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POSSIBILITIES OF IMPROVEMENT OF AUTOMOBILE ENGINES PERFORMANCE PARAMETERS WITHOUT NEGATIVE IMPACTS ON FUEL CONSUMPTION AND EXHAUST FUMES EMISSION LIMITS

In its introduction, the article deals with the control unit of the combustion engine – the possibility of the software modification (chip – tuningom). It states the reasons why, since its fabrication, the control unit is not programmed in order to gain the maximum power in the course of gaining the emission norms. The next part contains the brief description of the work in the process of performing the chip-tuning and its possible difficulties. In conclusion, there are the demonstrations of the measurments on two vehicles with a positive result.

Keywords: *power parameters of automobile vehicles, modification of the control unit, emission limits, method of chip – tuning, defficulties of chip – tuning, results of measurments after chip-tuning.*

1. Introduction

Improvement of performance parameters of automobile combustion engines is nowadays becoming an actual subject for research and development not only by producers but also by adjustors – i.e. car tuning companies. In this context, the appropriately improved engine power and torsion moment is understood as a factor positively influencing the fuel consumption and at the same time as the factor eliminating production of harmful emissions contained in exhaust fumes.

2. The chosen problems of the chip tuning

The process consists in the exchange of EPROM memory, i.e. an electronic memory unit with a serially supplied programme is exchanged for an identical EPROM memory with the programme already modified. Modern engine vehicles are computerized by ECU (Electronic Control Unit) influencing the injected amount of fuel according to the operating condition of the engine. Serial producers have to configure these programmes according to certain criteria with significant reserves. The motor vehicle equipped by these standards must function in the same way e.g. in the Nevada desert and in the Siberian winter. In the program "data field", there must be the space for low quality fuel as well as for hostile operation conditions of the engines, and even for economic efficiency when compared with the concurrence.

Every individual producer optimizes the control unit in order to comply with all regulations valid in the countries where the vehicle shall be used. Except for the two contradictory requirements – high performance of the engine – low fuel consumption, the engine has to correspond with the limits of exhaust fumes as well as different kinds and range of quality of gasoline in particular countries. Therefore, the engine has to be set for the "most favourable" conditions that can occur in the course of using the vehicle. In case, the vehicle is used in a country with a good quality of fuel, the engine can be re-programmed and thus optimized for the conditions it is used in. The control functions are usually designed with reserves and thus the entire engine potential is not used. Nowadays, mechanically identical engines with nearly the same construction and different power variations are offered by almost all producers. The more powerful performance variation of mechanically nearly identical engines, which is usually more expensive, is often achieved by modified software in the control unit.

In the past, the more powerful variations were offered one or two years following the sales start, in order to motivate the existing customers to buy a new vehicle. In this respect, marketing departments considerably influence production and the market. The vehicle maintained regularly disposes of relatively high performance potential; however its economy with fuel is decreased in the course of full performance. This is the reason why the so called tuners are involved in order to secure the considerable enhancement of hierarchic control of all components in the entire engine system. The spectre of influence on the control units consists in the possibilities of the injection characteristics optimalization.

As it can be derived from the name itself, chip tuning is the tuning of micro processor. The effect of chip tuning is not identical with every single engine. The main precondition for a good dynamics of a motor vehicle (vehicle below) consists in the correspondent ratio between the motor power and the vehicle weight. The two types of vehicle – Škoda Octavia and Škoda Felicia – equipped by the engine of 1600 kg and the power of 55 kW can be considered as an example. Škoda Octavia weighing 1300 kg (depends on construction) has the engine power of 55 kW. It follows that 1kg of weight corresponds to 0.04 kW of engine power and vice versa, 1 kW of engine power corresponds to 23,6 kg. In contrast, Škoda Felicia weighing 1000 kg, with the engine power of 55kW has 1 kg corresponding to 0.055 kW and 1 kW corresponding to 18.1 kg. It is therefore obvious that Felicia has a better ratio of engine performance and weight and thus disposes of better dynamics. In Octavia, the higher weight is corrected by better gearing. After tuning, Octavia shall have the engine power e.g. 62 kW, 1 kg of weight thus corresponding to 0.047 kW and 1 kW corresponding to 20.96 kg. However, these parameters are still worse than those of Felicia.

As it follows from the name, chip – memory i.e. control module, tuning – set, tune (as stated above) is tuning of the operation programme of the engine control unit – ECU, which controls the entire engine as well as further functions of the vehicle. The engine is controlled on the ground of the information received from sensors placed in the car (engine temperature, temperature of the air taken in, altitude, lambda probe, speed, engine revolutions, position of the accelerator, the gear shifted etc.). These information constitute "maps" out of which, the unit chooses the needed values according to the values measured. In terms of chip tuning, the interest is called upon the control module containing control programme or data tables. Thus the tables storing the

data on the engine control are modified. According to the type of engine, the maps of advance, fuel, supercharge pressure etc. are modified. The needed parameters are therefore possible to be achieved by the appropriate alteration.

