

OPTICAL METHOD OF REGISTRATION OF PROCESS OF THE INJECTION AND THE BURNING IN THE CHAMBER OF THE CYLINDER OF THE ENGINE GDI

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Abstract

In this article method of a visualization of a process of injection and burning of the air-fuel mixture was presented in cylinder of engine GDI. Intention of the visualization is a possibility of a determining and a selection how the most profitable parameters of injection for the work of engine during burning of the various load.

Apparatus of the firm AVL - VideoScope 513 D was used to performance of positional tests, having on purpose registration of a dislocation of the stream of the fuel from the moment of injection, one by one a reflection of fuel from the bottom of the piston until for the connection under the spark plug, and next an expansion of the flame from moment of the ignition until to the end of process of burning.

Results of carried out visualization are in form files of the type of avi. These files are intended to a presentation of a record of respective frames as a moving image. From editorial reasons in this article results of visualization are presented in a form of single cinematographic frames following in turn after themselves what the certain degree of the angle of the rotation of the crankshaft. Values of angles for which next frames were presented are placed in a bottom left corner of a single frame. All executed registrations archive images in the function of angle of rotation of crankshaft no from one, but from many of the cycles of the work of engine.

1. Introduction

The possibilities of an improvement of the energetic parameters and also decreasing of the emission toxic components of fumes of internal combustion engine need more and more precise an organization of the course of process of injection and burning of fuel.

In purpose of an optimization of processes occurring inside of cylinder of engine analysis of changes of basic of output parameters of engine stops therefore to suffice exclusively. To direct of

an opinion of course of the fuel injection, method of creation of air-fuel mixture and also of burning of her more and more indispensable is becoming a possibility of visual opinion of these phenomena. There are series of important problems involved with registration of images inside of cylinder of internal combustion engine. To the most important belong: the high temperature and the pressure of the working substance affected on the optical element of the measure apparatus, the lack of sufficient quantities of place in the cylinder heads of modern engines to the optical access to the interior of cylinder and also a very large fast changeability of the registered phenomena.

Nowadays applied visualized systems differ in respect of speed of registration and the frequency sampling of image, the resolution and the optical sensitivity and also the possibility of archiving of images.

From point of view of usefulness two methods of visualization of burning applies to analysis in motor tests. First method concerns an application of the fast camera and a filming of the part of one cycle of work engine with small resolution of sampling. Second method applies the digital camera to registration of images coming from different cycles of work of engine and moved about required, the little interval of angle of rotation of crankshaft (frequency of registration of images max. what $0,1^\circ$ OWK).

To the positional tests carried out in present article method of images coming from different cycles of work of engine was applied.

2. Methodology of carrying of positional tests

Conditions of measurements of visualization of course of processes of injection and burning of fuel in cylinder of benzine's engine distinguish somewhat measure apparatus this type from systems of the fast filming applied in different fields of science. To specificity of motor measurements is possible to classify a necessity of a preservation of optical elements before high temperature, a minimalization of dimensions of the probe (of the endoscope) assured optical access to the combustion chamber and also measurements executed in function of angle of rotation of engine's crankshaft (and no in function of time). It should to have fact on attention, that measurements executed in function of time are not adequate to measurements executed in function of angle of rotation of engine's crankshaft. It results of course as a rule of work of internal combustion piston engine, for which the angular speed is function of angle of rotation of crankshaft also in established conditions of work of engine. Therefore in different stages of a realisation of the thermodynamical circulation, other intervals of angle of rotation of crankshaft will fulfill these same intervals of time.

From shown reasons it more profitable seems use to visualization of course of injection and burning fuel in benzine's engines of digital measured systems archived images in function of angle of rotation of crankshaft no from one but from many of cycles of work of engine, so as it was presented in schematic method on Fig. 1.

During of analysis of images fulfilled this same angle of crankshaft (coming from different cycles of work of engine) is possible a statistical processing of results of tests giving opinion on an uniqueness of tested phenomena also a possibility of an averaged determining or representative cycle of work of engine. After the measurement for next angles of rotation of crankshaft of engine is possible a creation of a special film enabling on visual analysis of course of process injection and burning of fuel in cylinder of benzine's engine.

