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LITHUANIAN SOCIETY OF AUTOMOTIVE ENGINEERS
THE DIVISION OF TECHNICAL SCIENCES
OF LITHUANIAN ACADEMY OF SCIENCES
KLAIPĖDA UNIVERSITY
VILNIUS GEDIMINAS TECHNICAL UNIVERSITY**

TRANSPORT MEANS 2013

PROCEEDINGS OF THE 17th INTERNATIONAL CONFERENCE

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Kaunas University of Technology,

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Klaipėda University

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The proceedings of the 17th International Conference Transport Means 2013 contain selected papers from 6 sections: Automotive Transport, Aviation, Defense Technologies, Intellectualized Transport Systems, Railway Transport, Waterborne Transport.

All papers were reviewed.

The style and language of authors were not corrected. Only minor editorial corrections may have been carried out by the publisher.

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PREFACE

17th International conference Transport Means 2013 takes place at Kaunas University of Technology and Klaipėda University on 24th – 25th October 2013. It continues long tradition and reflects the most relevant scientific and practical problems of transport engineering.

The aims of the conference are to share the latest information on the issues of transport means engineering and transportation technologies, to develop international relations of Lithuanian professionals in the science of transport as well as to get students interested in the transport research.

The reports cover a wide variety of topics related to the most pressing issues of today's transport systems development.

The main areas covered in plenary session and in the sections are: design development, maintenance and exploitation of transport means, implementation of advanced transport technologies, development of defense transport, environmental and social impact, advanced and intelligent transport systems, transport demand management, traffic control, specifics of transport infrastructure, safety and pollution problems, integrated and sustainable transport, modeling and simulation of transport systems and elements.

In the invitations to the conference, sent five months before the conference starts, the instructions how to prepare reports and how to model the manuscripts are provided as well as the deadlines for the reports are indicated.

Those who wish to participate in the conference should send the texts of the reports that meet relevant requirements under indicated deadlines. Each report must include: a short description of the idea or technique being presented, a brief introduction orienting to the importance and uniqueness of the submission, a thorough description of research course and comments on the results.

The submissions are matched to the expertise according to the interests and are forwarded to the selected reviewers.

Scientific Editorial Committee revises, groups the properly prepared reports according to the theme and design the conference programme.

The Proceedings are compendium of selected reports presented at the Conference.

Chairman of the Division of Technical Sciences of
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Prof. V. Ostaševičius

Diesel Engine Common Rail Injector Acoustic Emission Pattern Obtaining

I. Kurjanovičs*, J. Feščuks**, M. Banovs**

* Riga Technical University, Kaļķu 1, LV-1658, Riga, Latvia, E-mail: igors.kurjanovics@rtu.lv

**Riga Technical University, Kaļķu 1, LV-1658, Riga, Latvia, E-mail: ndt_ae@inbox.lv

Abstract

The paper deals with experiment of investigating the possibility to use Acoustic Emission (AE) testing method for testing diesel engine Common Rail system injectors. The test bench Bosch EPS200 used as different mode modulator of injector work process to make measurements of AE signal with Pocket AE-2. The acquired data was processed by "AEwin for PCI" software. Output results have shown that different values differs at different test steps.

KEY WORDS: *acoustic emission, common rail, injector*

1. Introduction

The biggest part of transport vehicles are equipped with heat engine where combustion occurs by means of mixing liquid fuel and oxidizer. In modern internal combustion engines, fuel is injected into combustion chamber by fuel injector. The work efficiency of heat engines is mostly dependable on fuel injection system condition. During lifespan of vehicle, parts are degrading and losing its normal condition thus influencing all system's work and changing output parameters. Not only economical but also ecological issues push operators' interest in field of predictive and non-invasive condition monitoring. Possibility to predict deterioration can reduce the costs of maintenance. Nowadays transport vehicle is complex device with many parts and main part of it is still engine. ECUs (Engine Control Units) govern engines by obtaining income signals from sensors, and sending output signals to actuators. The major actuators are fuel injectors, which injects certain amount of fuel into cylinder calculated by ECU.

