УДК 621.455
ББК 394.62 Англ
М 268

Рецензент: *А.И. Гайворонский*

Маркова И.Г.
М 268 Internal Combustion Engines: Методические указания по обучению чтению научно-технической литературы на английском языке по теме «Двигатели внутреннего сгорания». – М.: Изд-во МГТУ им. Н.Э. Баумана, 2004. – 27 с.: ил.

ISBN 5-7038-2453-2

Приведены оригинальные тексты, знакомящие студентов с наиболее часто встречающейся терминологией в области поршневых двигателей внутреннего сгорания и представляющие интерес с точки зрения грамматики – в них используются распространенные в технической литературе грамматические конструкции и обороты.

Для студентов старших курсов, обучающихся по специальности «Поршневые двигатели»

Ил. 9.

УДК 621.455
ББК 394.62 Англ

ISBN 5-7038-2453-2

Part I

Engine and Fuel Technologies for Future Car Developments

Text A. Engine and Fuel Technologies

In view of the continuing rise in the demand for mobility and the clear desire on the part of the customer for cars which offer good fuel-economy and low emissions, we need to ask the question – which advanced technologies are going to dominate engine construction? It is plain to see that car engines with direct fuel injection are set to conquer a wide field of application. This poses the question, whether the direct injection gasoline engine will be able to close the gap on the DI diesel engine's current fuel economy advantage. Comparative studies show that with the rapid development of direct injection gasoline engines these may succeed in achieving part throttle fuel consumption levels similar to those of a diesel, but overall, the diesel engine will be able to retain its fuel economy advantage in that the difference between diesel and gasoline engines is clearly becoming less significant and smaller differences are being recorded as regards CO2. But even if both processes are developed towards optimum compression ratios, advantages still remain in favor of the diesel engine.

However, the further future of direct injection engines may only be seen as secure if the problems of applying the possible technologies for treatment of exhaust gas produced with surplus oxygen (deNOx and NOx-adsorber catalytic converters) are overcome. This may only be done with a development contribution from the petrochemical industry to ensure that high-quality fuels with a sulfur content of only a few ppm are in future available worldwide.

ACTIVE WORDS AND WORD COMBINATIONS

mobility подвижность, маневренность

emissions эмиссия, выбросы
advanced technology передовая технология
to conquer завоевывать
to pose a question поставить вопрос
direct injection (DI) gasoline engine двигатель с непосредственным впрыскиванием бензина
to succeed in преуспевать в ...
fuel consumption level уровень потребления топлива
throttle дроссельная заслонка
optimum compression ratio оптимальная степень сжатия
secure надежный, безопасный
surplus oxygen дополнительный кислород
sulfur content содержание серы
deNOx catalytic converter восстановительный каталитический нейтрализатор оксидов азота
NOx-adsorber catalytic converter каталитический нейтрализатор (адсорбер) оксидов азота
ppm единица объемного содержания токсичных компонентов в отработавших газах

EXERCISES

1. Read through the text and compare advantages of direct injection gasoline engines and diesel engines

2. Answer the following questions:

1. What car engines will find a wide field of application? 2. What engines are compared in this text? 3. What can help to solve the problem of treatment of exhaust gas produced with surplus oxygen?

3. Complete the following sentences and determine the functions of infinitives in the sentences:

1. Car engines with direct injection are set to .... 2. Will a direct injection gasoline engine be able to ... ?

4. Find sentences with Passive Voice constructions in the text. Translate them.

5. Translate the following word combinations into Russian:

1) to offer good fuel economy and low emissions; 2) to conquer a wide field of application; 3) to develop towards optimum compression ratios; 4) to overcome the problems of applying the possible technologies for treatment of exhaust gas.

Text B. Problems and Aspects for Discussion Concerning Car Diesel Engines and Gasoline Engines

If you closely follow the automobile development scene – that includes the latest international conferences, journal publications, all sorts of academic reports and the latest discussions – you get the impression that engine developers have been extremely busy. A range of new terms and development areas are presented to the astonished observer.

For example, you sometimes hear that the car diesel engine has no future because for a diesel (which in the vast majority of cases will be a direct injection engine) future pollutant limits will be an insurmountable obstacle. And the gasoline engine, as the same sources say, is catching up on the diesel and will soon be achieving equally low fuel consumption levels. So, where is the need for diesel engines which would then be relatively expensive by comparison?

We would now like to attempt, from a European automobile manufacturer's perspective, to find an answer to many questions about whether there really is a future for the car diesel engine when compared to the gasoline engine. Such a question, especially given its implicit skepticism, cannot fail to provoke a response from a manufacturer such as Mercedes Benz which has for many years been powering cars with diesel engines and has developed them to a high level of refinement. A comparative discussion must also take in the question of whether there are contributions to be made by other disciplines associated with the automobile industry. One matter to be addressed is what sort of contribution the petrochemical industry should make, for example. It should be made clear what can be done and what needs to be expected in order to secure the future of the internal combustion engine through the further development of technology.

ACTIVE WORDS AND WORD COMBINATIONS

to astonish поражать, изумлять
an insurmountable obstacle непреодолимое препятствие
to catch up on догонять
to provoke a response вызывать ответную реакцию
to power a car снабжать машину силовым двигателем
a high level of refinement достичь высокого уровня совершенства
implicit skepticism скрытый скептицизм

1. Look through the text and determine the problems under consideration:

2. Match the following parts of the sentences:

1. The automobile development scene includes	a. an insurmountable obstacle.
2. Future pollutant limits for a diesel engine will be	b. the diesel engine.
3. The gasoline engine is catching up on	c. to secure the future of the internal combustion engine.
4. Mersedes Benz has for many years	d. the latest international conferences, journal publications, academic reports.
5. A wide range of problems should be solved	e. been powering cars with diesel engines.

