Reduction of the Common Rail fuel injectors repair costs

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Summary. This paper presents the analysis of costs reduction of Common Rail fuel injectors repairs. The task of fuel injectors is to spray and distribute fuel very precisely in combustion chamber. It has to be reliable to accomplish this task. The requirements for CI engines are low emission of toxic substances in fumes and low fuel consumption. In order to meet the rigorous standards, the Common Rail fuel injection system has been implemented, which increased fuel injection pressure and introduced multi – stage dosage. The cost of this 's repair is very high due to sophisticated spare parts and technology. This article describes how to lower the cost of modern fuel injectors repair.

Key words: Common Rail system, fuel injector, high pressure system, low pressure system, Diesel engine, engine diagnostics.

INTRODUCTION

Modern fuel injection systems with Common Rail high pressure hydraulic accumulator have replaced the conventional system with mechanical fuel injectors [9, 10]. The main reason for this were the environmental standards about toxic substances in fumes. Fuel injectors are located in the engine head directly in combustion chamber. The pressures and temperatures there are very high so the injectors are susceptible to faster run down. The main tasks of CI – engines fuel injectors - are to distribute and spray appropriate fuel dosage in combustion chamber. In the common rail fuel injection systems, the engine controller and fuel injector are responsible for the quantity of injected fuel. Injector malfunctions start with changes in the volume of injection doses and return doses, called the overflow volumes [2, 13]. The overflow volume is the discharge of injectors working fluid and its values at the full load should not exceed 40 mm^3/h (needle travel lift). If return dosage exceeds this value, precision vapour or inner sealer starts to run down. Fuel injector repair process is very expensive and not all can be repaired. The best way of

using the modern CI – engines is preventing the injection systems from damaging. It is very important to teach new CI – engines users how to operate Common Rail system. It very often occurs that fuel injectors damages are connected with another sub – assembly of the engine (for example solid particle filter). High pressure pump produces metal filings. This is normal and it is a result of it construction [16, 17]. There are many friction elements. Many users do not realize this and exploit the engine till the first symptoms of damage. This is too late because all the system is so polluted that cleaning and repair is very expensive and sometimes not profitable. The article describes how to correctly exploit the modern injection system to avoid injectors expensive repair and, if injectors are damaged, how to reduce repair costs [15].

STRUCTURE AND OPERATION OF COMMON FUEL INJECTORS

Common Rail fuel injectors could be divided into repairable and non-repairable (Fig. 1.) [11, 12, 14]. The non-repairable ones are the injectors without original spare parts and repair technology. There is a possibility to repair them but without guarantee. The structure of Common Rail injectors has been described on the example of electromagnetic Bosch injector generation 1.0.

Common Rail fuel injector is assembled with steering valve, injection nozzle, washers, springs, electromagnetic coil, internal sealing, nut and main body [4]. Figure 2 presents a fuel injector disassembled into spare parts. The figure has been divided into three elements: A – atomizer part, B – steering valve part and C – main body. The most important sub – assemblies are the atomizer, the steering valve and precision vapour elements. As to technical conditions these parts depend on injection and return dosages [18, 19, 20]. A fuel injector works on the pressure difference between atomizer and steering valve parts. If the pressure in both the parts is the same, the injector does not work. When electromagnetic coil is controlled, the armature rises and the pressure in upper

