Common Rail Diesel Feed System Diagnosing Technology

R. Ilves[1], V. Mikita[1], Ü. Traat[1] and A. Gregor[2]

[1]Institute of Technology, Estonian University of Life Sciences,
56 Kreutzwaldi Str., EE51014 Tartu, Estonia; e-mail: risto.ilves@emu.ee
[2]Department of Thermal Engineering in Tallinn University of Technology
Tallinn University of Technology, 116 Kopli Str., EE11712 Tallinn, Estonia;

Abstract: For testing common rail diesel feed systems, the company responsible for the production has issued test plans that include cycle values and repair technology. This particular article provides the reader with an overview of the common rail diesel feed systems' changes in cycle value due to control parameters and diagnosing technology that does not use test plans.

Keywords: Combustion engine, common rail, diagnosing, characteristics

INTRODUCTION

In Estonia, several companies deal with the technical maintenance, diagnostics and repair of diesel feed systems. The particular software and hardware used in these operations is rather expensive, thus limiting business in this field. The technical condition of a mechanical high-pressure pump is evaluated on a test stand. In addition to the test stand, electronic feed systems require a control unit. Different feed systems require different control units. In addition, test plans describing the productivity of the feed system on fixed control characteristic values are necessary for diagnosing the feed systems (Bosch EsiTronic). This kind of software and hardware can be purchased from the manufacturer of the feed system; however, it could be argued whether the diagnostic method described in this article is more effective. The common rail diesel feed systems used nowadays can be diagnosed without test plans. For doing so, it is crucial to know the principles of changes in the characteristics that are required for an engine's work.

MATERIALS AND METHODS

There are specific standard requirements for testing feed systems. Test liquid temperature should be 40° C during the test. The measurement of glass accuracy when using a 500 cm^3 measuring glass is ± 0.5 cm^3. When measuring a liquid, the dimensional error could be ± 1° C and in case of a fuel ± 1% of the measured quantity (Standard, ISO 4008/2).

Ten measurements were carried out during every test, the average of which was calculated. The regression equation was worked out on the basis of the data received. Microsoft Excel was used to process the data.

When dealing with high-pressure pumps, the fuel supply is regulated by turning the plunger and regulating the active gear. The regulation of the compression spring of the injector changes injection pressure. In case of common rail feed system, the electronic control system simplifies the equipment and the previously mentioned change in control parameters is electronic (Heisler, 2001).

When diagnosing a common rail feed system, the extent of cycle value released by it is measured. The cycle value describes the amount of fuel injected into the cylinder in mm^3 during one working cycle. The cycle value of common rail feed systems can be measured with three characteristics: injection pressure, opening time of the injector and rotational speed of the high-pressure pump (Mikita, 2008).

Injection pressure

In the common rail system, injection pressure is regulated by the pressure controller, which is in turn regulated by the control unit of the engine (Fig. 1). The injection pressure is regulated according to the rotational speed of the high-pressure pump and the opening time of the injector (Bosch, 2002; Bosch, R. 2002, Autoelektronik). Moreover, the extent of the cycle value is influenced by the productivity of the high-pressure pump. If the amount of fuel running through the injectors exceeds the maximum productivity of the pump, injection pressure will remain on a certain level and will stop increasing.

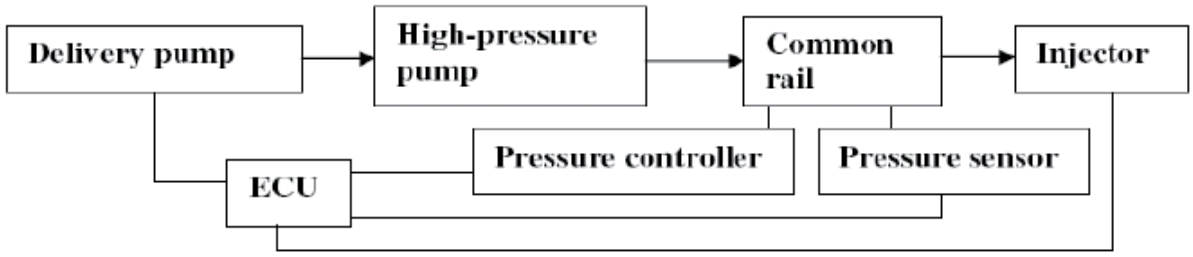

Fig. 1. Functional schema of common rail (Reif, 2007).