3. Find the modal verb "should" in the text and translate the corresponding sentences.

4. Find two sentences in the text which contain the indirect general question. Pay attention to the word order in the sentences and to the translation of the word "whether".

Text C. Gasoline Engine Technologies

Today's gasoline engines have reached a level of development which in terms of power density, smooth running, noise and pollutant emissions is almost unbeatable that, at least, is the first impression. However there exist some problems. One example is the dispute between manufacturers over the number of intake and exhaust valves in today's engines. Five or three? Or four, after all?

There is consensus on the aim of an optimized gas exchange and minimized losses. All users are equally attracted by claims of high spark plug performance and long plug life. This testifies to the advanced level of this technology. The next dispute may be over whether one or two spark plugs per cylinder are the right choice. What can be said is that the spark plug will be a factor in technological progress; their number and position in the combustion chamber will depend on the individual application.

New technologies offer various methods to make "low friction" engines, to reduce their weight by use of light materials or to provide effective cooling as protection against overheating with suitable coolant passages in the right places. This is all state of the art. And all these functions are monitored and managed by a highly integrated engine control system.

Besides other problems, the injection system is of central importance. Pressure of up to 120 bar* is used which, when using gasoline, represents a major challenge for developers of injection systems.

* 1B (bar) = 10^5 Pa

Exhaust gas recirculation, which has played such a major role in diesel engines, will also become an increasingly important element for gasoline engines. Two inlet ducts with an integrated switching mechanism appear to be a promising approach to allow sufficient variability in the fuel mixture over a wide range of engine speeds.

NOx in the exhaust gas must be reduced by surplus oxygen and particulate emissions which are likely to increase slightly must also be kept at the lowest possible lewel.

ACTIVE WORDS AND WORD COMBINATIONS

unbeatable непревзойденный
smooth running мягкость работы
power density удельная мощность (отнесенная к единице объема)
pollutant emissions выбросы
intake valve впускной клапан
exhaust valve выпускной клапан
claims требования, заявления, утверждения, претензии
spark plug свеча зажигания
long plug life долговечность свечи зажигания
"low friction" engine двигатель с малыми силами трения
coolant passage канал для охлаждающей жидкости
challenge вызов
inlet duct впускной трубопровод
particulate emissions выбросы частиц
combustion chamber камера сгорания

EXERCISES

1. Read through the text and answer the following question:

What kind of problems do gasoline engine manufacturers have to deal with?

2. Answer the following questions about the text:

1. What positive characteristics of today's gasoline engines can you mention? 2. What number of intake and exhaust valves in today's engines do manufacturers offer? 3. What are users' claims concerning spark plug? 4. How can the weight of the engine be reduced? 5. How can effective cooling be provided? 6. What engine system is of central importance? 7. How can the content of NOx in the exhaust gas be reduced?

3. Find two sentences in the text where complex subject constructions are used with the words "to appear" and "to be likely" as predicates. Translate these sentences. Make up your own sentences using these or such like predicates.

Text D. Diesel Engine Technologies

Many developments in the automobile industry now deal intensively with the use of direct injection diesel engines in cars. It is, however, noticeable that these activities are mainly to be observed in Europe. Occasionally, doubts are raised by those groups of countries which openly declare that diesel engines for cars do not represent a significant area in their development activities. You at least hardly ever see a presentation on car diesel engines coming from the USA. A possible explanation might be the fact that fuel prices there and the fuel distribution infrastructure give no reason for customers to want to drive a diesel car for the sake of fuel economy. But contributions from Japan on this subject are also relatively rare compared to those from Europe. The development of a small number of standard engines, however appears to have confirmed the diesel's potential. By contrast, Europe's engine manufacturers have a much more progressive record. In the case of many Mercedes Benz models, 20% of the cars supplied are diesel-powered.

Mercedes Benz learned in the development of prechamber engines what sort of an advantage the 4 valve technology could be for the diesel engine. It was found that combustion in the main chamber, which is initiated from the center of the cylinder, spreads out evenly in all directions to the cylinder wall and a clever arrangement of the combustion holes on several levels allows the available oxygen to be used. Spontaneous pressure peaks causing high noise were eliminated using refined injection technology and pintle-type injectors and by optimization of the prechamber geometry. The relatively high efficiencies achieved by these refinements explain the low consumption levels of this combustion process. The very low raw emissions resulting from the two-stage combustion process and the low particulate emissions have demonstrated that this process should have further potential in terms of limiting exhaust gas pollution. Nevertheless, it must be considered that the high heat losses to the walls and the long combustion time cannot be sufficiently reduced.

It was planned to put the direct injection process into series production. Four valves, a centrally positioned injector nozzle and the high flexibility of the electronically controlled high-pressure injection system together with electronically controlled turbo-charging allow high torques to be reached at low engine rpm.

The direct injection process is a system where relatively high nitrogen oxide levels may be considerably reduced by exhaust gas recirculation, but this technology alone is not sufficient to meet the extremely demanding combination of limits that will be applied in the future. Research departments are, therefore, working on a breakthrough in deNOx technology.

