternative energy sources [1]. In this regard, research in the field of improving the economic performance of internal combustion engines are relevant.

Chip-tuning increases the comfort of driving by improving the acceleration dynamics in the low and mid range, stabilizing the idle speed, increasing engine power by 5-8%. When setting the economic firmware fuel consumption is reduced by 15-20% [1].

Professional software package ChipTuningPRO 9 is widely used to implement these procedures. It is used to edit calibration data in the electronic control units (ECU) firmware of the VAZ and GAZ engines, Hyundai, Daewoo, Renault, Opel and others. To perform a tuning chip, as a rule, it is necessary to remove the ECU from the car.

The J5 On-Line Tuner software and hardware package (SHP) is designed for real time set up calibration data of the engine electronic control units Janvar-5.1, VS-5.1 or Janvar-7. When using this SHP it is not necessary to remove dozens of times from

the car for reprogramming the controller to get the desired result, all the changes in calibrating tables and constants in the program are immediately recorded in the ECU through the standard K-Line interface, which decreases the time of setting the car. Advantages of this approach are especially noticeable when working with modern vehicles, the setting of which does not require a significant amount of time (with the result may be far from optimal).

The SPT software package for sports systems (4-8 injectors) is intended for professionals involved in setting up control systems for motorsport. The usual calibration system with the J5 On-Line Tuner engineering system, the ability to work at very high engine speed (up to 12,000 rpm.). ChipTuningPRO v. 6.5 or higher and J5 On-Line Tuner v. 3.0 or higher are required for work. Software exists in two versions: for ECU Janvar-5.1 and for ECU Janvar-7.2. This software packages makes it possible to maximize power of the engine at maximum speeds and torque [2].

The considering software packages allows change the firmware parameters, but they are not tied to the main characteristics of the engine for which chip tuning is carried out. This leads to the need for multiple changes in firmware parameters, which significantly increases the time spent on chip tuning and reduces its quality.

The aim of the research. Development of effective technique of chip-tuning of the automotive engine on the basis of the choice of the main characteristics of the automotive engine, which form the practical limitations on the calibration constants of the ECU firmware.

Presenting main material. Engine work is an eternal compromise between many parameters, norms, needs and capabilities. The control unit has its own algorithm of work. The program of the microprocessor is stored in a read only memory (ROM) and is a data processing program for one, two, and three-dimensional variable tables. Calibration for different engine operating modes (economical, high power, idling speed) are different and are used depending on the mode in which the engine is running. The control unit, receiving signals from various sensors, manages the operation of the actuators to provide the optimal (in the opinion of the developers) of the power unit. The required parameters for managing the actuators are calculated in accordance with the data received and the correction factors set in the ROM. By changing the ROM data, we can affect the performance of virtually any actuating device operated by the ECU. For other power characteristics, you can change the pre-ignition angle, the amount of fuel injection time, the gas distribution phase, switch off or change the operating system of the systems that control the toxicity of the exhaust gases. In addition, you can change the idle speed, the maximum permitted engine speed and many other parameters [3, 4]. The main stages of the chip-tuning are presented in Fig. 1.

It contains algorithms for the operation of all systems, depending on the input signals of the engine sensors. The ECU manages the actuators in such a way as to ensure the optimum performance of the engine. The parameters of optimality are set at the manufacturer. There, the correction factors are set in the system, for more precise control. ECU is a specialized microcomputer that processes data coming from sensors and, by a certain algorithm, manages the actuators.

