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PROBLEMS OF STARTING-UP IN MODERN DIESEL ENGINES

PROBLEMY ROZRUCHU W NOWOCZESNYCH SILNIKACH WYSOKOPRĘŻNYCH

Abstract

The paper contains chosen concerning problems of new solutions of glow plug. Well working and unfailing glow plug are indispensable at every cold diesel engine starting. Introduced constructions are a connection of successes of the knowledge of commercial materials, the thermal technics and the electronics. Parameters of these modern glow plug make possible the unfailing start of subtle technically new engines in every weather conditions.

Keywords: diesel, engine starting, glow plug

Streszczenie

W niniejszym artykule przedstawiono wybrane zagadnienia dotyczące nowych rozwiązań świec żarowych. Dobrze działające i niezawodne świece żarowe są niezbędne przy każdym zimnym rozruchu silnika o zapłonie samoczynnym. Przedstawione konstrukcje są połączeniem osiągnięć materiałoznawstwa, techniki cieplnej i elektroniki. Parametry nowoczesnych świec żarowych umożliwiają niezawodny rozruch wyrafinowanych technicznie, nowych silników o zapłonie samoczynnym w każdych warunkach atmosferycznych.

Słowa kluczowe: silnik o zapłonie samoczynnym, rozruch, świeca żarowa

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1. Introduction

The development of the motorization in last years is especially dynamic with the range of their drive. Last years of the development of the motorization are characteristic for their explosion engines. There appeared many new constructions of engines, especially the diesel engines, exceeding answering to them with the capacity engines about the spark-ignition without the supercharging. The average diesel engine has today completely other operating parameters comparatively to solutions of once practical. Mercedes 260 D from the year 1935 had the engine about the capacity 2,5 dm³ had a power 33 kW, attained 100 km/h at the fuel consumption about 10 dm³ of the fuel on 100 km. First passenger cars with diesel engines needed about 0,3 dm³ of diesel oil on 1 kW and present modern diesel engine similarly about 0,03–0,04 dm³/1 kW, that is to say near 10 times less.

Modern diesel engine are the power about 1 dm³ of the capacity about 60 kW, the torque almost 200 Nm, also with 1 dm³. These engines are more and more economic, to be satisfied the more and more smaller fuel consumption, emit less toxic compounds of combustion gases. All that causes that the participation of these engines in the European car market all the time grows. Problems which still exist this greater than in spark-ignition engines the noise and vibration, the smaller elasticity, the more complicated and more expensive construction – the clearly higher buying cost. Basic problems of present diesel engines one can seize shortly as groups of following problems:

- the improvement of the combustion process- the gentle growth of the pressure at the high efficiency and the high pressure of the fuel injection,
- the supercharging – enlargements of the expense of turbo-compressors, diminutions of the inertia,
- the stint of the emission of particulate matter and nitrous oxides,
- reducing of the noise, loud work and vibration,
- the construction – the diminution of the mass of engines and the usage of energy-saving technologies.

2. Direction of the improvement of combustion processes

The improvement of the combustion process in combustion engines has a prevailing meaning for the enlargement of their efficiency of being effective with the diminution of the fuel consumption of so important for requirements of the farming with the energy. Basic problems are the optimization of the course of the combustion assuring first of all the gentle growth of the pressure at the high efficiency and the high pressure of the fuel injection.

High values of the pressure of the fuel injection cause better his spraying, besides the fuel injection lasts shorter and can begin and finish in the sensitively well-chosen moment. Modern injectors in Common Rail systems inject the fuel under the pressure 1600–1800 bars, pump injectors – 2000 bars. Works driven over modernizing of injection's systems and with the course of the injection refer liftings of the pressure of the injection, what in the future will be surely still one of main ways of the modernization of injection's systems and his course. Lately in new constructions uses the repeated injection with the partition of the dose of the fuel on five injections: two pilotting injections, one of principle and two

burning out. Piloting injections improve the acoustics of the work of the engine to limit his hardness of the work (dp/da), instead injections burning out supplement the injection of principle, to cause the after burning of remainders of the mixture, contributively to the diminution level the emission of impurities already in the chamber of the engine. The use of different variants of the repeated injection less or more affects the process of the combustion, to cause the diminution of injurious components of combustion gases, level the noise and the fuel consumption.

Demands this however uses of injectors about the very short time of steering, this condition is realized by piezoelectric (Fig. 1) injectors, more and more widely practical. Piezoelectric injectors assure the opening time to 0,1 ms. Most quicker till now electromagnetic injectors warranted the equal opening time 0,303 ms [1].