ACTIVE WORDS AND WORD COMBINATIONS

prechamber engine предкамерный двигатель
to eliminate устранять
to spread evenly распространяться равномерно
combustion hole углубление камеры сгорания
pressure peak пиковое (максимальное) давление
refined injection technology усовершенствованная технология впрыскивания
pintle-type injector форсунка штифтового типа
prechamber geometry геометрия предкамеры
raw emissions неполные выбросы
centrally positioned injection nozzle центрально расположенное впрыскивающее отверстие
flexibility подвижность
turbo-charging турбонаддув
high torque максимальный крутящий момент
engine rpm частота вращения двигателя

EXERCISES

1. Read through the text and find advantages and disadvantages of diesel engine technologies.

2. Compare the attitude of European countries, USA and Japan to the use of direct injection diesel engines in cars.

3. Answer the following questions about the text:

1. What are the advantages of the 4 valve technology? 2. What is the role of the clever arrangement of the combustion holes on several levels? 3. In what way were spontaneous pressure peaks causing high noise eliminated? 4. What disadvantages of the 4 valve technology can you mention? 5. In what field do research departments work?

4. Insert the missing words. Use the following necessary words:

torques, combustion holes, engine rpm, cylinder, cylinder wall, oxygen, diesel engine, injection nozzle, the center.

1. Many developments in the automobile industry deal with the use of direct injection .... in cars. 2. Combustion in the main chamber is initiated from .... of the .... It spreads out in all directions to the .... 3. Clever arangement of the .... on several levels allows the available .... to be used. 4. Four valves, a centrally positioned .... allow high .... to be reached at low ....

Part II

Effect of Difference of High Pressure Fuel Injection Systems on Exhaust Emissions from HDDI Diesel Engine

The air pollution caused by automobile exhaust gas is a serious problem. To protect the environment from air pollution and to reduce CO2, improvement of fuel efficiency and reduction of exhaust emissions have become of extremely important concern recently, a high pressure injection technique has been developed and researched as one of the most effective countermeasures for Heavy Duty Direct Injection (HDDI) diesel engines.

In this paper, three different types of high pressure injection systems, such as the in-line pump, the common rail injection system and the unit injector, are compared and demonstrated on a single cylinder naturally aspirated diesel engine. Injection characteristics and effects of the difference among those high pressure fuel injection systems on exhaust emissions are compared.

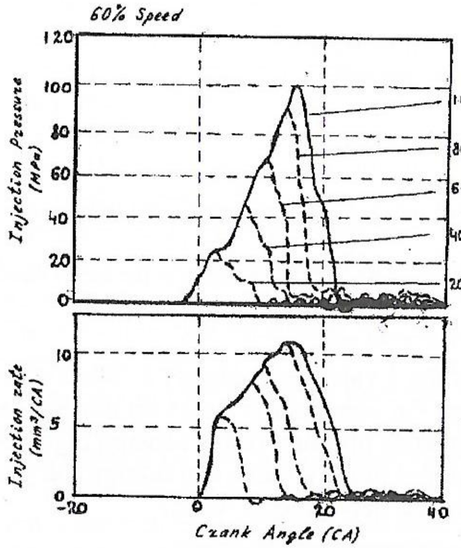

Fig. 1. Injection rate shapes with the in-line pump system

The injection rate of each injection system is measured with a Bosch type injection rate measuring instrument. Fig. 1 shows the injection rate of the in-line pump system at 60 % of rated engine speed. Fuel delivery varies from low load to full load range. A concave cam (Fig. 2) is used in the in-line pump system for injection rate control. The injection pressure is generated according to the cam profile. The injection rate was then controlled by the cam profile. With the common rail system (Fig. 3), injection pressure is controlled independently of the engine speed and load. The rail pressure was adjusted to the peak injection pressure with the in-line pump system at the same injection quantity. The maximum injection rate of the common rail system is in proportion to the rail pressure. When the injection pressure is set higher with the same fuel delivery, the injection rate becomes higher and the injection period becomes shorter. Fig. 4 shows the injection rate of the unit injector. It consists of a cam driven mechanism similar to the in-line pump system. Thus, the injection rate begins at a low rate and then gradually increases.

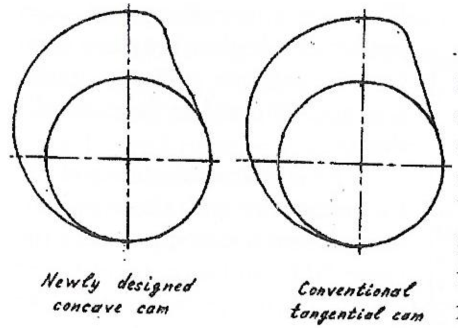

Fig. 2. In-line pump system cam profile

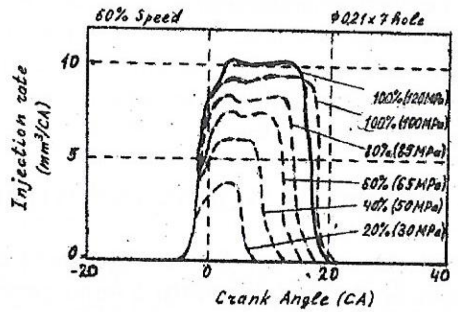

Fig. 3. Injection rate shapes with the common rail system

Fig. 5 shows the maximum peak injection pressure at full load condition over the engine speed range. In order to compare the peak injection pressure, the injection nozzle specification is selected with the same injection period. With the common rail system, the injection pressure is controlled independently of the engine speed and load. However the maximum injection pressure of the cam driven injection systems, such as the in-line pump system and the unit injector, is produced according to the cam speed.