This method of proceeding enables filming and analysis according to two methods:

- type A (Fig. 1) - registration of different cycles of work of engine for this same angle of rotation of crankshaft,
- type B (Fig. 1) - registration of images with different cycles of work of engine for next angles of rotation of crankshaft moved about declared interval (maximal „resolution” of sampling is equal $0,1^\circ$ OWK).

Endoscope enables optical access to combustion chamber (Fig. 2). This element is connected

directly with the objective of digital camera. Cooling of endoscope is assured by constrained flow of air between so-called rod lenses inside endoscope.

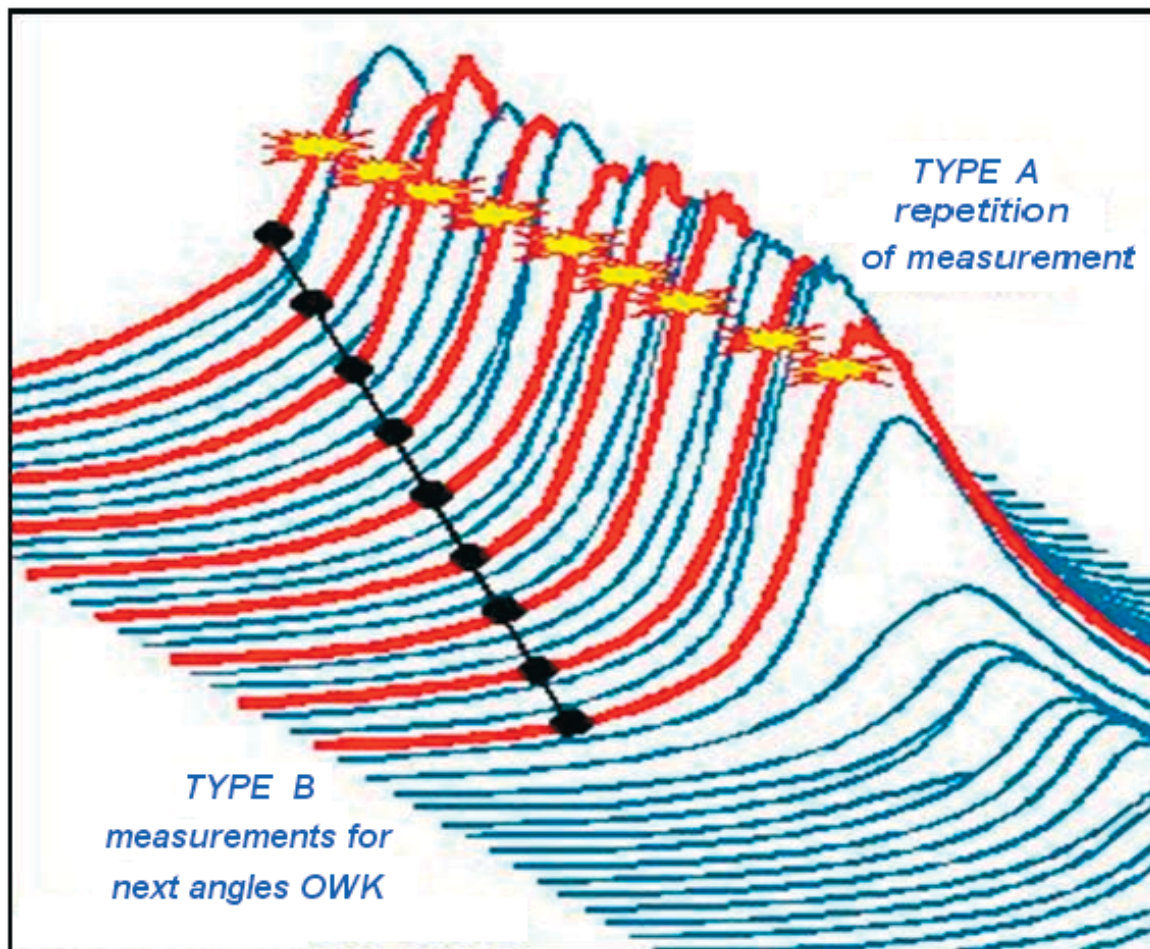


Fig. 1. Diagram of filming of processes in cylinder of engine by means of system AVL 513D Engine Videoscope [1]