Injection pressure influences the extent of the cycle value and injection quality. The greater the injection pressure, the better its productivity. Fig. 2 demonstrates the increase in cycle value due to injection pressure.

As can be seen from the graph, with the injection pressure of p_f = 750 bar and opening time of t_o = 1 m s^{-1}, the cycle value released by the injector is V_f = 40 mm^3 $cycle^{-1}$. If the injection pressure is doubled, the cycle value doubles as well. Therefore, the same feed system can be used with different engines by regulating the necessary amount of fuel electronically.

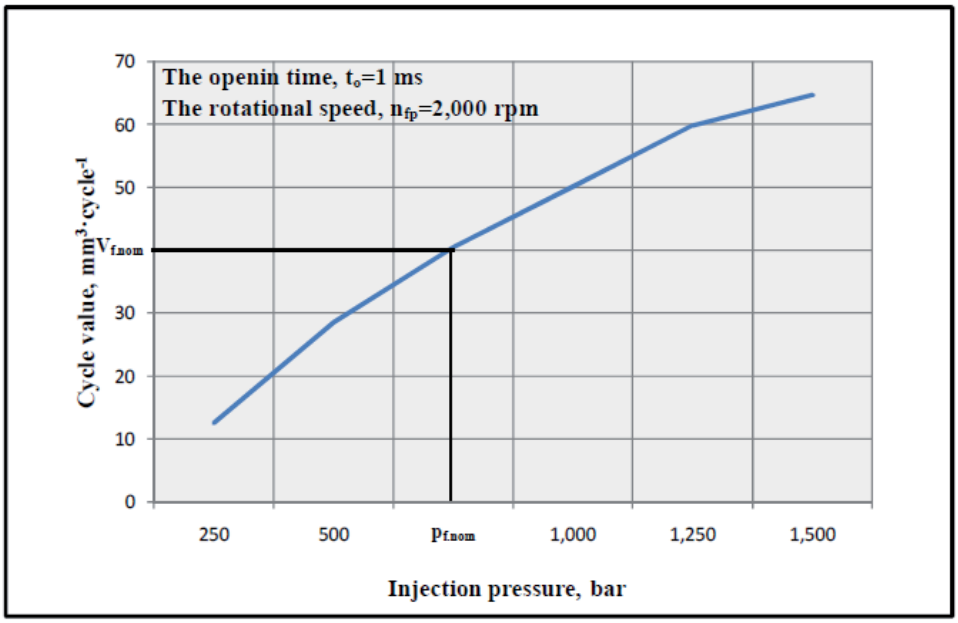

Fig. 2. The increase in the cycle value due to injection pressure.

The opening time of the injector

The productivity of the injector is regulated by changing its opening time. The opening time of the injector influences the extent of the cycle value, namely, the longer the opening time, the greater the cycle value. Fig. 3 describes the relation between the cycle value and the opening time of the injector.