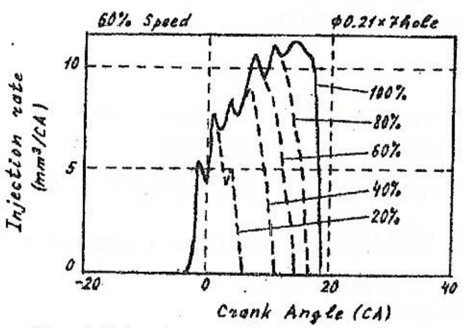

Fig. 4. Injection rate shapes with the unit injector rail system

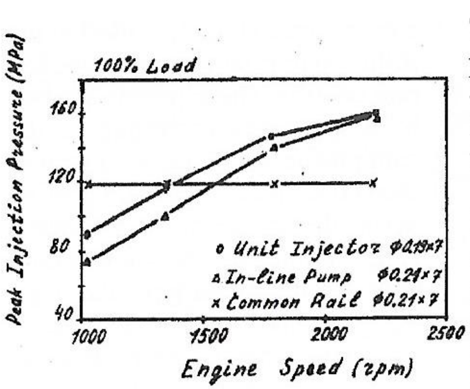

Fig. 5. Comparison of peak injection pressure between three injection systems

The common rail system then produces a higher pressure than other injection systems under low speeds and low load conditions.

The smoke emission and the fuel economy with these injection systems are compared at the same NOx emission level based on the in-line pump system. As far as the common rail system is concerned, the injection timing is retarded, and the injection pressure is increased to match the NOx emission with the results of the in-line pump system.

For further reduction of exhaust emissions and improvement of fuel efficiency, it will be necessary to use the higher pressure injection technique and the precise injection rate control technique simultaneously. The sophisticated injection system development will become an increasingly important subject.

ACTIVE WORDS AND WORD COMBINATIONS

HDDI (Heavy Duty Direct Injection) diesel engine дизельный двигатель большой мощности с непосредственным впрыскиванием
injection system система впрыскивания
to reduce сократить, уменьшить
reduction сокращение, уменьшение
to improve улучшать, усовершенствовать
improvement улучшение, усовершенствование
countermeasure контрмера
in-line pump рядный насос
common rail injection system система впрыска “common rail”
unit injector объединенная форсунка (насос-форсунка)
maximum peak injection pressure максимальное давление впрыскивания
naturally aspirated diesel engine дизельный двигатель с естественным воздухоснабжением (без турбонаддува)
injection rate скорость впрыскивания
cam profile профиль кулачка
concave cam вогнутый кулачок

tangential cam тангенциальный кулачок
fuel economy топливная экономичность
NOx emission эмиссия оксидов азота
smoke emission выброс дыма
rated speed номинальная частота вращения
to retard задерживать
injection timing момент впрыскивания
fuel delivery подача топлива

EXERCISES

1. Look through the text and answer the following question:

What types of high pressure injection systems have been considered and compared?

2. A. Say a few words about
1) the dependence of the injection pressure on the injection rate and the injection period;
2) the maximum peak injection pressure with the common rail system.
B. Answer the question:

What techniques are necessary to use for further reduction of exhaust emission and fuel efficiency improvement?

3. Look through the text and find Passive Voice constructions in Present Perfect and Past Indefinite.

4. A. Look through the text and complete the following sentences. Find the subject and the predicate in the sentences.

1. A concave cam was used ... . 2. The injection pressure was generated ... . 3. The injection rate was controlled ... . 4. The rail pressure was adjusted ... . 5. The injection pressure was set ... .

B. Change the completed sentences using Active Voice instead of Passive according to the example:

A concave cam was used for injection rate control. –
They used a concave cam for injection rate control.

5. Speak about the advantages of HDDI.

Part III

Dependence of Diesel Fuel Bulk Modulus on Temperature and Pressure

Text A. Diesel Fuel Bulk Modulus

In recent years, a great deal of research activity has been directed at understanding and improving the combustion process in diesel engines.

The ultimate aim has been to improve thermal efficiency and at the same time control pollutants emitted in the burned gases. The success of the combustion process in a direct injection diesel engine depends largely on the quality of the mixture formed in the chamber. Mixture formation is a complex process involving two-phase media, but it is generally agreed that the quality of the mixture formed in the chamber is largely determined by the characteristics of the fuel injection system and how they are matched to a specific combustion chamber.

One of the important characteristics is the fuel injection pressure. There are indications that the combustion process in a direct injection engine can be improved by increasing injection pressure. The pressure developed in a fuel compression system depends, among other things, on how the fuel is compressed and on the properties of the fuel itself, one of them being the fuel bulk modulus. Information on the values of the bulk modulus and its dependence on fuel pressure and temperature is highly desirable where high fuel pressures are to be generated.