Engine parts interacting each other produces various signals, which can be interpreted as "noise" until they are decoded. The research object is 1st generation Common Rail system (Fig. 1) Diesel engine fuel injector. Various authors have made investigations on diesel injectors using AE method and admired that this testing method is good to detect changes in work condition [1, 2].

The aim of investigation was to check a possibility of use EPS200 test bench (Fig. 2) in further research of common rail injector by AE method.

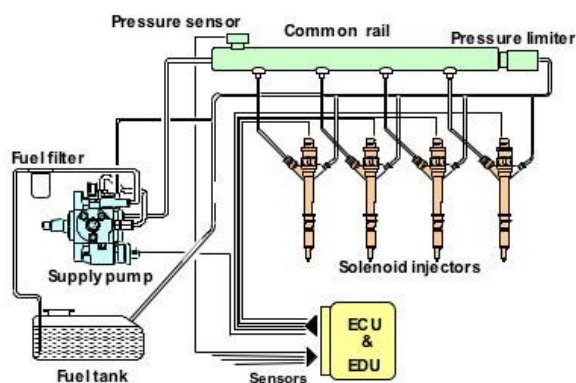


Fig.1 Common Rail Diesel Engine system



Fig. 2 Fuel injector test bench EPS200

2. Materials and Methods

The experiments were carried out on Bosch EPS200 test bench (Fig. 2), which have preprogramed test program for injector testing. EPS 200 is a compact automatic injector tester for Common Rail injectors, Unit Injectors and Nozzle Holder assembly. The AE acquisition equipment consisted of Pocket AE-2 portable 2-Channel Acoustic Emission System with AE resonant sensor. Sensor was attached to injector body. The signal acquisition window established 5 ms for event and threshold 32dB. Obtained data was processed with "AEwin for PCI" software. Parametric signal was taken from injector's solenoid connector. The description of injector electrical governing is taken

from EPS200 help file and voltage and current curves are shown in Fig. 3. The injector's solenoid work is divided in 4 phases: booster, pick-up, holding and cut-out phases.

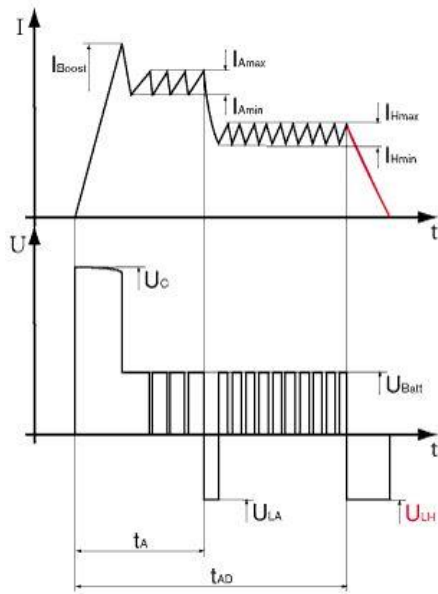


Fig.3 Injector solenoid work phases diagram



Fig. 4 Connection to solenoid

In the booster phase, also called the opening phase, the predefined capacitor voltage (U_C) is applied to the solenoid valve of the injector. The capacitor voltage (U_C) is generated in the control electronics and can be several times higher than the battery voltage (U_{Batt}).

In response to the capacitor voltage (U_C), the current in the coil of the solenoid valve rises sharply until the predefined set point I_{Boost} is reached. After reaching the set point (I_{Boost}), the control electronics supply the battery voltage (U_{Batt}) to the solenoid valve of the injector. By pulsing the battery voltage (U_{Batt}), the current in the coil of the solenoid valve is controlled between I_{Amin} and I_{Amax} until the energization time (t_A) is reached.

The magnetic force generated by the solenoid valve actuates the magnetic inductor in the injector and the nozzle needle is raised from its sealing seat. Injection begins.

In the deactivation phase, the current in the coil of the solenoid valve is first lowered by a predefined negative extinction voltage (U_{LA}) to I_{Hmin} . Then the control electronics regulates the current by pulsing the battery current (U_{Batt}) between I_{Hmin} and I_{Hmax} until the predefined actuation time (t_{AD}) is reached.