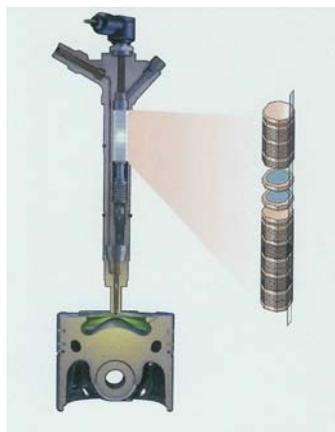


Fig. 1. The piezoelectric injector of the engine
Toyota 2.2 D Cat

Rys. 1. Wtryskiwacz piezoelektryczny silnika
Toyota 2.2 D Cat

The development of systems of the injection aims to more and more the precise dosage of the fuel, especially in the aspect of high pressures of the injection and in due measure the elastic steering with injectors. The firm Bosch foresees the introduction of the fourth generation of Common Rail systems with the hydraulic strengthening enlarging the pressure of the fuel in the injector [3]. The injector qualified with the symbol HADI (Hydraulically Amplified the Diesel Injector) uses the special crowd which at the value 1350 the bar in the container Common Rail enlarges the pressure in the injector even to 2500 bar (Fig. 2).



Fig. 2. The injector Bosch HADI Common Rail
with the hydraulic strengthening [3]

Rys. 2. Wtryskiwacz Bosch HADI Common Rail
z wzmocnieniem hydraulicznym

Planning introduction of such injector one foresees for a year 2008. Is this new approach which at the lower pressure in the container makes possible the obtainment very high-pressure in themselves injectors, at it enlarged their dimensions, to make possible the strengthening to 1:2 and at the lineal growth of the pressure. The optimum-utilization of injection's systems has to make possible the new driver of the engine (EDC 17), wherein to use an any number of the information and signals, will be one can analyse and choose parameters of the injection severally for every cylinder.

3. Methods of the aid of the start

The enlargement of the efficiency of the combustion process and his more gentle course, also smaller increases of the temperature in the situated chamber in the crowd makes possible the usage of low values of the degree of compression pressure. Very high degrees of compression pressure are required first of all for the start, especially in low temperatures, instead on-the-job the efficiency of these engines is greatest when the value ϵ is near 16. At present for sufficient start is the degree of compression pressure about 17, until quite lately this was about 21. These low degrees of compression pressure are more profitable for smaller tractive resistances during the growth of the pressure in the cylinder.

The engine Toyota 2.2 D-4D Cat possesses lowest on the world the degree of compression pressure equal 15,8. He there is possible thanks to the usage in these engines of modern ceramic glow plug embers attaining of the temperature 1175°C, that is to say higher about 100°C with relation to earlier.

Well working and unfailing glow plug are indispensable at every cold diesel engine starting. Good glow plug deliver to the combustion space the heat energy, to produce optimum conditions of the ignition of injected dose of the fuel where through assure the quick ignition and the friendly combustion environmentally, also below freezing temperatures. A fundamentally main problem of glow plug is delivering of the additional necessary energy to the engine starting.

The glow plug subjected is to the activity of burnt fuel. From this regard she must be resistant on the high temperature, the high pressure, vibrations, the activity of chemical compounds causing the corrosion, and also should quickly attain the proper working temperature and be characterized with the long vitality. Glow plugs demand besides steerings which or impromptu manual, or behind indirectly of the special driver, will regulate the definite time of the production of the tension. Heaps of times such system possesses also the indicating lamp which shines under of glowing initial. Lengthening glowing causes that the fuel can burn away to the end, where through the secretion smoky becomes lesser even about 49%. Besides the fuel burns away more evenly and put on weight, what causes arising of the greater energy, and the temperature in the combustion space grows up more quickly, diminishes this the inequality of the work during the start, audible as characteristic for diesel engines „clattering”.

The firm NGK Spark Plug, well-known since a long time the producer of spark plugs, joined to producers of glow plugs and has significant successes in this sphere [3]. In the series D-Power one worked out series of types glow plugs marked out for about 1400 models of cars. They attain at present in the unamended time of warming higher temperatures. One reached this by the modified diameter, the number of rolls and the length of

the heating spiral of executed from the new special alloy. The corps of the glow plug one covered with the permanent rust-inhibitive coat brought galvanically. The process of glowing can take run multi stagely (the feed heating, the initial warming, scorching). In the period of warming of the engine in gear barren assure the greater equableness of the work, to receive the lower current and to produce the higher temperature of the feed heating. Modern contact-sockets assure certain connecting and the stable construction protects the heating spiral before the damage in consequence of twitches or short-circuits.