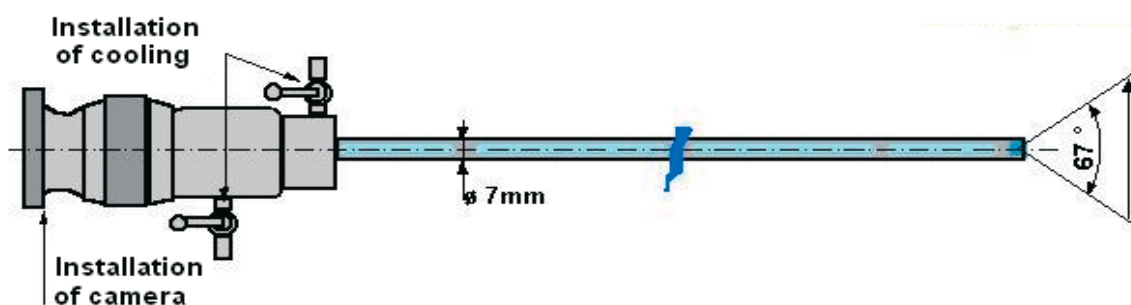


Fig. 2. Endoscope of appliance AVL Engine Videoscope 513D [1]

3. Course of visualization on testing position

Visualization contained registration of real conditions of process of injection and burning of fuel in benzine's engine with direct injection to cylinder for chosen states of work of engine. From regard on work of engine C6X9GDI Mitsubishi about capacity 1834 cm³ in two modes of work i.e. on the homogeneous mixture (fuel injection during the stroke of the suction) and also on the heterogeneous mixture (fuel injection during stroke of the compressing) executed also registration in presence of large loads and high rotatory speeds.

Tests passed according to the following order:

1. Location and preservation of vehicle on rolls of the chassis place to braking.
2. Starting of engine in order to warm of his to correct temperature of work. Immobilizing of engine after about 3 minutes of work.
3. Installation of apparatus AVL Engine Videoscope 513D and cooling system of endoscope. Taking out of dummies with bush of cylinder head, and in them place inserting of tip of endoscope and illumination.

Endoscope is cooled air given by means of compressor under the pressure 0,6 [MPa].

4. Starting of engine and system of cooling of endoscope.
5. Choice of determined of state work of engine.
6. Execution for so established state of work of engine visualization contained registration of process of injection and burning of air-fuel mixture.

