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THE IMPACT OF ALTERATIONS IN CONTROL UNIT SOFTWARE ON THE BMW 3.0D ENGINE POWER AND TORQUE

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Abstract

At present, there are different methods to increase the performance of compression-ignition engine with Common Rail fuel supply system. One of them is to use external modules of the Tuning Box type. These modules are the simplest and cheapest solution to increase power and torque and reduce fuel consumption. Another method is to re-programme original bitmaps in control unit memory. The charge storage is read from engine controller memory via a diagnostic connector to EDC16 engine control units or by mechanical intervention into the driver itself. It is a labour-intensive method, which involves removing the driver from a vehicle, dismantling the cover, unsoldering the memory chips, reading the data programmer and re-programming the memory chip. This method is used for vehicles equipped with EDC15 engine control units.

The paper presents a modification of the control unit software of BMW E39 530D vehicle which increases its torque at low and medium engine rotational speed range by eliminating the so-called "turbo lag" and improves vehicle driving dynamics. Reading was done with EEPROM programmer device and software via an EOBD diagnostic connector; fuel injection, EGR valve, boost pressure and smoke limiter bitmaps were modified and the memory was re-programmed.

Keywords: *combustion engines, impact on power and torque, chip tuning, Tuning Box*

1. Introduction

The emergence of first electronic vehicle management systems, i.e. EDC (Electronic Diesel Control), has allowed the introduction of alterations into the factory driver software controlling the operation of a drive unit. As a result, it is possible to easily influence and optimise engine operation through its individual modification.

This paper aims at presenting possible methods of intervention into the factory driver system controlling engine operation and offering necessary tools and software. This objective was achieved using the factory driver software controlling engine operation of BMW E39 530D vehicle.

It should be pointed out that car manufactures, currently releasing vehicles from the production line to the market, strictly limit their power, thereby protecting themselves against inappropriate car use and too rare servicing.

The work of tuning specialists that is the persons altering factory software settings allows safe improvement of engine parameters with no significant impact on its life. The most effective method of improving parameters is chip tuning. By using the chip tuning, that is the modification of the factory software of engine control unit, it is possible to adjust and bring out the "hidden" potentials of car drive unit.

It must be remembered, however, that software alterations should not be done without applying an appropriate procedure. Before reading the bitmaps, vehicle and engine diagnostics should be conducted to make sure that engine and power transmission units (clutch, gearbox, drive shaft) are in working order and withstand higher power and loads.

With the gradual development of ECU, different methods of intervention into the engine control software have appeared, including, among others, replacement of EEPROM programmer software, connection of external modules – the so-called Tuning Boxes, and, the most popular now, programming via an EOBD (European on Board Diagnosis) diagnostic connector.

2. Test bed

To determine real engine parameters. such as power, fuel consumption, etc., being termed operating parameters, research centres perform specific experiments in special laboratories on a test bed called engine dynamometer, with a direct measurement on engine crankshaft or with an indirect measurement by means of chassis dynamometer measuring the parameters on wheel and taking into account the losses in power transmission system.

The study was performed on a single axle chassis dynamometer V-tech VT-2 (Tab. 1). This dynamometer allows engine power and torque measurements to be made in the inertia mode and presents engine operating parameters by means of DynaVTECH software.

In the study, a BMW E39 vehicle was used, equipped with a M57D30 (Tab. 2) compression-ignition engine with Common Rail fuel supply system.

Tab. 1. Technical parameters of V-tech VT-2 chassis dynamometer

Dynamometer type	inertia
Dimensions (L × W) [mm]	1200 × 3300
Max / min tread [mm]	2200 / 900
Minimum tyre diameter [mm]	400
Maximum axle load [kg]	3000
Number of axles	1
Eddy current brakes	option
V_{max} [km/h]	300
Test mode	inertia
P_{max} [HP]	450
Measurement accuracy [%]	0.1

Tab. 2. Technical parameters of M57D30 engine

Number of cylinders / valves	6 / 24
Cubic capacity [cm^3]	2926
Maximum power [kW(KM) / rpm]	142(193) / 4000
Maximum torque [Nm / rpm]	410 / 1750
Boost	GARRETT GT2256V turbocharger
Gearbox applied	Manual
Year of manufacture	2003

In the example being discussed, control programme reading, as well as its further writing, was done with a MPPS v13 programmer via a diagnostic connector. The software used for this purpose was a programme attached to the interface.