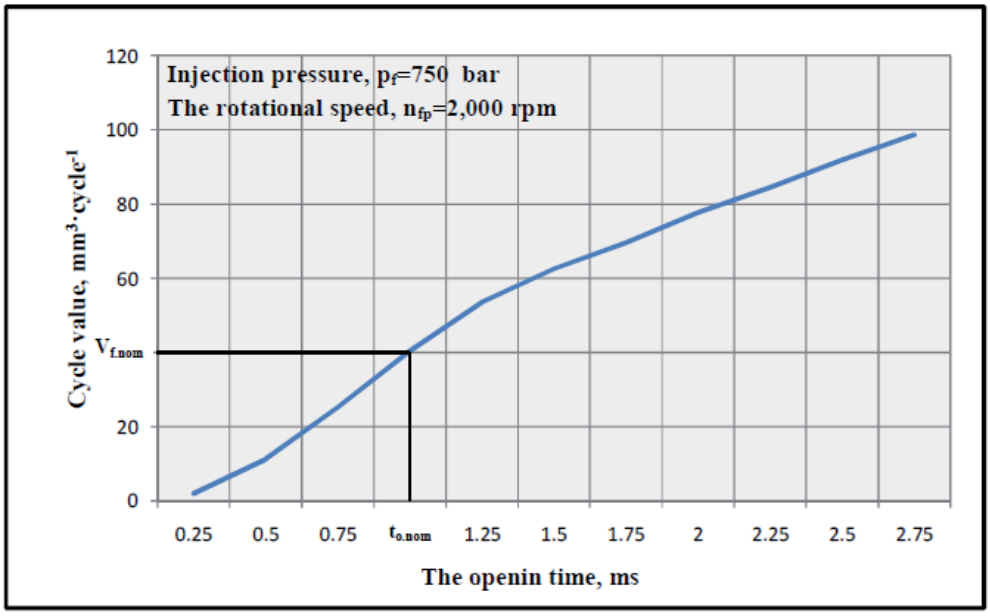

Fig. 3. The relation between cycle value and the opening time of the injector.

The rotational speed of the high-pressure pump

The rotational speed of the high-pressure pump influences the productivity of the pump and the maximum pressure in the feed system. Fig. 4 characterizes the dependence of system control characteristics on the rotational speed of the high-

pressure pump. As can be seen from the graph, in case of longer opening times of the injector, the pump is not able to keep the pressure in the system at a slower rotational speed which starts to fall. In this way, the boundary conditions of the feed system's work, or, in other words, the conditions allowing the use of the feed system at a certain rotational speed of the pump, are fixed.

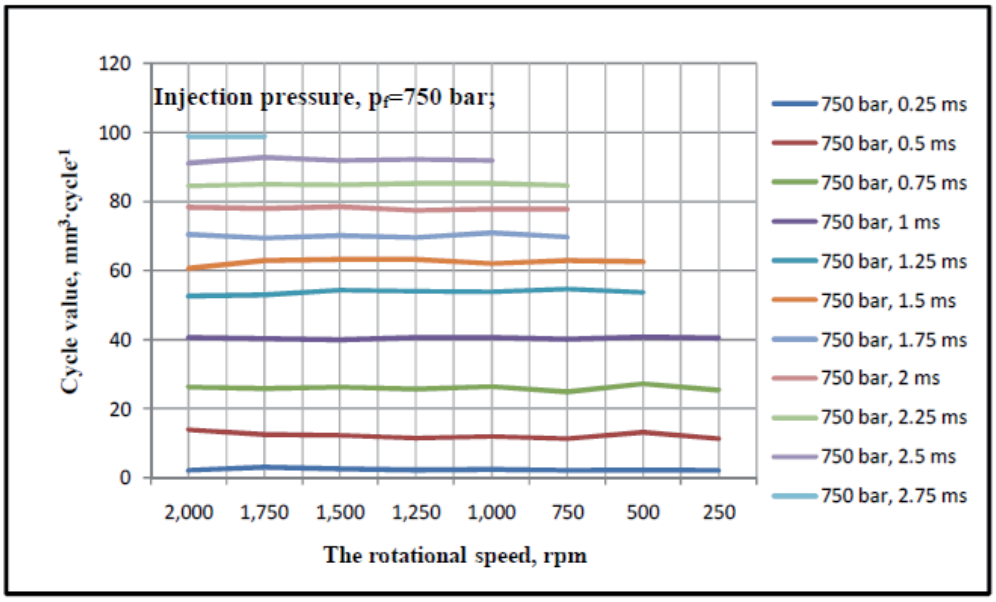

Fig. 4. The relation between cycle value and the rotational speed of the high-pressure pump.

As a part of the research, a three-dimensional characteristic has been designed (Fig. 5), taking into account the previously mentioned control parameters. It characterizes the cycle values of the feed systems.