At present, information on the bulk modulus of diesel fuel at high pressure is very meager. An earlier study on the measurement of adiabatic bulk modulus was limited to diesel fuel pressure of about 40 MPa. It has been indicated that diesel fuel bulk modulus decreases with temperature and initially increases with pressure, but actual values with pressure variation were not given, particularly for high fuel pressure. Values of compressibility of some hydrocarbon fuel indicate that it decreases with pressure, but there is no data on diesel fuel over the pressure range of interest in some of the injection systems under development

ACTIVE WORDS AND WORD COMBINATIONS

fuel bulk modulus модуль упругости топлива
diesel fuel дизельное топливо
combustion сжигание
thermal efficiency термический КПД
direct injection непосредственное впрыскивание
under development разрабатываемый, создаваемый
medium (*Pl.* **media**) среда
to match to a combustion chamber соответствовать форме камеры сгорания
meager скудный, недостаточный
hydrocarbon fuel углеводородное топливо
MPa МПа

EXERCISES

1. Look through the text and answer the following questions:

1. What is one of the most important characteristics of the fuel injection process? 2. How can the combustion process in a direct injection engine be improved?

2. Look through the text and find:

1) the absolute participle construction (независимый причастный оборот) in paragraph II.
2) two gerunds (in paragraph I) and determine their functions in the sentence.
3) three participles II in the function of an attribute (in paragraph I). Pay attention to their places in the sentences.
4) the infinitive (in paragraph I) and determine its function in the sentence.
5) one participle I in the function of an attribute.

3. Answer the following questions:

1. What is the aim of improving the combustion process? 2. What does a mixture formation process involve? 3. What determines the quality of the mixture formed in the chamber? 4. In what way does the general diesel fuel bulk modulus depend on temperature and pressure?

4. Find in the text:

1) the synonym to the modal verb "must" (in paragraph II);
2) "it" in the function of the formal subject (in paragraph II).

5. Translate into English. Use the verbs with prepositions:

зависеть от, повышаться, понижаться, улучшать (посредством чего-либо).

6. Translate the following sentences into English:

1. Целью исследования является повышение эффективности сгорания. 2. Важнейшей задачей является контроль за токсичными веществами, выбрасываемыми с отработавшими газами. 3. Процесс образования топливной смеси включает образование двухфазных сред. 4. Качество образующейся топливной смеси зависит от характеристик системы впрыскивания топлива. 5. Одной из важнейших характеристик является давление при впрыскивании топлива. 6. Давление при впрыскивании зависит от свойств самого топлива, причем одним из них является модуль упругости топлива.

7. Модуль упругости дизельного топлива понижается с повышением температуры и повышается с повышением давления.

SUPPLEMENTARY ACTIVITIES

1. Discuss the following problems:

1. Ways of improving the combustion process in diesel engines.
2. Ways of improving thermal efficiency and controlling pollutants emitted in the burned gases.

2. Match the following parts of the sentences:

1. The success of the combustion process depends on	a. characteristics of the fuel injection system.
2. Mixture formation is a complex process involving	b. the quality of the mixture formed in the chamber.
3. The quality of the mixture formed in the chamber is determined by	c. how the fuel is compressed and on fuel itself.
4. The pressure developed in a fuel compression system depends on	d. two-phase media.
5. One of the fuel properties	e. decreases with pressure.
6. Compressibility of some hydrocarbon fuel	f. is fuel bulk modulus.

Text B. Experimental Apparatus

There are at least two distinct methods of measuring the bulk modulus of fluids: the *P-V-T* method and the ultrasonic velocity method. In the present study, the *P-V-T* method is used to measure diesel fuel bulk modulus. A specially designed piston-plunger arrangement was used to compress the fuel. The stainless steel cylinder is made of three pieces, as shown in Fig. 6. The inside surface of the cylinder bore and the outside surface of the plunger are ground and lapped to prevent any leakage between the two surfaces. In addition, special seals made from hard fiber are used to prevent any leakage out of the compression chamber. Initially, a number of trial runs was made to determine the suitability of various types of seals. Most of them were judged to be unsuitable, either because they failed at high pressures or they absorbed a small amount of fuel after a number of runs. Hard fiber material was judged to be good to 180 MPa at temperatures as high as 60 °C.

The test fuel was compressed in the cylinder by the plunger which was driven by a fast-acting hydraulic ram. In an actial high speed fuel injection system the rate of fuel compression can be as high as 40 MPa/ms, but such high rates of compression could not be achieved in our experimental

set-up which was limited to 600 MPa/s. Some experiments also were conducted at lower compression rates to evaluate the effects of compression rate on bulk modulus. A piezoelectric transducer, calibrated to 200 MPa, was used to measure the instantaneous fuel pressure in the compression chamber. Fig. 7 shows a typical pressure rise trace in the chamber.

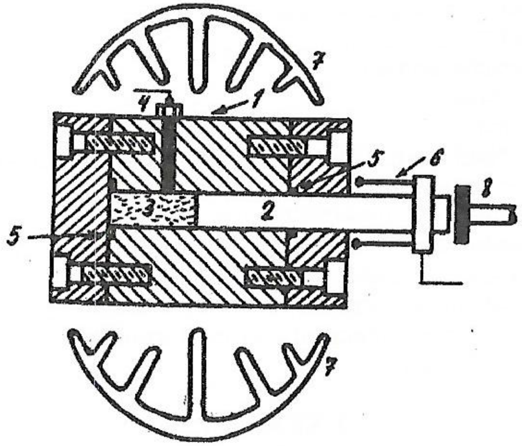

Fig. 6. Experimental apparatus:
1 – compression chamber; *2* – plunger; *3* – fuel; *4* – pressure transducer; *5* – seals; *6* – displacement; *7* – hot/cold air ducts; *8* – hydraulic ram.

During experiments, either cold or warm air was blown on the cylinder-plunger system to maintain the required temperature. During compression, the temperature rise of the fuel was judged to be within ±1 °C.