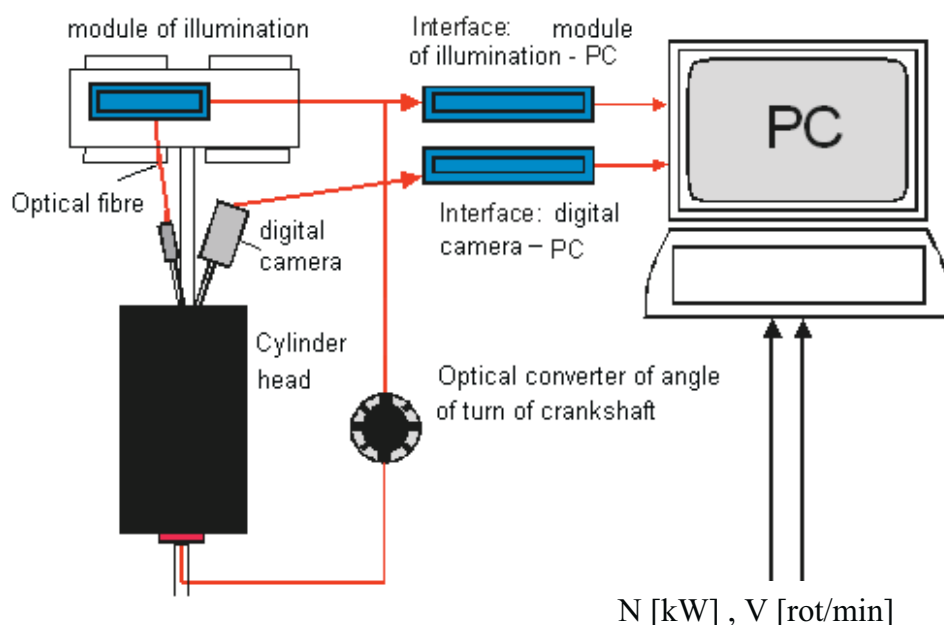


Fig. 3. Diagram of position to tests

4. Processing and analysis of images of registered phenomena

Application of endoscope in presence of digital filming of processes of injection and burning in cylinder of tested engine by means of appliance AVL Engine Videoscope 513D enables on achievement images about 32-bit real color, resolution 786 x 484 points and the exposition shifted about 0.1 angle of rotation of engine's crankshaft. Results performed visualization are in form of files of type of avi. These files are intended to performance of record of respective of frames as moving image. From editorial reasons in this article results of visualization are presented in form of single cinematographic frames following in turn after itself what certain degree of angle of rotation of crankshaft. Values of angles for which next frames were presented are placed in the bottom left corner of single frame. All executed registrations archive images in function of angle of rotation of crankshaft no from one, but from many of cycles of work of engine.

5. Results of tests

Performed visualization concerned of process of injection and burning during work of engine on homogeneous mixture. Registration was carried out for rotatory speed of engine 3750 [rot/min] for partial load. Value of the singular fuel consumption achieved 300 [g/kWh]. Fuel injection took place for 35°OWK after GMP. On shown cinematographic frames (Fig. 4) performed chosen photographs concerning of course of injection fuel to cylinder of engine GDI.