The actuation time (t_{AD}) for the injector is specified in each individual test step (Table 1.). By lowering (extinguishing) to the holding current (I_H), the power loss in the control electronics and injector is reduced. During the extinction phase, energy is released. This energy is stored in the capacitor for the next booster phase.

In the deactivation phase, the current in the coil of the solenoid valve is reduced to 0 ampere by a predefined negative extinction voltage (U_{LH}). The solenoid valve in the injector is deactivated and the nozzle needle retracts into the sealing seat. The injection process is complete. By extinguishing the current, energy is also released and stored in the capacitor for the next booster phase.

The AE pocket parametric input allows to measure values $\pm 10V$. The capacitor boost voltage is up to 60 V and for reduction of voltage the probe (1:10) from oscilloscope was connected.

Our test object was reconditioned common rail injector – Bosch product Nr. 0445110024 CR/IPS19/ZEREA10S. Before experiment, the injector was placed in test bench according to manuals and was flushed. The Bosch preprogrammed test consisted of 5 steps and after the test completion the result (Fig. 5) based on measurements was printed. Test of injector showed that injector is in good condition.

3. Results

Processed in software data results are shown graphically (Fig. 6-11) and in Table 1. From processed data were chosen next parameters: Duration of signal (μs), Rise time (μs), Signal strength pV, Counts to Peak, Absolute energy (aJ), Initiation Frequency (kHz). Recording process was from 0 to 350 seconds. Results are clearly seen at the different test steps.

EPS 200 protocol
Common rail injector test



Common rail injector
 Type number: 0445110121
 Manufacturer: Bosch
 Actuation profile: 14V
 Description: CRI 1

Measurement results

Serial number: ----								
Test step	Actuation time (μ s)	Pressure (MPa)	Measurement time (s)	Injected fuel quantity		Return quantity		Evaluation
				Set value (mm ³ /H)	Actual value (mm ³ /H)	Set value (mm ³ /H)	Actual value (mm ³ /H)	
Leak test	0	140	200	--- \pm ---	---	35 \pm 35	---	✓
VL	800	135	90	54.9 \pm 4	53.61	45 \pm 28	26.24	✓
EM	500	80	40	15.8 \pm 3.4	17.59	--- \pm ---	---	✓
LL	675	25	40	4.3 \pm 2.2	5.08	--- \pm ---	---	✓
VE	160	80	40	1.6 \pm 1.3	1.03	--- \pm ---	---	✓

Fig. 5 Injector test protocol (Leak test, VL - full load, EM -emission point, VE - pre-injection, LL-idle)

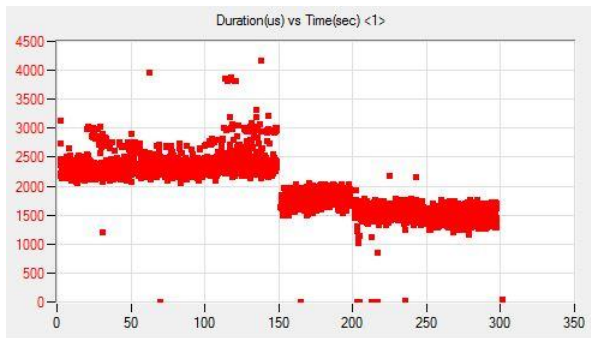


Fig. 6 Duration of signal (μ s)

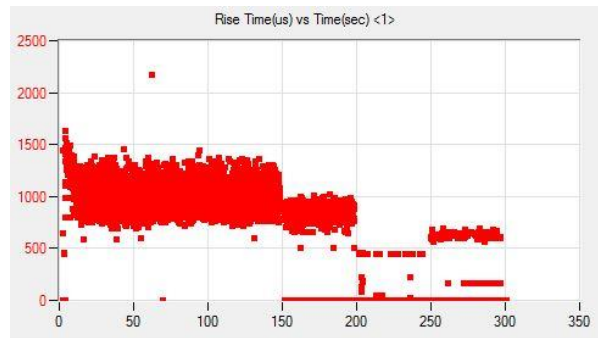


Fig. 7 Rise time (μ s)