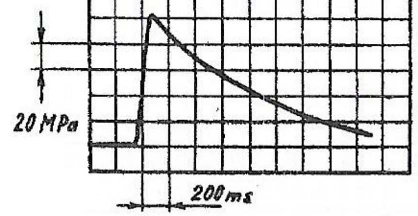

Fig. 7. Rate of fuel pressure rise

In addition, measurements of pressure drop in the compression chamber were made after the fuel was compressed at pressures as high as 70 MPa. These measurements indicated that the pressure drop due to cooling during the compression process was negligible. Thus the bulk modulus measured in these experiments was evaluated under almost isothermal conditions.

Active words and word combinations

ultrasonic velocity method ультразвуковой метод (*измерения ско-*

рости звука в топливе)
piston-plunger поршень-плунжер
arrangement устройство
a cylinder bore втулка с цилиндрическим отверстием
to grind (ground, ground) полировать
to lap притирать
leakage утечка
seal прокладка
hard fiber твердое волокно
trial run испытание
set up установка
piezoelectric [pai(i:zou,i(lektrik] **transducer** пьезоэлектрический датчик (*преобразователь*)
compression chamber полость сжатия
to calibrate тарировать
trace график (*осциллограмма*)
isothermal conditions изотермические условия
hydraulic ram гидравлический силовой цилиндр
ms мс (миллисекунда)

EXERCISES

1. Look through the text and describe in brief the *P-V-T* method of diesel fuel bulk modulus measurement.

2. Complete the following sentences and translate them:

1. The *P-V-T* method was used to measure ... . 2. A piston-plunger arrangement was used to ... . 3. The stainless steel cylinder was made of ... . 4. Special seals made of ... were used to ... . 5. A number of trial runs were made to ... . 6. The test fuel was compressed in ... by ... which was driven by ... . 7. A piezoelectric transducer was used to ... . 8. During experiments, either cold or warm air was blown on ... to ... .

3. Find Passive Voice constructions in the text.

4. Insert the required predicates in Passive Voice.

Begining of sentence	Predicate	Final part of sentence
1. A piston-plunger arrangement	...	to compress the fuel.
2. The stainless steel cylinder	...	of three pieces.
3. The test fuel	...	in the cylinder by the plunger.
4. During experiments, either cold or warm air	...	on the cylinder plunger system.
5. The P-V-T-method	...	to measure diesel fuel bulk modulus.
	...	

Text C. Experimental Results and Discussion

Isothermal fuel bulk modulus (K_t) was calculated by measuring the pressure rise and change in fuel volume during the compression process. This was done by selecting various initial pressures and various plunger displacements (which gave measure of fuel volume change) over a range of pressures up to 150 MPa. The results thus obtained are shown in Fig. 8 for the three different fuel temperatures used in the study. For each fuel temperature, measurements were made at different ambient conditions (see Fig. 8). Fuel bulk modulus decreases with temperature increase, but also increases with fuel pressure increase. The results show that the bulk modulus at 150 MPa pressure can be 30 % higher than its corresponding value at atmospheric pressure, depending on fuel temperature.

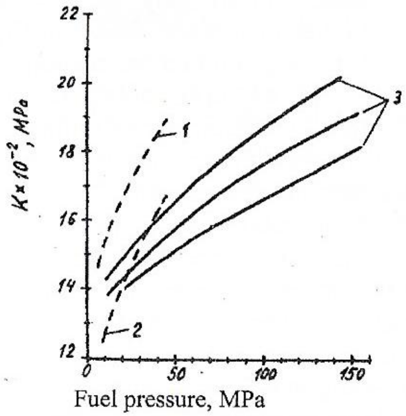

Fig. 8. Effects of pressure and temperature on bulk modulus at 600 MPa/s compression: *1* – results from Talbot (1935) at 7 °C; *2* – results from Talbot (1935) at 40 °C; *3* – the data received by the author at different conditions

Fig. 8 also shows a comparison between the results of the present study and those of an earlier investigation of adiabatic bulk modulus of diesel oil. In calculating the isothermal bulk modulus (K_t) from the adiabatic bulk modulus (K_s), at fuel temperatures of 7 and 40 °C, a value of (γ = 1,2 was assumed. This value was based on the average values of y for petroleum oils near room temperature. K_t is related to K_s as:

$$K_t = K_s / \gamma.$$

The bulk modulus is generally known to increase with an increase in the specific gravity of fuel, but it is not clear why the two sets or curves tend to diverge at high pressures. Diesel fuels are not held to very strict limits in composition and it is possible that the present grades of diesel fuel are different than those used in the earlier study. This may explain why the results of the present study at higher pressures do not agree well with the earlier results.

Fig. 9 shows the effects of fuel compression rate on bulk modulus; slightly lower values for bulk modulus were obtained when the compression rate was decreased from 600 MPa/s to 50 MPa/s. Thus, in an

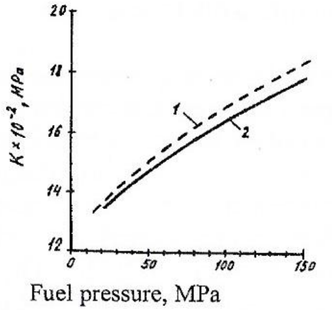

Fig. 9.. Effects of compression on bulk modulus: *1* – 600 MPa/s compression; *2* – 50 MPa/s compression.

actual diesel fuel injection pump where a compression rate as high as 40 MPa/ms sometimes is achieved, values of the bulk moduli may be slightly higher than those shown in Fig. 8 for a given fuel temperature.