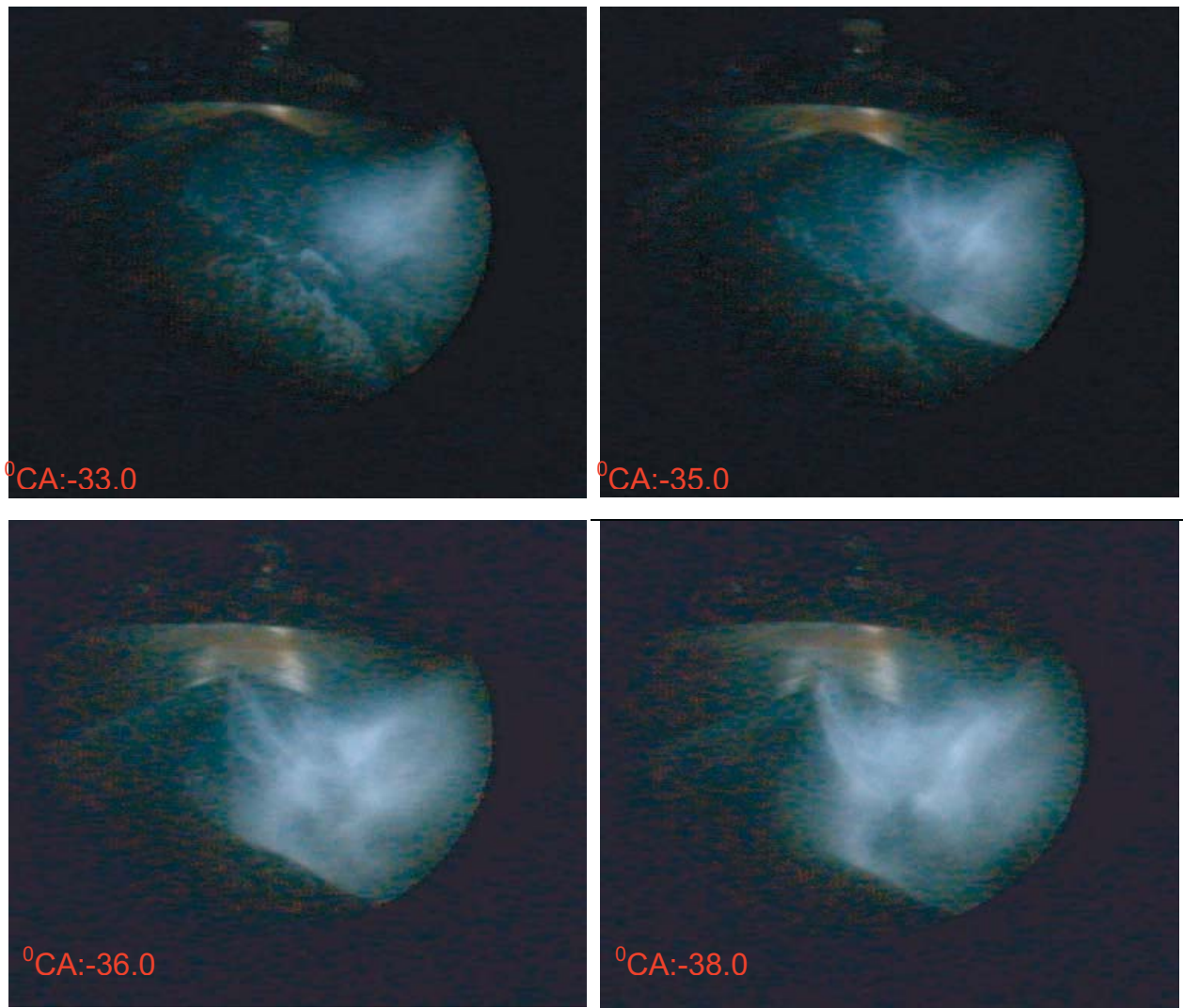


Fig. 4. Respective phases of fuel injection for chosen angles of localization of crankshaft

However on Fig. 5. it showed chosen cinematographic frames with performed visualization concerning of course of burning in engine GDI during work on homogeneous mixture. Moment of ignition occurred for 15° before GMP.

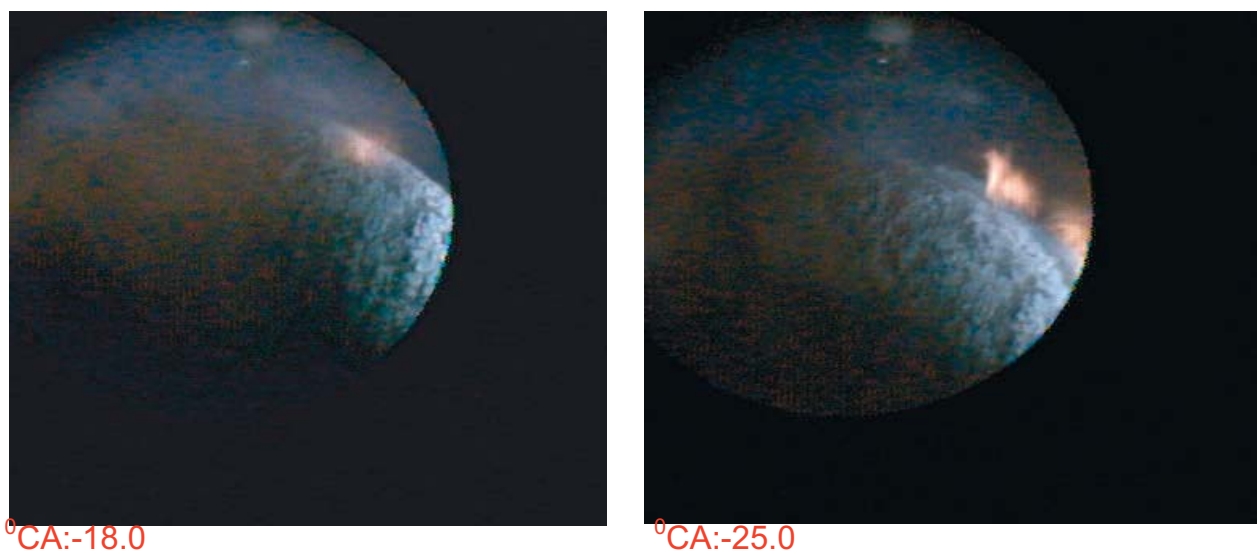


Fig. 5. Respective phases of fuel injection for chosen angles of localization of crankshaft

5. Conclusions

1. Possibility of observation of dislocation of stream of fuel from moment of injection, one by one reflection of fuel from bottom of piston until for the connection under aperture between electrodes of spark plug and also expansion of flame from moment of ignition until to end of process of burning.
2. Results achieved during visualization of process of injection and burning give image real conditions occurring inside of cylinder of engine.
3. Visual opinion of phenomena is becoming indispensable method to precise determining of parameters decided about correct course of process of injection and burning.

6. Literature

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