3. Comparison of bitmaps

The bitmap for fuel injection dose illustrates the quantity of injected fuel (mg/stroke) according to engine rotational speed and accelerator pedal position. In the modified bitmap (Tab. 3, Fig. 1), a fuel dose was raised by approximately 10-15% in the range of 1205-4845 rpm.

Tab. 3. Original bitmap for fuel injection dose in text mode

(acceleration pedal position, engine rotational rate), /mg/stroke/

RPM \ %	1	5	10	20	30	53	80	100
0	2	19	34	43	50	55	60	66
409	1	13	24	34	42	51	58	66
591	1	10	20	30	39	49	57	66
796	0	7	15	25	35	47	56	66
1001	0	5	11	21	31	45	56	66
1205	0	4	8	17	29	45	57	72
1501	0	3	6	13	25	43	58	72
2002	0	3	4	8	23	43	57	72
2502	0	3	4	6	20	40	56	72
3002	0	3	4	6	16	38	56	72
4003	0	3	4	6	14	34	54	72
4845	0	3	4	6	10	30	52	72

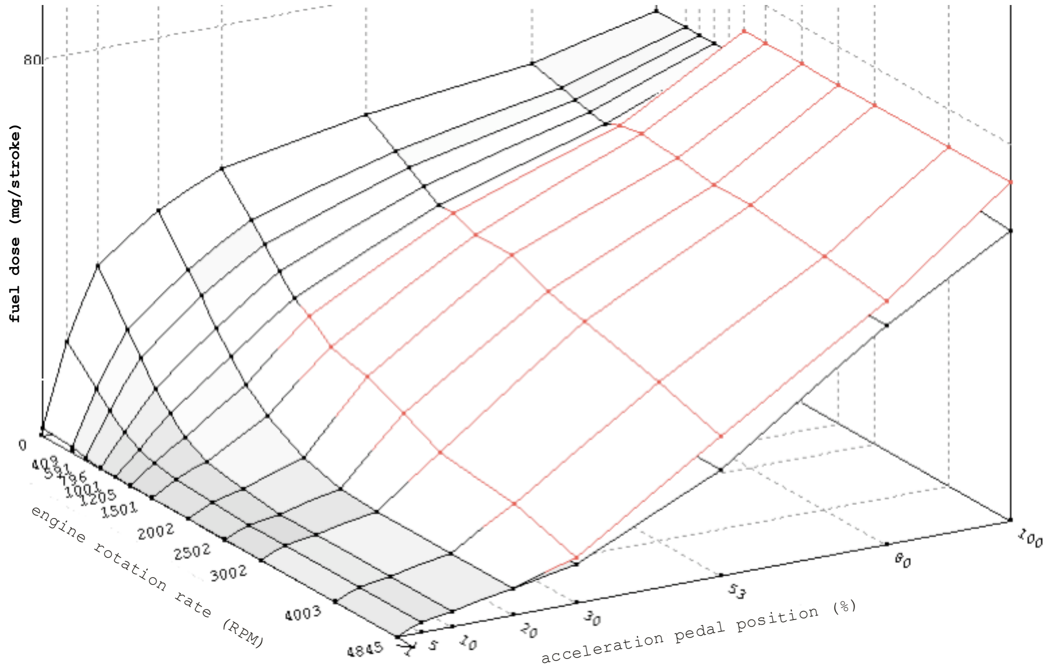

Fig. 1. Modified bitmap for fuel injection dose

The bitmap for engine torque limiter (Fig. 2) introduces fuel injection limitation (mg/stroke) in relation to current engine speed (rpm) and atmospheric pressure. In some controllers, atmospheric pressure is not taken into account, with engine rotational speed being an important parameter; this is the case of an EDC15C4 controller and consequently, the bitmap is being represented on the co-ordinate system (x, y), and gives the fuel value in milligrams as a result.

The bitmap for smoke limiter (Tab. 4, Fig. 3) determines an allowable fuel dose possible to be safely combusted. This bitmap forms the relationship of injected fuel quantity in mg/stroke to air quantity and engine rotational speed where, after referring to fuel injection dose, it is possible to read what fuel quantities would be desired by a driver at any given time. The smoke limiter is nothing more than a fuel dose calculator, being dependent on the air mass measured within the engine speed range.