Glow plugs NGK deliver exceptionally a lot the energy. They there are assembled in the cap of the engine. The ending of the glow plugs assembled in the cap of the engine stands toward of the combustion space and should be situated exactly on the edge of the whirl of the mixture. Like this the ending delivers warmly exactly to the place, wherein it is required. The ending glow plug should not stand too much far inside the combustion space, because would cause this irregular enrichment of the fuel and the preclusion of the creation himself suitable to the combustion of the mixture fuel-aerial. Before an engine starting, to the spark plug becomes bringing tension, where through the core glow plug becomes warm to the temperature passed 800°C. The high temperature improves the ability of the actuation of the cold engine. Warmly produced by the glow plug optimizes besides the process of the combustion, thanks to what considerably limited becomes the formation smoky and other matters hitting her mark to the atmosphere.

Glow plugs of the new generation, ceramic become warm considerably more quickly. This is the third generation of high-temperature glow plugs marked NHTC (New High Temperature Ceramic glow plug). Glow plugs produced by the firm NGK have a longer and thinner heating element which becomes warm considerably faster to obtain the temperature 1000°C during not longer than 2 seconds, at the possibly working period even to 10 minutes from the moment of the actuation. These glow plugs reduce the issue of toxic components of combustion gases by the possibility of scorching on-the-job of the engine, especially in ranges of the work (the composition) connected with the applying of the brake of the vehicle with the engine (Fig. 3).



Fig. 3. Glow plugs of the new generation ceramic NGK [3]

Rys. 3. Świece żarowe nowej generacji ceramiczne NGK

NGK introduced for the first time on the secondary market the glow plugs of the technology AQGS. This glow plug of the quick start assures into 43 models BMW with Diesel engine environmentally friendly of natural the start of the cold engine in the course several seconds.

The rod glow plug NGK Y-547AS has an ending about the diameter only just 3,5 mm. She is through this clearly thinner than traditional metallic rod glow plugs. Besides works at low the service voltage carrying out only just 5 the Volt – the most of glow plugs needs from 10 to 12 the Volt. Becomes warm to the temperature 1000°C during 2 seconds.

Still prior are here proprieties of the warming. Thanks of the technology AQGS (Advanced Quick Glow the System) of the firm NGK the candle Y-547AS becomes warm only just in the course 2 seconds to the temperature 1000°C and causes the quick and unfailing automatic ignition of the mixture of the fuel. Issues of injurious matters during the phase of the warming, become minimalized before a success of the optimum-operating temperature of the engine.

Introduced are also so-called intelligent glow plugs integrated with the sensor registering of the value of the pressure in the combustion space, the type PSG (Pressure Sensor Glow Plug) production firms Beru AG (Fig. 4). These lowered values of the compression pressure are effective with the smaller fuel consumption and the lower level of the issue of combustion gases, especially nitrous oxides [3]. Glow plugs one uses also to the transfer of the information from combustion spaces, especially in for valved engines in which the lack is places on the assembling of additional sensors. Above-mentioned the candle PSG is integrated from piezoelectric sensor of the pressure in the combustion space. Herself glow plug differs from traditional this that the heating rod is not into her casing, but the state the separate, moving part bouncily fastened. The rod delivers the pressure on the measuring diaphragm under which is found the sensor of the pressure, unexposed on the influence of occurrent high temperatures in the chamber. In the head of the glow plug one placed the the system the electronic delivering signal for the driver.

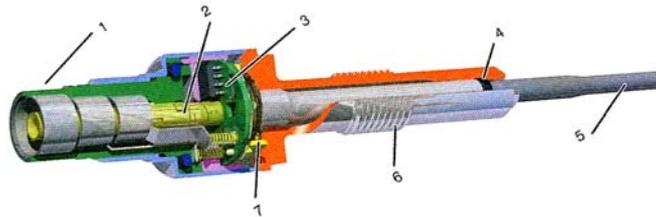


Fig. 4. The glow plug PSG: 1 – the seat, 2 – the power supply, 3 – the printed circuit board with the gasket, 4 – the heating rod, 5 – the casing, 6 – the measuring diaphragm [3]

Rys. 4. Świeca żarowa PSG: 1 – gniazdo, 2 – zasilanie, 3 – płytką drukowaną z uszczelką, 4 – pręt grzejny, 5 – obudowa, 6 – membrana pomiarowa

The modern technology of the start offers in the last period the firm Bosch [3]. Glow plugs of this firm possess the heating element executed from the ceramics and the elastic and formed metal cover. This technology called "Flexible Design" posts her preservative endurance her before for example with deformations at bad screwing in. Used ceramics assures glow plugs the high thermal resistance and the considerable persistence.