Due to the alteration of these parameters, improvement of the engine power, reduction of the fuel consumption, reduction of exhausts etc. can be achieved.

In practice, the procedure of a current tuning process is the following:

- the control unit of the vehicle in entirely good order is dismantled,
- the data of the control unit are calculated and checked,
- according to the type of the control programme, either a debugged or a newly created software pursuant to the customer's demands is used,
- the modified data are saved to the control unit, the control unit being mounted again (the original data are archived in case the new saving to the control unit was needed),
- the control unit is installed into the vehicle,
- the new setting is tested.

Except for the process described above, there exists another method of chip tuning which is possible in case of new control units and which consists in re-programming through the diagnostic port. Such a specialized device enables the modification of software without opening the control unit. This system is used by some of the vehicle services in the process of diagnostics. Of course, within the process they use only the programme which they receive from the producer and which is not modified for improving the performance.

The complex map of the electronically programmable memory EPROM consists of the following graphs, which are being modified in the course of the control unit adjustment:

- the graph of a fuel dose injection at partial load,
- the graph of a fuel dose injection at full load,
- the graph of a fuel dose injection at starting the engine,
- the graph of exhaust fumes recirculation,
- the graph of the torsion moment elimination,
- the graph of smoke emission elimination.

The program menu offers as well:

- the memory content.
- the memory content in the form of a graph.

3. Difficulties of solutions by chip tuning

Adjustment of the engine control unit is an intervention not only to software, but also an indirect intervention to hardware, because the alteration of the engine operation changes the functioning of mechanical parts of the engine. Thence, the "maps" of the EPROM control unit operation module may be modified only after the expiration of the engine guarantee period. Except for this, the car producing companies do not fully approve of this after-production activity, because it does not always bring any positive effect to the model and consequently to the automobile mark as a whole.

The difficulties in using chip tuning are therefore justifiable as for the point of view of producers, since the companies practicing the modification of control units can be divided into four different quality categories as follows:

- the first qualitative level includes several companies existing worldwide and having a direct or indirect connection to the producers of control units (Bosch, Marelli, Delphi, Siemens), as a result they know how the particular systems work and how the control unit operating system is built. Upon the information, they know the position of data fields and the function of the control function. These companies then process the relevant data and transfer it to the companies in the second category. They do not directly modify the control units, since they act like data "stores" for processing the programmes needed for the control unit modification,
- the second category includes a number of serious and responsible companies being able of using and modifying the data in order toe achieve the results needed for the adjustment of the control units,
- the third category consists of companies purchasing the already prepared software and changing it in the control units. In some cases, these companies do not seriously fulfil the customer's demands because they do not always re-programme the control unit "made to measure" which can lead to a fast devaluation of the vehicle engine,
- there exists one more category – "sub – standard" companies gaining the software illegally and trying the possibilities of its usage. Due to the developing control systems protection, this category is on decline, as the interchange of software in the control units without the authorized licences is not possible.

The third and the fourth category do not usually comply with the expectations of the automobile producers as far as serious problem solving in the area of EPROM control units operation modules modification. On the other hand, there are also companies who have certain agreements on research tasks in the field of engine operation on the ground of gathering experience in running the vehicles. Such experiences represent the most ideal knowledge about the tuning of programs for the producer who can therefore proceed in further engine control development. The Slovak market is represented by the company Motortech Ružomberok which cooperates with the mark of Seat in a similar way.

4. Modification of the engine operation programme while running

In order to provide objective information, two modification processes of engine control with the combination of charging pressure adjustment shall be described on two different vehicles.

Modification of the MITSUBISHI PAJERO

Type of engine, engine cylinder capacity: 3.2 DI-D, 3200 cm^3
Year of production: 2001
Maximum power: 119kW/3800 min^{-1}
Maximum torsion moment: 375 Nm/2300 min^{-1}
Fuel, gear unit: NM, M5
Limit emissions: $k_{value.}$ 3.00 m^{-1}, SMOKE 73 %
Combined consumption: 8.5 l/ 100 km

A power box programmed by the company MOTORTECH Ružomberok was installed in the engine of the tested vehicle behind the engine control unit. Power box is a supplementary control unit modifying the control unit output data. Therefore, it can be understood as a kind of chip tuning on the vehicle engine. Prior to measurements, the power box was deactivated in order to perform the engine testing without control correction using the original parameters from the producer. Afterwards, the power box was activated again and measurements with the corrected

control programme were performed. There were three different measurements performed on the vehicle (emission measurement of free acceleration and engine idling – according to the regulation, emission – performance measurement – on the fourth speed gear) all of these while the power box was off and the same measurements while the power box was on.