In addition, depending on the surrounding environmental temperature and the type of injection system used, the fuel temperature can increase when the pump is operated over a long duration. For example, fuel temperature at the start may correspond to ambient temperature but after the engine has been running for a period of time the fuel temperature may be higher than at the beginning.

From the results obtained the following may be concluded:

At higher fuel pressure, bulk modulus increased almost monotonically with fuel pressure while at lower pressures a steeper slope of the curve was obtained.

An increase in fuel temperature was found to lower the bulk modulus.

It also appears that bulk modulus depends somewhat on the rate at which fuel is compressed, but this dependence is judged to be insignificant compared to the temperature and pressure effects.

ACTIVE WORDS AND WORD COMBINATIONS:

isothermal fuel bulk modulus изотермический модуль упругости топлива
adiabatic fuel bulk modulus адиабатический модуль упругости топлива
fuel specific gravity удельный вес топлива
displacement перемещение
ambient conditions условия окружающей среды
petroleum oils нефтяные масла
due to благодаря (*чему-либо*)
a grade of diesel fuel качество дизельного топлива
fuel compression rate скорость сжатия топлива
an effect влияние
steep slope of the curve крутой наклон кривой
MPa/s МПа/с

EXERCISES

1. Look through the text and try to explain how fuel bulk modulus varies with temperature and pressure.

2. Answer the following questions:

1. In what way was isothermal fuel bulk modulus (K_t) measured? 2. How does fuel bulk modulus depend on temperature and pressure? 3. What is the dependence of the bulk modulus on the fuel specific gravity? 4. Why do the results of the present study at higher pressures not agree well with the earlier results? 5. Why can the fuel temperature increase when the pump is operated over a long duration? 6. Under what conditions does the bulk modulus increase monotonically? 7. Under what conditions was a steeper slope of the curve obtained?

3. Find three sentences with a Complex Subject construction in the text.

4. A. Translate the sentences into Russian:

1. The bulk modulus is generally known to increase with an increase in specific gravity of fuel. 2. An increase in fuel temperature was found to lower the bulk modulus. 3. This dependence is judged to be insignificant.

B. Make up (in writing) your own sentences with the same (or similar) predicates.

SUPPLEMENTARY TEXTS

WHO WILL WIN THE FUTURE?

To tackle this guestion we would like to use a number of comparative and partially simplifying observations to show what position Mercedes Benz takes on this subject with reference to the direct injection processes. The following comparisons are naturally based on comparable parameters or refer to identical engine capacities.

Gasoline versus Diesel Engine

Modern indirect injection diesel engines in the capacity class (chosen for the sake of example) of 2.0 to 2.5 liters today have a fuel consumption measured in the relevant driving cycles which is between 10 and 15 % lower than their gasoline-powered competitors. Direct injection diesel engines widen this gap by up to another 12 %. In the current market situation this gives an economy advantage for modern direct injection diesel engines of almost 25 % in individual cases. The incorporation and modification of the common rail system as a standard component will lead to the consolidation of the advantages at this level.

If the gasoline engine is to close the gap on the diesel engine or even overtake it (as some observers predict it will), then the new systems currently under development must make up these 25 %. The first series production models of this new generation of gasoline engines with direct injection have so far failed to come close to this target according to measurements conducted at the New European Driving Cycle.

However, the latest data from research and series production developments clearly show there are good reasons to expect suitable combustion chamber modifications with high-pressure injection and appropriately adjusted ignition systems to lead to similar figures as those achieved by a diesel in the map range that is most important in determining fuel consumption.

If we examine how the energy flows of these two processes compare at one point in the part throttle range we observe the following: the fuel energy going into both processes (in this example 300 g/(kW·h)) is utilized in different ways, but the useful work achieved is the same.

Calculation results demonstrate the following things:

Based on the practical limits of everyday use – specified by fuel qualities, the achievable and the necessary cold start limits, noise quality and material characteristics to be considered – it must be assumed that at the currently achievable and required compression ratios (ε (for a direct injection gasoline engine roughly 12.0 and for a diesel engine – 19.0) almost identical high-pressure efficiencies of 41.5 % may be achieved. Theoretically there exists, however, a difference between the possible optimum values for the gasoline engine at $\varepsilon = 14$ and for the diesel engine at $\varepsilon = 15$ of almost 2 percentage points in the diesel engine's favor due to its better combustion process. Further development efforts are therefore necessary to unlock these ε -potentials.

Without going into further detail, it is clear that the car diesel engine is not going to be supplanted by the gasoline engine. On the contrary, the gasoline engine with direct injection will close up on the diesel engine in that range which affects fuel consumption.

The acoustic qualities of the two processes will tend to become increasingly similar.

Modern Fuels as a Basis for Engine Developments

Coordination within the worldwide operating petrochemical industry is a difficult task. Like in other industries, local, national and international aspects are in constant conflict with each other, especially where the cost issues in international operations play a decisive role.

On the other hand it cannot be ignored that where the subject of mobility and its ability to meet the demands of the future is concerned the legislator must, on the basis of sensible regulations, be in one boat together with the automobile industry and the petrochemical industry. The automobile industry must also set out a clear policy on the introduction of future high-quality fuels.