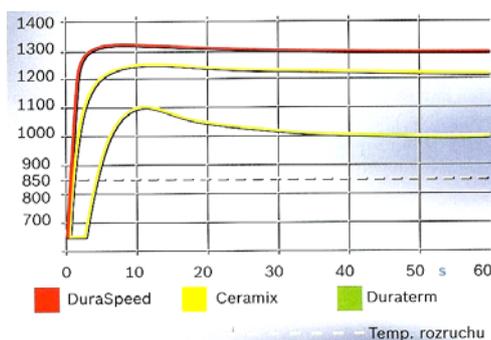
The firm offers three kinds of glow plug: DuraSpeed, Ceramix and Duraterm. Glow plug DuraSpeed low-voltage, ceramic become warm to the temperature 1000°C during shorter than 2 seconds. There makes possible this the high coefficient of the leadership of the warm of used ceramic material, besides the voltage of the power supply 7 V, considerably lower from the voltage in the vehicle that is to say 12 V. Quick attaining of the high temperature of the start in the phase of warming is possible by the power supply of glow plug a higher tension, is so to say an extortion of warming especially in difficult conditions of the start in low temperatures of the environment. These glow plug assure the long of warming after the actuation, to limit the noise of the work of the cold engine and put into

port profitably on the issue of toxic components of combustion gases. Scorching after the engine firing reduces the smokiness of the engine and helps the periodic regeneration filter of particulate matter. The high temperature and outlasting time of scorching make easy the usage of turbo-compressors about the low compression ratio and lower the issue of nitrous oxides, profitably bear on worse parameters of the work of turbo-compressors in the phase of the start and at working in the cold conditions. Glow plugs DuraSpeed the first time was used in engines HDI Renault about the capacity 2,0 dm³ and farther in other models Renault and Nissan and in engines of Asiatic producers.

An important product of the firm Bosch are high effective glow plug Duraterm. One used in them the self-regulative heating element executed from the special alloy cobaltic-ferric whose the electric resistance grows along with the temperature considerably more quickly than in the chance of the often practical nickel. The operating temperature of the glow plug during scorching is like this limited to make impossible the burn-through of the heating spiral at the elevated tension or the elongated time of glowing. Glow plug Duraterm attain 850°C during 4 seconds. This permits on the limitation of the delay of the self-ignition and diminishes the issue of combustion gases and the noise in the phase of warming of the engine. The construction of candles Duraterm is each time adapted to combustion spaces of suitable engines, inclusive with older constructions of the indirect injection, to locate her top so the combustion would take place in optimum conditions.

Fig. 5. The course of warming of glow plug Bosch

Rys. 5. Przebieg nagrzewania świec żarowych Bosch



Glow plug of the firm Bosch, particularly DuraSpeed are in respect of the time warmings most quicker on the world. The course of warming of glow plug offered by this firm one introduced on the Fig. 5.

4. Conclusions

The development of explosion engines, in this diesel engines, follows also thanks to the quick development of the technics, especially electronics. New engines more better parameters of the work, are also more unfailing. The great supply of new vehicles and engines, the gigantic competition and outright the fight for the customer, places producers more and more greater requirements. Indicated higher conditionings, connected for example with the usage of lower compression ratio, demand very efficient systems of starting of these engines.

Herein to the paper one introduced chosen concerning problems of new solutions of glow plug. Introduced constructions are a connection of successes of the knowledge of commercial materials, the thermal technics and the electronics. Parameters of these modern glow plug make possible the unfailing start of subtle technically new engines in every weather conditions.

References

- [1] Idziór M., *Rozwój silników spalinowych w aspekcie metod ich wytwarzania*, Silniki Spalinowe 1/2006(124), Czasopismo Naukowe, Polskie Towarzystwo Naukowe Silników Spalinowych.
- [2] Idziór M., *Energetyczne aspekty rozwoju silników spalinowych o zapłonie samoczynnym*, Materiały I Międzynarodowej Konferencji Naukowo-Technicznej nt. „Gospodarka Energetyczna”, ENERGIA 2006, PAN O. Lublin.
- [3] Materials of firms Bosch, Beru, NGK Spark Plug.

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