part of injector decreases [7]. Then the needle in atomizer picks up and the injector starts working. If the current is turned off by the steering device in electromagnetic coil, the injector stops working. The armature and needle returns to the original position under the force of springs.
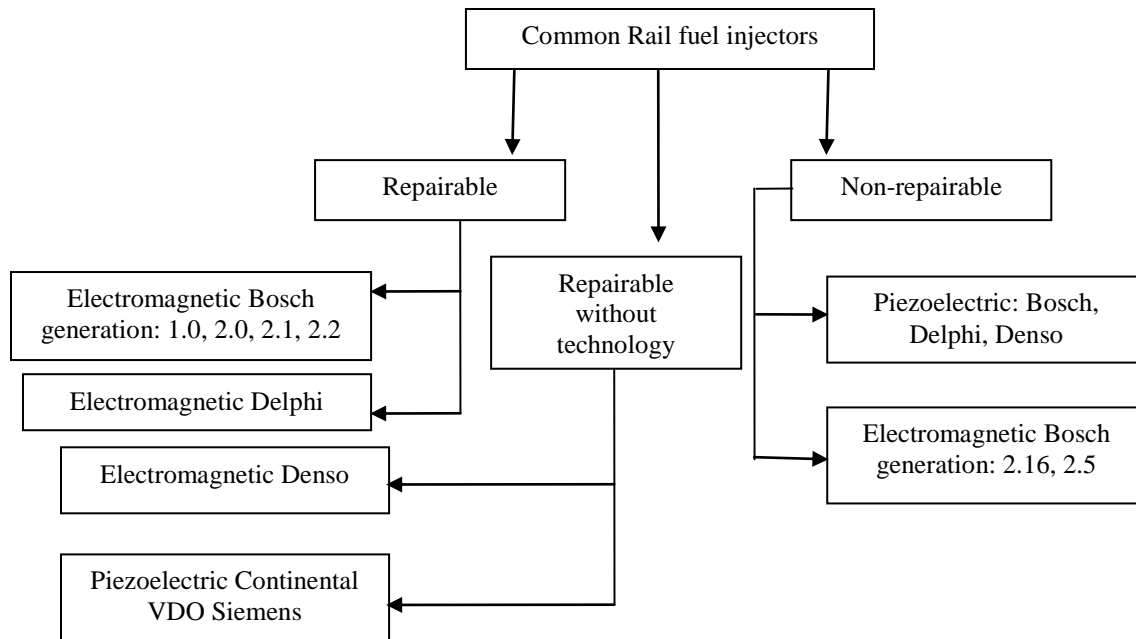

Fig. 2. The difference between Common Rail fuel injectors

Fig. 2. Common Rail fuel injector disassembled into spare parts: A – atomizer part, B – steering part, C – main body part

## THE ANALYSIS OF FUEL INJECTORS REPAIR COSTS

Fuel injector repair process depends on many factors. The most expensive are spare parts. If the injector does not work correctly, it has to be checked on the test bench [6]. After tests a decision is taken about further proceedings. When the return dosage is very high (more than 50–60 mm^3/H) the injector should be dismounted. Then the injector needs to be verified under a microscope. After verification a decision is made about repair costs. Table 1 shows the whole repair costs of electromagnetic coil Bosch fuel injector with the number 0445110083.

Table 1. Repair costs of the investigated fuel injector including spare parts

	Price [zł]
Repair	180
Steering valve	324,24
Atomizer	211,19
Nut	25
Valve sealer	12,79
Solenoid gasket	2,82
	Total: 755,96

Figures 3, 4, 5, 6, 7 present the elements which are responsible for the correct work of a fuel injector.
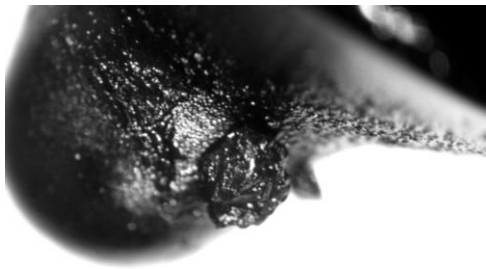
Fig. 3. Fuel injector polluted nozzle
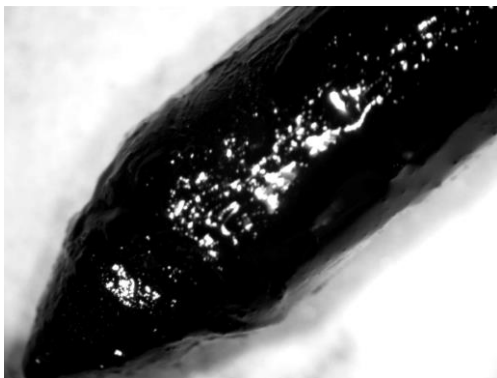
Fig. 4. Run down and polluted fuel injector needle