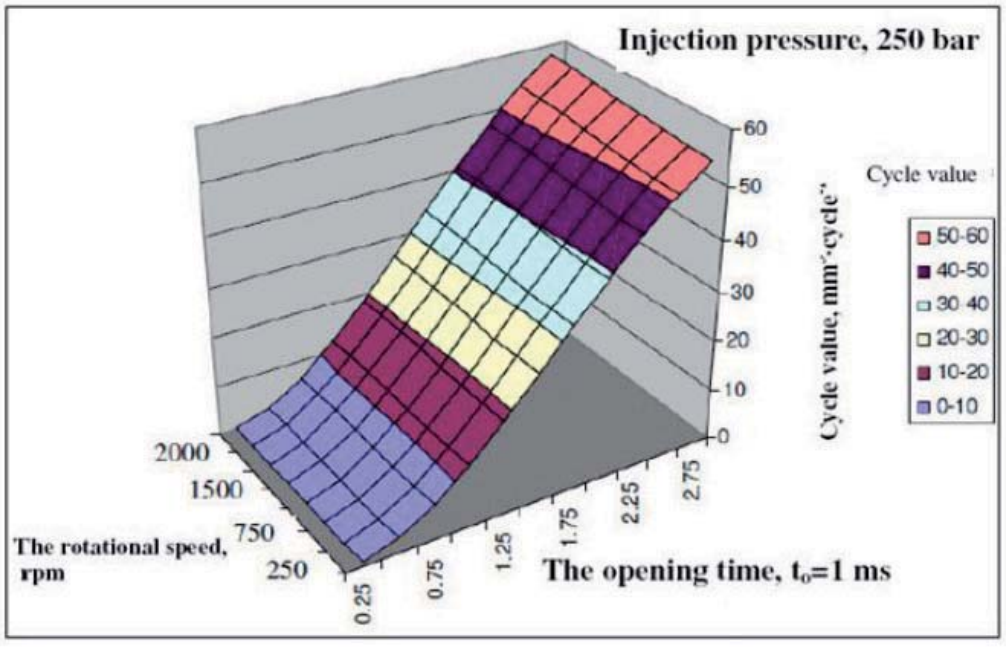

Fig. 5. The characteristic describing the common rail feed systems work.

DISCUSSION

Fig. 5 can be perceived as a test plan, which gives the cycle values of the feed system on the pressure 250 bar. When diagnosing the feed systems, the cycle values ought to be compared with the ones on the characteristic to decide whether the feed system is in good order. Comparative measurements such as these should be conducted on at least two pressure values, 250 bar and 1,000 bar. In the first case, the value would represent the ignition mode, and in the second one – the working mode of the engine. If the diagnostics reveals that the received cycle values of these particular pressures are smaller than permitted, the injector tip is clogged up or the backflow valve is worn-out, respectively.

The necessary characteristic and the corresponding database for diagnosing the common rail diesel feed system has been designed as a result of research which involved stand tests without the engine. The three-dimensional characteristic can be described with the following mathematical expression:

$$y(x_1, x_2) = \left| \begin{array}{l} 1{,}7718 - 4{,}57 \cdot 10^{-3} \cdot x_1 - 4{,}5902 \cdot x_2 + 3{,}66 \cdot 10^{-6} \cdot x_1^2 + 19{,}7507 \cdot x_2^2 - \\ - 1{,}04 \cdot 10^{-9} \cdot x_1^3 - 3{,}9913\, x_2^3 + 9{,}98 \cdot 10^{-4} \cdot x_1 \cdot x_2 \end{array} \right|$$

where $250 \leq x_1 \leq 2{,}000$ min^{-1} and $0{,}25 \leq x_2 \leq 2{,}75$ m s^{-1}.

CONCLUSION

The particular example deals with the common rail feed system diagnosing technology where the necessary cycle value test results are obtained through the mathematical expression on the pressure 250 bar. Characteristics such as these and the corresponding characterizing mathematical expressions can replace the test plans of the feed system manufacturers.

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