The modification presented here aims at increasing the fuel dose for the range of medium and high engine speed (1600-4600 rpm) by approximately 5-10%. Smoke limiter modifications must be associated with corresponding alterations in the bitmap for turbo boost pressure and fuel injection dose to minimise the risk of excessive increase in engine temperature and increased emission of toxic compounds.

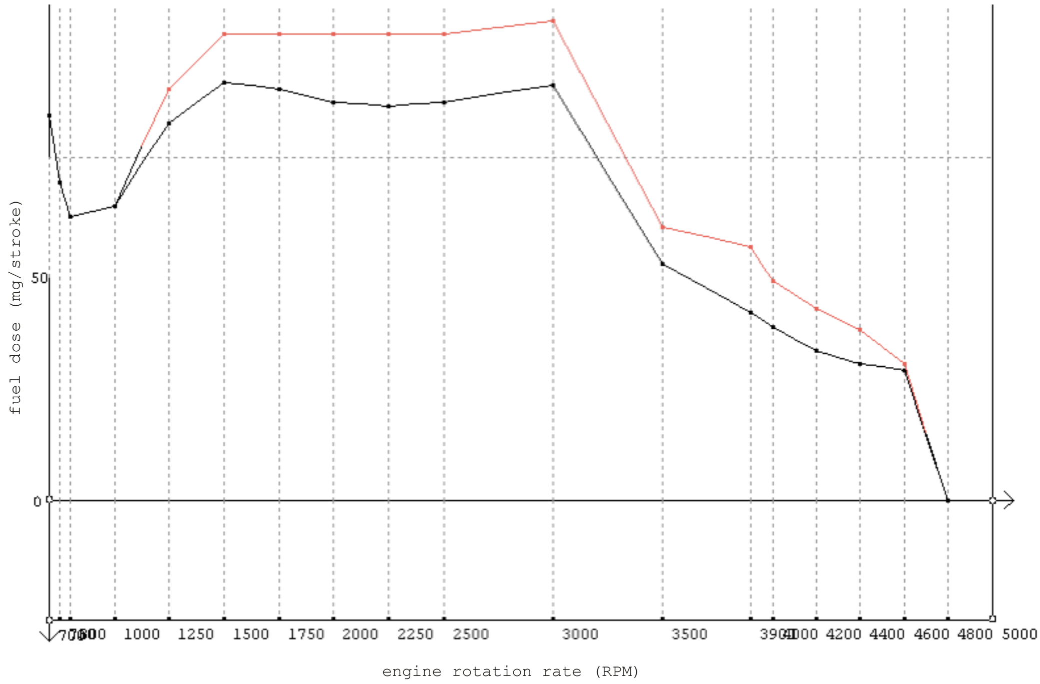

Fig. 2. Modified bitmap for engine torque limiter

Tab. 4. Modified bitmap for smoke limiter presented in text mode

mg / PM	(air mass, engine rotational rate), /mg/stroke/ 250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000
550	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47	47
650	40	40	40	40	42	44	46	47	47	47	47	47	47	47	47	47
750	35	35	35	35	38	40	43	45	47	47	47	47	47	47	47	47
1000	24	24	26	28	31	35	39	43	47	50	50	50	53	53	53	53
1300	23	23	24	27	29	32	37	41	46	54	57	59	62	62	62	62
1600	23	23	24	27	29	32	35	40	44	49	53	58	67	71	72	72
1900	23	24	26	28	30	32	35	39	43	47	51	57	66	74	74	76
2200	23	24	26	28	30	32	35	39	43	48	52	57	65	74	74	76
2500	23	24	26	29	31	33	36	39	43	48	52	57	65	74	74	76
2800	23	24	26	29	31	33	36	39	43	48	52	58	65	74	74	76
3100	23	24	26	29	31	33	36	39	43	48	52	58	65	72	74	76
3400	23	24	26	28	30	33	36	39	42	47	51	57	65	69	70	75
4000	23	24	25	25	28	31	34	36	40	44	49	53	65	70	70	70
4300	21	22	22	24	27	30	33	36	39	44	48	51	59	60	67	60
4600	19	20	21	23	26	29	32	36	39	43	45	46	57	50	62	50
4900	17	18	19	21	24	27	31	33	36	37	37	37	37	37	37	37

4. Analysis of the obtained results

The modification of Bosch EDC15C4 engine control unit parameters of a BMW E39 530D vehicle was to increase the engine torque in the low and medium engine speed range, which induced improvement in the driving dynamics.