Fig. 5. Precision vapour element on the injector needle
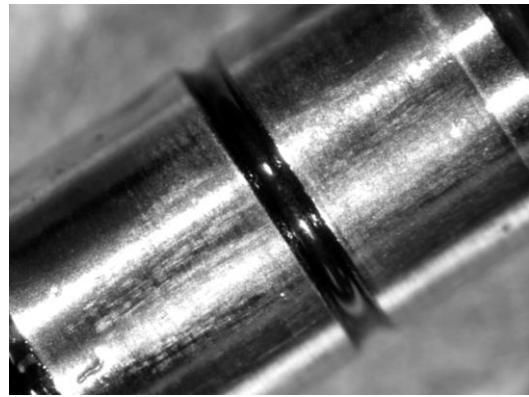
Fig. 6. Precision vapour element on the injector steering valve

Fig. 7. Fuel injector steering valve

Most of the fuel injectors' damages are caused by low quality fuel and too long intervals between fuel filter replacements. Injection systems should be clean at any time of service. The factors which damage injection systems are divided into external and internal. The external factors are pollution from the air and fuel and the internal ones are the products of chemical changes in fuel, metal filings from high pressure injection pump and peeled paint from metal fuel tank [8]. After the fuel injector's repair procedure the whole injection system should be cleaned and fuel pump checked using a microscope for metal filings. Metal filings come from the high pressure pump. This is a normal phenomenon that the pressure pump produces filings. It results from its work. Metal filings very slowly damage fuel injectors and so the whole system should be cleaned. Figure 8 presents the procedure of repairing fuel injectors. During a standard procedure the steering valve and injector nozzle with nut have been replaced. This is an expensive operation, therefore, following the procedure the whole system with fuel tank should be cleaned.
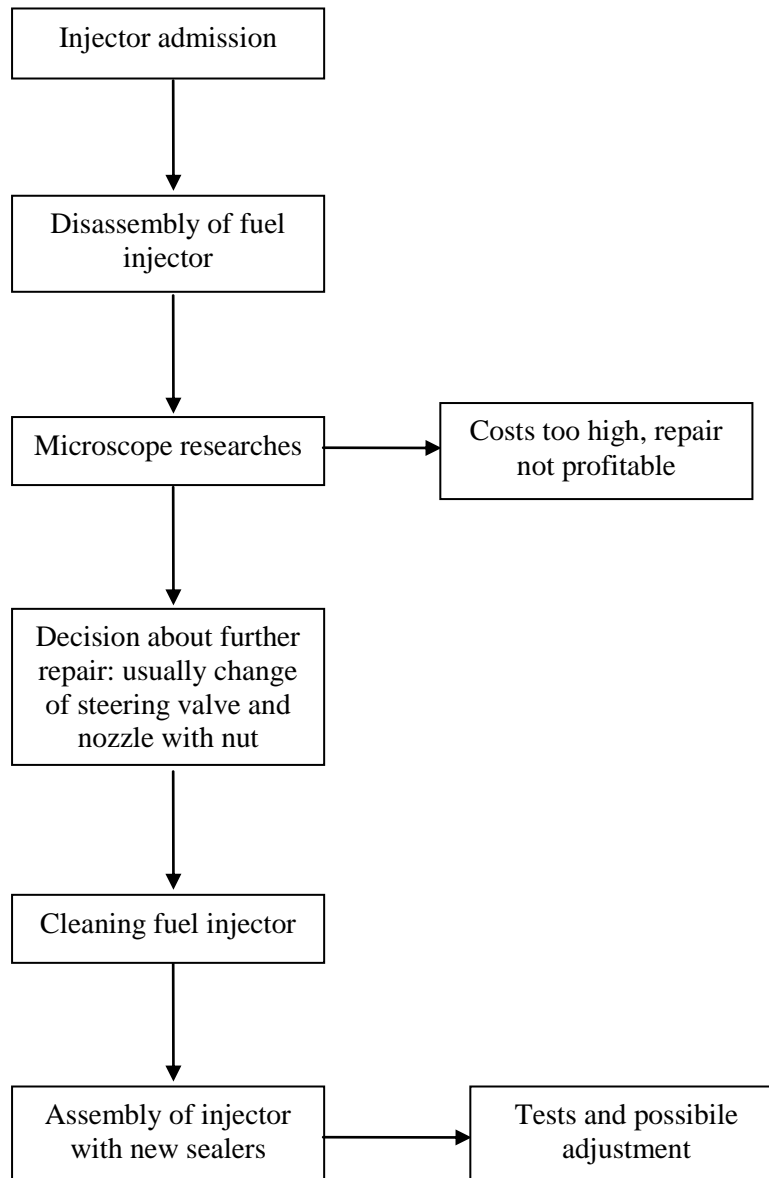
Fig. 8. Procedure of fuel injector's repair