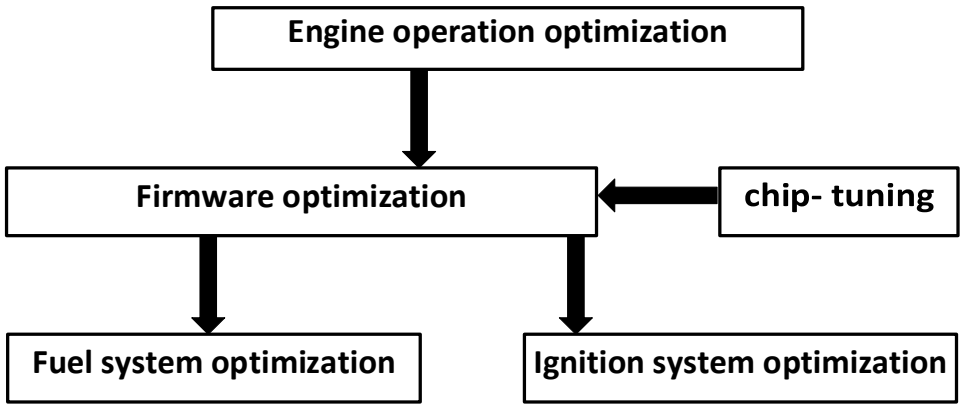

Fig. 1. The main stages of the chip tuning of the automobile internal combustion engine

The program itself is stored in a read only memory (ROM), the English name of the integrated circuits - chip, hence the name chip tuning. The content of the "chip" - usually divided into two functional parts, a program that performs data processing and mathematical calculations and a block of calibrations. Calibration is a set of fixed data for running a control program.

A common type of software is the "tabular" method of setting the output parameters, depending on the input data. This method is most used in most engine control systems, it is the easiest to create, set parameters-calibrations and their correction. But it has a significant drawback - the higher the accuracy we want to get the more tables we have to lay in the ROM and more parameters in each table should be. There is another method - the so-called mathematical model of the engine. This kind of firmware was used by Bosch in some engine control systems. It has the advantages of maximum precision in the formation of control action, as well as in the reliability - even when several important sensors were denied - the system continues to work correctly and optimally generates control signals based on signals from working sensors. But such a system is complicated in the development and creation of internal software and the implementation of chip-tuning.

During chip-tuning, a change in the calibration data of the ROM is carried out, and in the future, static and dynamic tests on the load test bench and ride tests are carried out. According to their results, a decision is made on further correction or completion of the process of chip-tuning. The nature of the correction depends largely on knowledge, experience and qualifications of the operator.

At the stage of changing the calibration data, it is proposed to use the dependence of the indicative efficience of the engine from the change in load and rotational speed of the crankshaft of the engine, the effect of the excess air ratio at the moment of engine power and the excess air ratio on fuel consumption. The specified characteristics limit the permissible values of the calibration data of the ROM by the actual characteristics of the engine.

Dependency of the indicative efficiency of the engine from the change in load and the rotational speed of the cranked engine is given on Fig. 2 and it can be obtained

by simulation and bench testing [5]. The given dependencies give an opportunity to follow the effect of the change in the data of calibrations constants to the efficiency of the engine at different operating modes.

Effect of the excess air ratio at the moment of engine power is shown in Fig. 3, and the effect of the excess air ratio on fuel consumption is shown in Fig. 4. The specified characteristics are taken off by manufacturers of plants during tests of serial engines. They can also be obtained on a load test stand. The indicated dependencies are used synchronously and allow choosing the calibration constants closer to the optimal values, which significantly reduces the number of repetitive operations with the chip-tuning of the internal combustion engine. The use of these dependencies eliminates the possibility of choosing the wrong values of calibration constants.

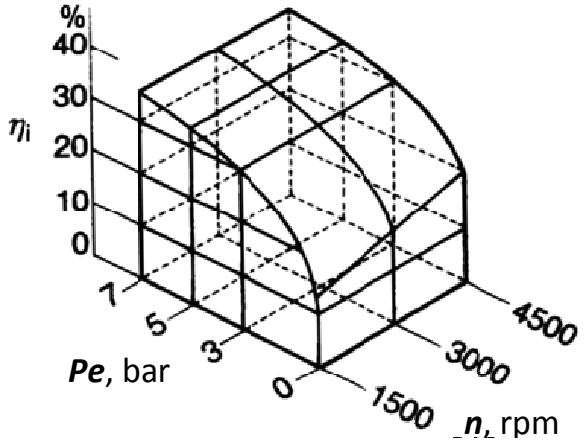

Fig. 2. Dependence of indicative efficiency of the engine from the change in load and the engine's crankshaft rotational speed