As can be seen from the external characteristic curve obtained on a chassis dynamometer (Fig. 4), the earlier assumed modification objectives were fulfilled in the form on increased engine power and torque, by 24 kW (32 KM) and 83 Nm, respectively. Maximum engine torque is available as early as 2739 rpm, which resulted in better vehicle acceleration compared to maximum engine torque prior to modification, being not available until 2980 rpm. Maximum engine power before modification was 141.5 kW (192.4 KM) at engine rotational speed of 3746 rpm, whereas it increased after modification to 164.8 kW (224 KM) at 4015 rpm. Following the longer use of the examined vehicle with modified bitmaps, a decrease in average fuel consumption was observed by 0.5 l/100 km, with the same style of driving as before modification.

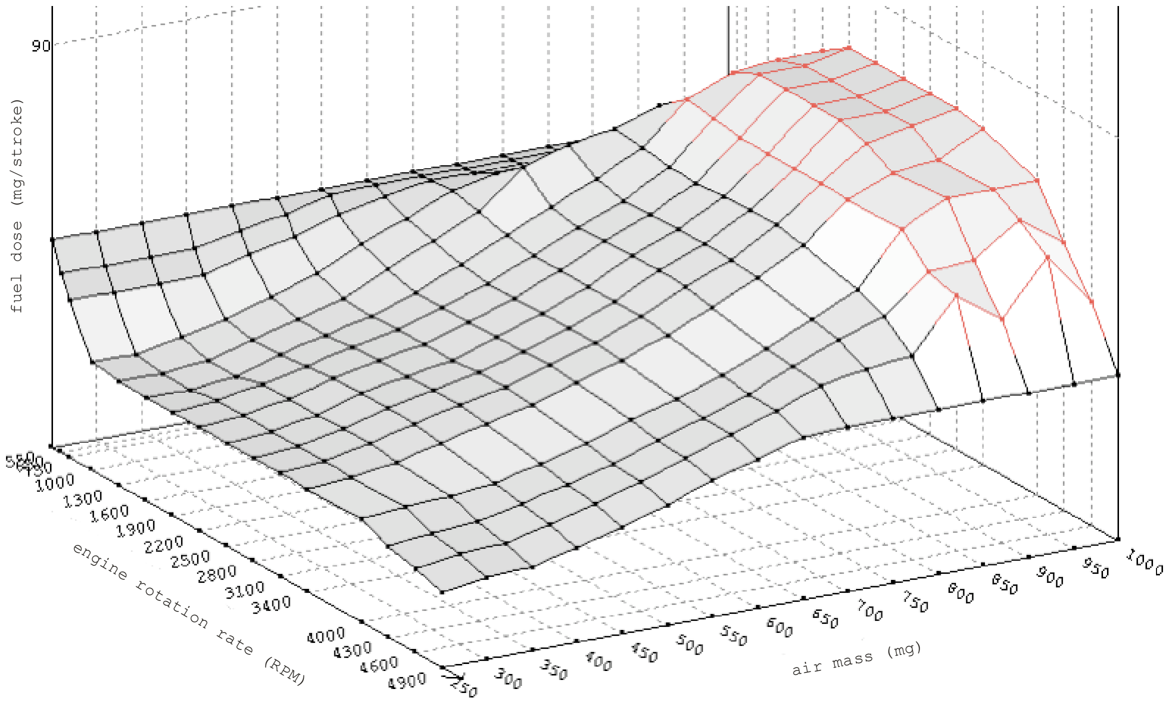

Fig. 3. Modified bitmap for smoke limiter

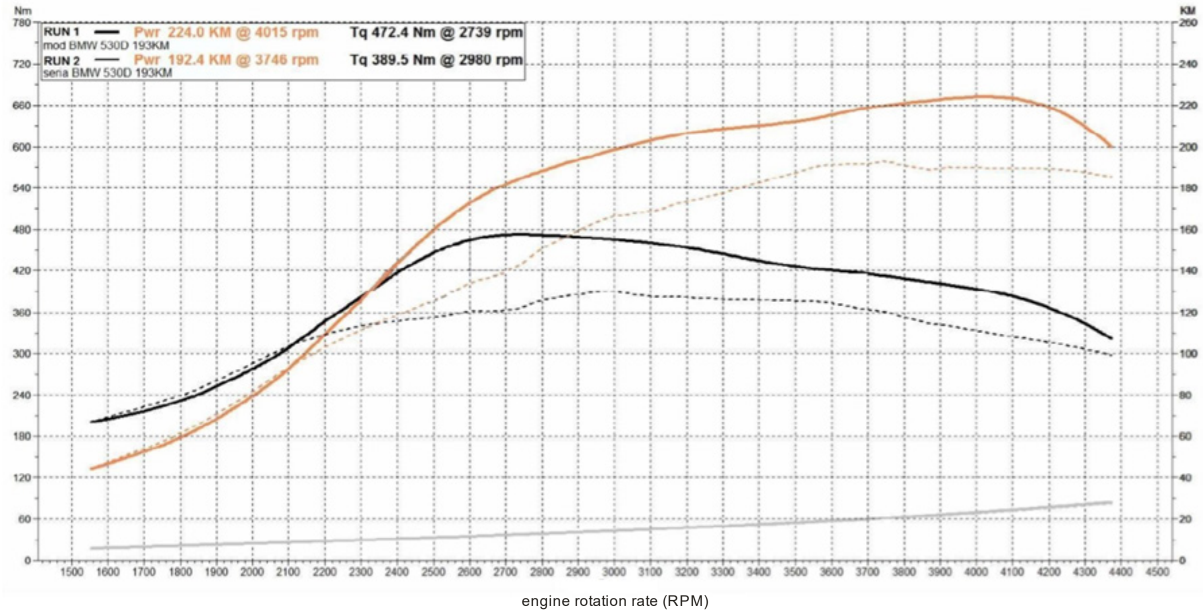

Fig. 4. External characteristic curve for M57D30 engine

5. Conclusion

Each parameter of the operation of modern engine is strictly controlled by a specific control programme, which is the result of relationships between several parameters. This is due to ever-greater demands made on internal combustion engines, in terms of both performance and exhaust gas cleanliness. Therefore, each modification should be tailored to specific needs and tasks. In addition, the limitations resulting from technical parameters for actuators should be observed. When making modifications, particular attention should be paid to the relationships between different control bitmaps, e.g. for fuel injection dose, boost pressure, and smoke limiter. Failure to necessary adjustments can lead to a damage of many engine elements, e.g. burned piston crowns, damaged turbocharger turbine, damaged flywheel.