POSSIBILITIES OF REDUCTION OF FUEL INJECTOR'S REPAIR COSTS

A test bench is necessary to examine injectors removed straight from the engine to reduce costs of repair [1]. The first test is very important. It could be observed how injector works before disassembly. Injection and return dosages are determined. Then the decision is taken. Very high return dosages in the whole injector's range of work suggest precision vapour damages. But if it occurs only at high pressure, it could be inner sealers leaking. By normal procedure the steering valve and nozzle would be changed, but when repair costs are reduced it can be only change of sealers. There is another way to repair precision vapour, by polishing with the use of special burnish and sponge. If the elements are not damaged, this method could work and it is very cheap. Then the injector is cleaned and provided with new sealers. The last steps are the adjustment of steering valve work range and test on the bench. If results of the test are correct, the injector has been repaired [5]. This method reduces costs because the assembly of fuel injector using parts does not demand cleaning the whole system and disassembly and cleaning the high pressure pump, which is very expensive. The system should be only precisely rinsed. With Delphi or Denso injectors this procedure is shorter because the repair technology is not very complicated.

Figure 9 presents the repair procedure of a fuel injector at a reduced cost. Figure 10 shows graphic dosages after fuel injector researches. Table 2 presents injector research protocol.
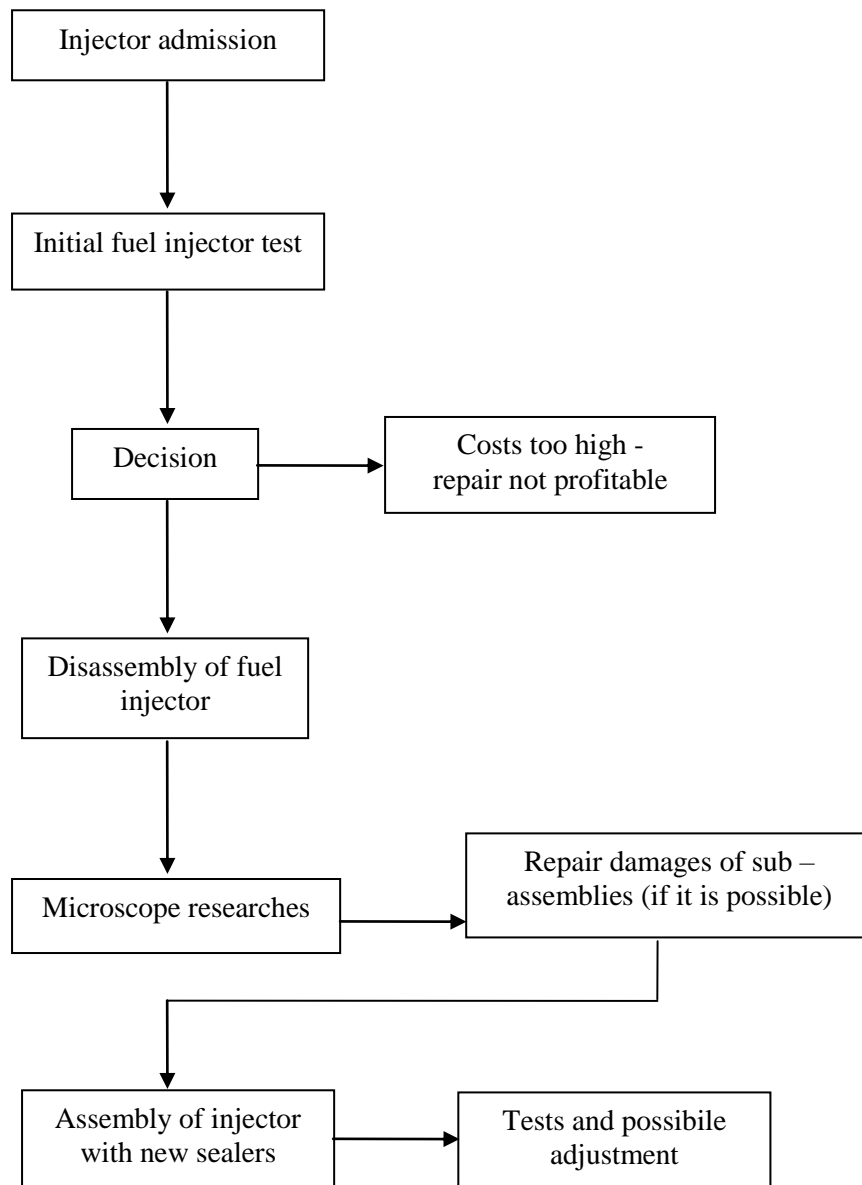
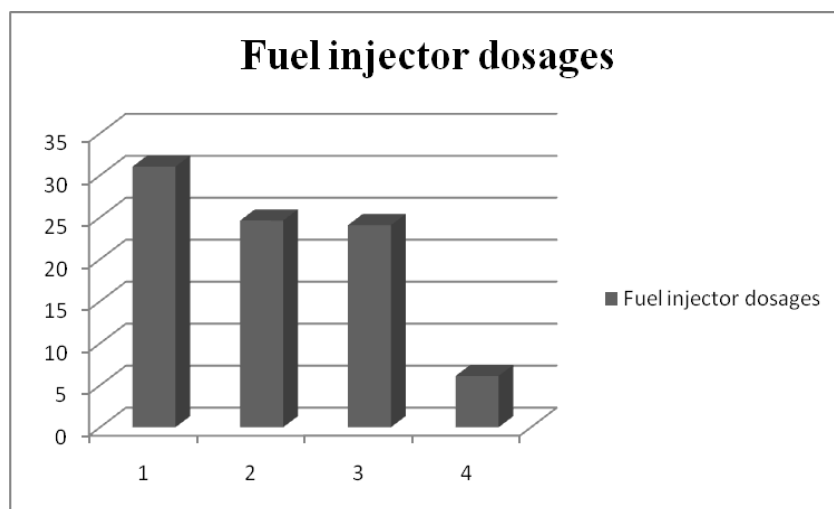**Fig. 9.** Procedure of fuel injector's repair at a reduced costs