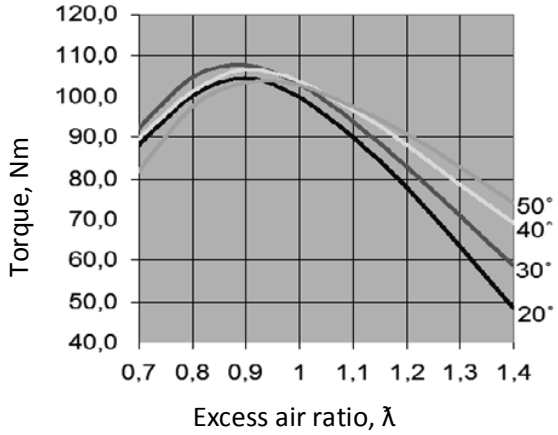

Fig. 3. Effect of excess air ratio to the moment of engine power

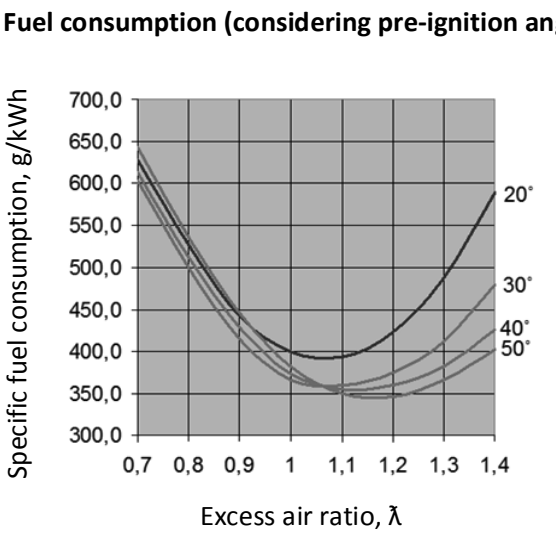

Fig. 4. Effect of the excess air ratio to fuel consumption

Conclusions. In this work the technique of carrying out chip-tuning of the automotive internal combustion engines with the use of the dependence of the indicative efficiency, the engine from the change in load and rotational speed of the engine crankshaft has been studied, as well as the excess air ratio from the moment of engine power and fuel consumption. The technique of chip-tuning allows to reduce the time for its conducting several times by eliminating the introduction of groundless calibration data in the ROM. The suggested method is used in the training process for the training of chip-tuning specialists at the Department of Computerized Systems of Automation of the National University "Lviv Polytechnic" on discipline "Design and programming of on-board computer systems".

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МЕТОДИКА ЧІП-ТЮНІНГУ ЕЛЕКТРОННИХ СИСТЕМ КЕРУВАННЯ ДВИГУНОМ ВНУТРІШНЬОГО ЗГОРЯННЯ АВТОМОБІЛЯ

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Проаналізовано програмні та апаратні пакети для налаштування чіпів електронного керування двигуном внутрішнього згоряння. У цій роботі запропонована методика проведення чипування автомобільного двигуна внутрішнього згоряння з використанням показників ефективності двигуна від зміни навантаження та швидкості обертання колінчастого валу двигуна, а також коефіцієнта надлишку повітря від моменту сили двигуна та споживання палива. Запропонований метод використовується в навчальному процесі підготовки фахівців з чип-тюнінгу на кафедрі комп›ютерних систем автоматизації в Національному університеті «Львівська політехніка».

Ключові слова: *чип-тюнінг, електронний блок керування, постійний запам'ятовуючий пристрій, коефіцієнт корекції, таблиці калібрування, програмно-апаратний пакет, оптимізація.*

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