Following this line of argument, it appears natural that the automobile industry shall be committed to making gasoline and diesel fuel the priorities. These fuels must be available worldwide in a standardized form and by virtue of their quality characteristics should contribute to controlling air pollution. The improvement of fuels according to specific targets, with the engine manufacturers making their own proposals on qualities and undesirable elements, will secure the development of exhaust gas treatment systems which will be essential to the future of direct injection engines.

The official standardization bodies (CEN, ISO or ASTM to name just a few) can define the internationally required minimum quality which must be used worldwide and meet the high quality standards of engine developments. Mercedes Benz supports all necessary efforts for better fuels and is, therefore, active in the ACEA and supports the ACEA Fuel Charter, but expressly refrains from formulating its own proposals for high-quality fuels.

The future of low-consumption engine technology with direct injection will crucially depend on having a fuel with as low a sulfur content as possible.

Alternative Drive Systems

Alongside development work on conventional internal combustion engines, the automobile industry is committed to investigating the capability of alternative drive systems to provide future solutions and developing them further as potential systems of the future. Mercedes Benz is working in three areas with future market potential, although initially of a limited scope.

Natural Gas as Engine Fuel. Running one of today's gasoline engines on compressed natural gas (CNG) is mainly just a task of adaptation requiring special attention to safety regulations. Up until now, though, due to uncertain conditions and the lack of an infrastructure covering all areas to supply the market with CNG it has not been possible to seriously take on the apparent development risks.

Hydrogen as an Energy Carrier. Hydrogen could also be an ideal energy carrier. Hydrogen is, however, not a direct energy source, but only an energy carrier and this is a decisive disadvantage.

Hydrogen does not occur naturally as H2 but is mainly bound to oxygen or carbon atoms, e.g. in water on in other hydrocarbons. To free the hydrogen from these accompanying atoms requires an energy input. Thus to use hydrogen requires the prior separation of hydrogen. A proven method for this purpose is electrolysis which, however, must currently be done using power from whatever gas mixture is available in region. Since the situation today and, it may be assumed, in the near future is such that not sufficient CO2-free power can be made available, it is not possible to realize this system's potential as an environmentally-friendly technology.

However if this technology was to become attractive with sufficient availability of hydrogen, engine manufacturers would have the necessary technology package ready to provide the converted engines relatively quickly.

A Future with the Fuel Cell. Finally we should not omit to point out that there is a more attractive area of application for hydrogen:

This third alternative drive system is the fuel cell which with a current efficiency of roughly 40 % is already on its way to becoming a drive source which could possibly replace today's internal combustion engines over the medium and long term. Its use is more clearly predictable today and more likely in the coming decade than the prediction of 10 years ago that electric cars would be in use by the end of the nineties.

The progress of technology will determine which will be the primary energy source of the future. At present methanol is the favorite, but it, like all other alternative fuels, would first need a distribution infrastructure to be set up.

New Piston Pumps from Parker

When Parker Hannifin decided to develop its newest piston pumps for mobile hydraulic applications, a global design was the key target. And thanks to an innovative design process, the company believes its

new P2 and P3 series piston pumps will be able to meet the needs of mobile equipment manufacturers worldwide.

"Traditionally Parker America and Parker Europe were more like two satellites operated under different management and the products sold in various countries were basically manufactured there," said Kjell Jansson, vice-president.

"About two years ago when we decided to make the world's best piston pump line, we said: *no more local products*. From now on in the hydraulics group, every product we make has got to be global."

The design team spent the first year of development in the U.S. and the following year in Europe,"so they were close to the product and systems engineering centers that were going to deal with this product later," Jansson explained.

The pumps incorporate a range of features designed to provide high performance and reduced noise in a wide range of mobile equipment applications. Among the most innovative of these features is the addition of a precompression or "ripple" chamber in the rear cover. The ripple chamber is engineered to absorb the pressure spikes that occur when the pump's pistons act against the fluid. "Every time the piston pumps, you get a pressure spike," said Jansson. "That happens in all piston pumps and it's where a lot of noise is generated. With the ripple chamber, part of that pressure spike is absorbed and doesn't go out into the system, which reduces the noise."

Bo Lindblom, manager, product support, Hydraulic Group, Europe, said that the noise reductions can be significant. "We reduce the pressure spike by 10 to 50 percent," he said. "That cuts down the hydraulic «noise» being generated and sent out into the system".

The P2/P3 series pumps also incorporate a rigid, cast iron housing, which is engineered to reduce vibration and noise transmission.

The P3 pumps have the same features as the P2 units, with the addition of an impeller around the piston barrel.

Another key feature of the P2/P3 pumps is their compact size - 10.9 to 13.7 in. long, 6.9 to 8.9 in. wide and 10.4 to 12.9 in. high. Pump weight ranges from 81 to 178 lb. "We were asked to have the envelope size small and we were able to succeed at that."

CONTENTS

Ирина Григорьевна Маркова

INTERNAL COMBUSTION ENGINES

Методические указания по обучению чтению научно-технической литературы на английском языке по теме «Двигатели внутреннего сгорания»

Редактор *А.В. Сахарова*
Корректор *И.Е. Мелентьева*
Компьтерная верстка *А.Ю. Ураловой*

Подписано в печать 05.02.04. Формат 60×84/16. Бумага офсетная.
Печ. л. 1,75. Усл. печ. л. 1,63. Уч.-изд. л. 1,51.
Тираж 100 экз. Изд. № 140. Заказ 38

Издательство МГТУ им. Н.Э. Баумана.
105005, Москва, 2-я Бауманская ул., 5.