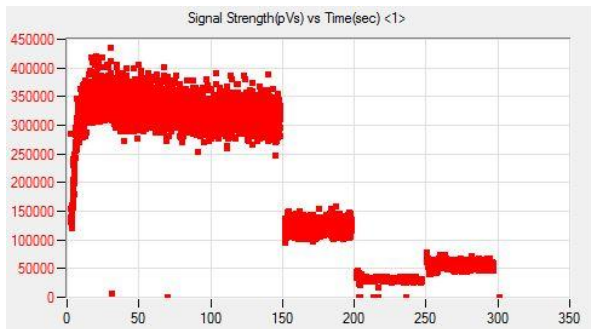


Fig. 8 Signal strength (pV)

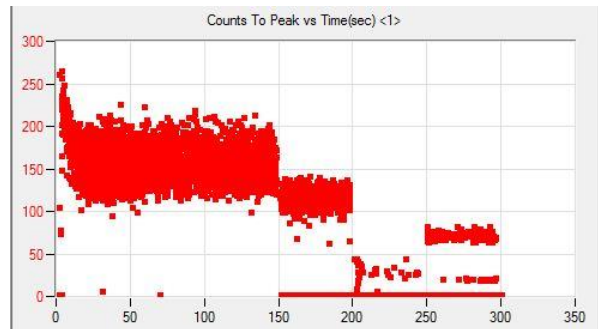


Fig. 9 Counts to peak

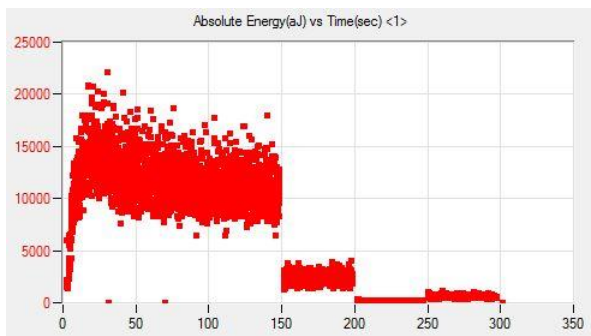


Fig. 10 Absolute Energy (aJ)

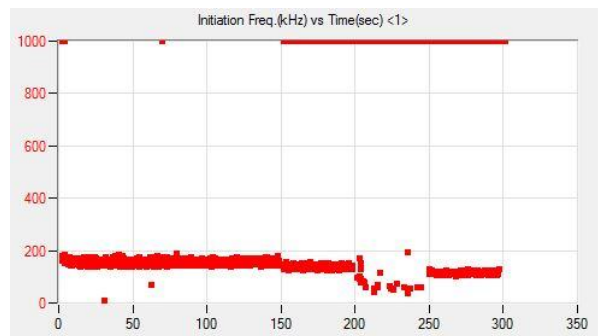


Fig. 11 Initiation frequency (kHz)

Table 1.

Results at different test steps

Test step	Actuation time (μ s)	Pressure (Bar)	Measurement time (s)	Duration of signal (μ s) From... to	Rise time (μ s) From... to	Signal strength pV From... to	Counts to Peak From... to	Absolute energy (aJ) From... to	Initiation Frequency (kHz) From... to
Leak test	0	1400	200	-	-	-	-	-	-
VL-Full load	800	1350	90	2000...2700	700...1400	280000...380000	120...200	8000...18000	140...170
EM-Emission point	500	800	40	1600...2000	700...1000	100000...160000	90...140	1200...4000	125...150
LL-Idle	675	250	40	1500...1700	400...500	26000...36000	20...40	150...250	40...100
VE-Pre injection	160	800	40	1300...1500	600...700	45000...70000	60...80	350...900	105...130

4. Discussion and conclusion

During experiments were difficulties to obtain a parametric signal from injectors electric signal connector for more accurate data about injection process beginning. When the parametric cable was connected (Fig.4), the test bench was malfunctioned and the test program was not starting. For the further experiments, the connection system of parametric input signal need to be upgraded.

Obtained results (Table1.) in values shows that there is a possibility to recognize the injectors work mode and continue further investigation to make measurements on faulty injector and compare the results with healthy using test bench EPS200.

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