The main assumption when modifying the factory software controlling BMW M57D30 engine was to increase its torque in the low range of rotational speed. The scope of modification was only intended to evaluate programming methodology, control unit parameter alterations and their impact on engine performance. The results of measurements obtained testifies to the correctness of the alterations being made, with an increase in engine torque and maximum power, by 21.3% and 16.5%, respectively.

References

[1] Blam, M., *Mocy, przybywaj*, autoEXPERT, No. 6/2008, Vogel Business Media, Warszawa 2008.
[2] Janiszewski, T., Mavrantzas S., *Elektroniczne układy wtryskowe silników wysokoprężnych*, PWKiŁ, Warszawa 2004.
[3] Kneba, Z., Makowski, S., *Zasilanie i sterowanie silników*, WKiŁ, Warszawa 2004.
[4] Kowalewski, A., *Sterowanie współczesnych silników z zapłonem samoczynnym*, Auto Moto Serwis, Nr 6/2008, Instalator Polski, Warszawa 2008.
[5] Myszkowski, S., *Podstawy tuningu silnika*, autoEXPERT, Nr 11/2008, Vogel Business Media, Warszawa 2008.
[6] Słupska, E., Słupski, M., *Chip-tuning*. Auto Moto Serwis, Nr 12/2010, Instalator Polski, Warszawa 2007.
[7] Słupska, E., Słupski, M., *Pamięci i kontrolery*. Auto Moto Serwis, Nr 3/2007, Instalator Polski, Warszawa 2007
[8] Staszewski, M., *Kilka słów o chiptuningu*, Serwis Motoryzacyjny, Nr 4/2009, Polska Izba Stacji Kontroli Pojazdów, Warszawa 2009.
[9] Praca zbiorowa: *BOSCH – Mikroelektronika w pojazdach samochodowych*, WKiŁ, Warszawa 2002.
[10] Artykuł redakcyjny, *Metody zwiększania mocy silników*, autoEXPERT, No. 3/2007, Vogel Business Media, Warszawa 2007.
[11] http://www.44tuning.pl/.
[12] http://www.chiptuners.org/.
[13] http://www.ecuconnections.com/.
[14] http://vtechdyno.eu/.
[15] http://www.v-tronic.pl/.