Fig. 10. Graphic description of the researched fuel injector dosages

Tab. 2. Repair protocol after injector researches

LKT 170 MPa, 120s	0 – 40 [g/min] R	7,67
eRLC	0,2 – 0,6 Ω	0,4
	60 – 110 μH	89
IVM1	10 – 80 [mg/STRK]	31,03
	0 – 32 R [mg/STRK]	29,76
IVM2	5 – 60 [mg/STRK]	24,63
IVM3	10 – 70 [mg/STRK]	24,06
IVM4	1 – 25 [mg/STRK]	6,11

CONCLUSIONS

The analysis of undertaken procedure showed that it is possible to reduce repair costs of fuel injectors. During fuel injectors repair the most important is appropriate diagnostic. It is not necessary to change the steering valve and injector nozzle. These parts are very expensive and increase repair costs. Fuel injectors work incorrectly due to pollution. There are many reasons for this: fuel is polluted, there are many metal filings in the high pressure system and dampness in the air. These factors damage fuel injectors. The most important is to maintain the injection system clean. There is a possibility to mend the injection nozzle and steering valve if damages are not large. The injection nozzle could be carefully cleaned and polished. The same procedure could be performed with precision vapour on the steering piston. If it is carefully polished, damages disappear. The steering valve is ground by a special bench grinder. In most elements these method works correctly. The repair price falls by 50 – 60 % than buying new parts. Very important is the correct injector adjustment according to the manufacturer's parameters. There is a possibility to mend other manufacturer's injectors Continental and Denso. There is no original technology and no spare parts, but many companies have prepared their own technologies and produce parts which are not original. This technology is not so effective, but it works and is not as expensive as the purchase of a new injector.

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