Damping of pressure pulsations in the fuel system of the motor

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Abstract. The paper presents results of works carried out to damp pressure pulsations in the fuel line of a gasoline engine to provide for the required environmental friendliness level. The paper describes testing of a modernized damped injector rail. Based on the obtained test results, conclusions were made on the efficiency of use of a fuel line damper reducing fuel pressure pulsations.

1. Introduction
During the operation of motor vehicle engines, their environmental performance is influenced by quite a big number of factors. Partially, these factors are operational and can be traced during the operation of motors in different conditions of road, traffic and climate. Another group of factors is related to the design features of both the vehicle and the engine proper. Design options of the engine feed system also influence a number of the engine operation parameters. One of the phenomena is the presence of a short-time fuel pressure change in the fuel line. [1] The elimination of pressure pulsations in the fuel system of UMZ-42164 engine is the main objective of the works summarized herein.

2. Description of the experimental setup
The pressure pulsation problem has occurred after introduction of a metal injector rail supply pipe. Due to high pulsations in the fuel system, the engine ceased to be compliant with the rules of UNECE/ECE No. 83-05B. [2]

In order to troubleshoot this problem, technicians of PEKAR Company have developed an injector rail with a damper Part No. 4216.1104010-20. [3] A necessity occurred for efficiency testing of the suggested measures to reduce the pulsation effects.

To assess the efficiency of the injector rail under test, comparative tests were conducted of the new injector rail with a damper and the conventional existing injector rail.

Fuel systems were tested in the following configurations:

- standard configuration (PEKAR 4216.1104010-14 injector rail);
- test configuration with a damper (PEKAR 4216.1104010-20 injector rail).

The injector rail was tested on UMZ engine Serial No. 421640E0802055 on a GAZ-322132 lorry. [4-6] The general arrangement of GAZ-322132 fuel system is shown in Figure 1.

GAZ-322132 fuel system under test consisted of a fuel module, a fine fuel filter, an injector rail and connection tubes. The fuel system under test is shown in a configuration without a return fuel line. The fuel return to the tank is provided for only by the fuel line section from the fuel tank outlet to the...
fuel module. The injector ramp is installed in straight design, without a fuel pressure regulator. The fuel pressure regulation in the system is provided for by the pressure regulator in the fuel pump module. The fuel pressure built-up in the system shall be 373 to 392 kPa. During fuel system operation, the rail operates as a liquid pressure accumulator maintaining the pressure on a constant level. Thereby, a phenomenon of short-time pressure changes (pulsations) can be observed which affects the carburation process.

Figure 1. General view of a fuel system of GAZ-322132 lorry with UMZ-42164 engine

For the appearance of PEKAR 4216.1104010-20 injector rail with a damper, see figure 2. During testing, the injector rail consisted of a damper, fuel nozzles connected to the rail with rubber rings, a fuel pressure relief valve, fuel supply nipple and two holders for rail support on the cylinder head.

Figure 2. PEKAR 4216.1104010-20 injector rail with a damper

During testing, a fuel module by SOATE was used, see Figure 3. The fuel module consists of a fuel pump inside an accumulator tank, a fuel pressure regulator, nipples for connection of fuel lines with quick couplings, an electrical connector and a fuel gauge sending unit.
3. Experimental research

The fuel system tests were conducted in the following modes:

- measurements and evaluation of high-frequency fuel pressure pulsations in the injector rail from the minimum idle rpm up to 4000 rpm;
- measurements and evaluation of high-frequency fuel pressure pulsations in the injector rail during testing for compliance with the requirements of Rules 83-05B.

As a fuel for testing and evaluation of the reduction of the pulsations in the fuel line, AI-95 gasoline was used.

For measurement of pressure pulsations, an absolute pressure sensor with 0...10 bar (a) measurement range was installed in the rail via an adapter nozzle and connected to an amplifier. The pressure pulsations in the rail was evaluated versus the rotation speed of the engine. For this purpose, one of the amplifier channels was a tachometer signal tapped from the electronic controller module. The measurement data were recorded by a laptop PC.

During testing, for all versions pressure pulsation vs. time and engine rpm diagrams were plotted.

Figure 5 shows a rail pressure pulsation diagram for the initial configuration of the fuel system in the driving cycle (exhaust toxicity).
Figure 5. Rail pressure pulsation (initial configuration, in driving cycle (exhaust toxicity), second curve showing engine rpm).

Figure 6 shows a rail pressure pulsation diagram for the modified configuration with a damped rail, in the driving cycle (exhaust toxicity).

Figure 6. Rail pressure pulsation (with damper, in driving cycle (exhaust toxicity), second curve showing engine rpm).
Figure 7 shows a comparative diagram of the rail pressure pulsations vs. engine rpm (black curve: initial version, gray curve: with a damper).

Figure 7. Injector rail pressure pulsations vs. engine rpm (black curve: initial version, gray curve: with a damper diagram).

4. Results and conclusions

Values of maximum pressure pulsations for all fuel system configurations are given in Table 1. The average rail pressure at working fuel pump during testing was 4.4 bar.

Table 1. Maximum fuel pressure pulsation values

| Fuel system configuration       | Maximum pressure amplitude, bar | Frequency of pulsations, Hz | Engine rpm |
|---------------------------------|---------------------------------|----------------------------|------------|
| Initial configuration           | 3.13                            | 15.2                       | 1,200      |
| Experimental injector rail with a damper | 0.24                            | 20                         | 4,000      |

The table and the diagrams demonstrate, that:
- in the initial configuration, the pressure is pulsing from 2.83 to 5.96 bar with 15.2 Hz frequency at 1,200 rpm;
- in the experimental configuration, the pressure is pulsing from 4.22 to 4.46 bar with 20 Hz frequency at 4,000 rpm.

Based on the analysis of the obtained test data, it is obvious that in comparison with the initial configuration, the damper on the injector rail reduces the pulsations by 13 times.

Thus, the results of the comparative testing of UMZ-42164 engine fuel system demonstrate that the use of PEKAR 4216.1104010-20 injector rail with a damper reduces the pressure pulsations by 13 times.
times and provides for compliance of the engine to UNECE / ECE Rules No. 83-05B in terms of toxic exhaust emissions.

References

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