Realization of measurements in the power test room MAHA LPS 2000 has shown that the engine performance increased from 125.5 kW to 138 kW, which is not a significant increase under given circumstances, however the torsion moment increased substantially – from 379 Nm to 468 Nm. The measurements of the emission parameters values in particular experiments have shown that the emissions are on higher level as for quality when the power box is on, even in case of measurement of performance in full load, the emissions make up a half of the maximum tolerable value as determined by the producer in engine idling speed (k_{value} 1.54 m^{-1}, SMOKE 48.5%), therefore the power box with this software is convenient for the correction of engine control in a given vehicle in respect of the ecologically – legal point of view.

In respect of the fact that a vehicle dealt with was equipped with a big capacity engine, the increase of torsion moment considerably decreased fuel consumption from 8.5 l/100 km to 7.6 l/100 km and also improved the running properties of the vehicle.

As a result, it can be expressly stated that the power box disposing of the program of fuel injection control is a positive contribution as for this engine. The question is, however if the construction parts of the driving mechanism of the vehicle are proportioned to such a high torsion moment to avoid its destruction. The question should be answered after one year of the vehicle running.

Modification of the ALFA ROMEO 156

Type of engine, engine cylinder capacity: 2.4 JTD, 2400 cm^3
Year of production: 1999
Maximum power: 100 kW/4200 min^{-1}
Maximum torsion moment: 310 Nm/2600 min^{-1}
Fuel, gear unit: NM, M 5
Limit emissions: k_{value}. 1.10 m^{-1}, SMOKE 38 %
Combined consumption: 6.7 l/100 km

The vehicle was imported from Italy, where control unit adjustment was performed and a mechanically adjustable valve for the turbocompressor intake was installed. The valve can regulate the maximum pressure of supercharging to cylinders from 0.9 bar to 1.3 bar. In the course of testing, the controlling software of the vehicle engine control unit was modified several times and the supercharged turbocompressor pressure was set in order to reach the best vehicle parameters in full compliance with the emission limits. In total, 17 measurements at 7 different operation modes, different ways of chip tuning and different charging pressure of the turbocompressor were performed.

The measurements were realized under the following modification modes:

1. The control unit (only CU below) is modified by an Italian company, the charging pressure of the turbocompressor is set to the serial value of maximum 0.9 bar (serial pressure of Alfa Romeo).
2. The modification (serial software Alfa Romeo) is uninstalled on the CU, the charging pressure of the turbocompressor is set to the serial value of maximum 0.9 bar (Alfa Romeo serial pressure).
3. The modification (serial software Alfa Romeo) is uninstalled on the CU, the charging pressure of the turbocompressor is set to the value of maximum 1.2 bar.
4. CU is modified by the Slovak company MOTORTECH Ružomberok, the charging pressure of the turbocompressor is set to the serial value of maximum 0.9 bar (Alfa Romeo serial pressure).
5. CU is modified by the Slovak company MOTORTECH Ružomberok, the charging pressure of the turbocompressor is set to the value of maximum 1.1 bar.
6. CU is modified by the Slovak company MOTORTECH Ružomberok, the charging pressure of the turbocompressor is suet toe the value of maximum 1.3 bar (which is the maximum possible setting).
7. CU is modified by another software by the Slovak company MOTORTECH Ružomberok, the charging pressure of the turbocompressor is set to the value of maximum 1.3 bar(which is the maximum possible setting).

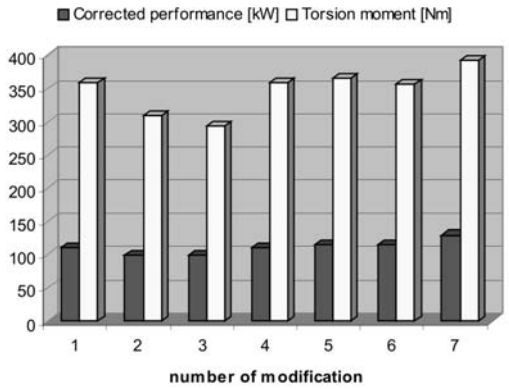

Fig. 1. Performance parameters of the ALFA ROMEO 156 under different modifications

As it is evident from the graph 1., the performance parameters of the vehicle have increased due to the modifications. The performance itself increased from 100 kW to 130 kW, except for this, the torsion moment increased from 310 Nm to 394 Nm.

Following all software adjustments of the engine control unit, the values of the maximum emission limits are not exceeded (k_{value}. 0.23 m^{-1}, SMOKE 9.5 %) being deeply below the maximum permitted value. According to the values measured, the given vehicle is thence fully capable of running even with a modified engine control a charging pressure, as for the ecologically – legal point of view.

Since there were several adjustments made on the vehicle at the same time, and the vehicle was tested afterwards, the combined consumption was found only after the last adjustment. The combined consumption also decreased from 6.7 l/100 km to 6.5 l/100 km. Consequently, it can be assumed that in the course of adjustments 4, 5, 6 the consumption was even lower.

4. Conclusions

The conclusion is similar also in this case. The control unit and charging pressure modification for the given vehicle were performed in order to increase the performance parameters as well as to improve the quality of exhaust fumes emissions and to decrease fuel consumption.

5. References

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