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Technical diagnostics fuel injection pump condition used of fuel with hydrogen containing admixtures

Diagnostyka stanu technicznego pompy wtryskowej pracującej na wzbogaconym dodatkami zawierającymi wodór paliwie

ABSTRACT

Article describes high pressure fuel pump CP1H Common Rail system which worked on fuel with hydrogen containing admixtures. It was presented how can high pressure injection pump diagnose. Research object was dismantled on spare parts and checked under microscope. Paper discusses construction and mechanism of action researched fuel pump. During the researches has been presented crucial elements of pump. It has been described the areas where are produced metal fillings in pressure pump and discussed the methods of prevents them.

Keywords: *high pressure pump, fuel dosages, Common Rail system, fuel injector, CI – engine*

STRESZCZENIE

W artykule przedstawiono pompę wtryskową układu Common Rail typu CP1H, która pracowała na zanieczyszczonym dodatkami zawierającymi wodór paliwie. Pokazano, w jaki sposób można zdiagnozować pompę wtryskową, rozmontowaną na części składowe oraz poddano badaniom mikroskopowym. W referacie została omówiona budowa badanej pompy oraz zasada działania. Podczas badań zostały przedstawione najbardziej newralgiczne elementy pompy. Przedstawiono również miejsca pompy, w których tworzą się niebezpieczne metaliczne opiłki oraz omówiono metody im zapobiegania.

Słowa kluczowe: *pompa wysokiego ciśnienia, dawka paliwa, układ Common Rail, wtryskiwacz paliwa, silnik ZS*

1. Introduction

Common Rail system is at present the most popular injection solution. Because of work condition whole system is very important right fuel quality. There is necessary to keep whole injection system in cleanness or in controlled [1-7]. Fuel pollution is frequent reason of fuel injectors or high pressure pump damages is spite of using special fuel filters. Main source of fuel pollution are: atmosphere factors, friction, corrosion processes and chemical reaction. The most frequent reason damages injection system aresolid bodies (metal filings, Si, Fe and Al oxides, HC), H_2O and corrosion products [8]. Figure 1 presents fuel from high pressure rail polluted with metal fillings.

Theoretically there is no possibility to get water to fuel during refining because of right production and cleaning technology. Water doesn't dissolve in the fuel only makes suspension. The main reason of getting water to engine fuel are transportation and distribution, not appropriate storing and condensation water vapour especially in fuel tanks. Water in engine fuel causes decrease fuel energetic value, corrosion in whole system, greasiness decrease, worst fuel pumping and filter what damages precision elements in fuel injectors and high pressure pumps [9].

2. Description of modern fuel pump

Main task of fuel injection pump is generate high pressure in system in all work engine range. Common Rail system pump generates pressure constantly independent of injection process. There is three section piston radius high pressure pump in cars and as well an in – line high pressure pump with two sections in trucks. High pressure pump is powered from engine through the clutch, flywheels, chain or fan belt. Rotation speed of fuel pump changes with rotation engine speed [10].

High pressure Common Rail system fuel pump is constructed with main body where is on the bearing high pressure section propulsion shaft [6]. Placed on the shaft eccentric makes high pressure section to sliding motion. The move of power from shaft to section piston occurs roller, slide ring and mounted under piston plate. Rotational speed of fuel pump depends on engines speed. Propulsion correlation between pressure pump and engine should be match so that quantity pump fuel were not so high but to cover fuel demand by full engine load [8].

Fuel is led to high pressure section and there is accumulated. Section are moved by pump shaft with help eccentric. High pressure is controlled by high or low pressure valve. It depends on sort Common Rail system. There are two ways of Common Rail steering (high or low pressure). The first systems were controlled only by high pressure valve. Fuel surfeit were transferred to fuel tank. This solution has fault because it was wasted to much energy to accumulate fuel and warm fuel were transferred back to tank. Therefore it was used low pressure valve (fuel dispenser). Main task

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of dispenser was transfer that much fuel to high pressure pump how much it was need in given moment. This solution reduced waste of energy [10].

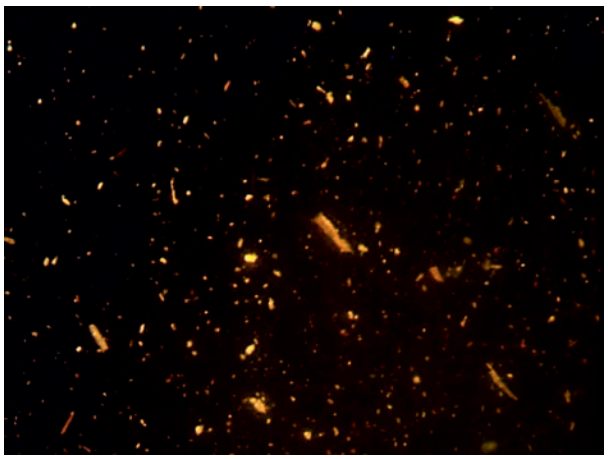

Fig. 1. Pollute fuel with metal fillings from high pressure system rail
Rys. 1. Zanieczyszczone paliwo metalicznymi opiłkami z układu wysokiego ciśnienia

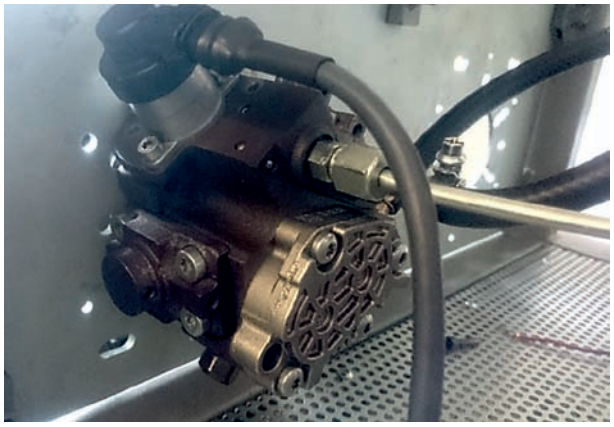

Fig. 2. High pressure Bosch CP1H fuel pump mounted on STPiW 3 test bench
Rys. 2. Wysokociśnieniowa pompa wtryskowa Bosch typ CP1H zamontowana na stanowisku probierczym

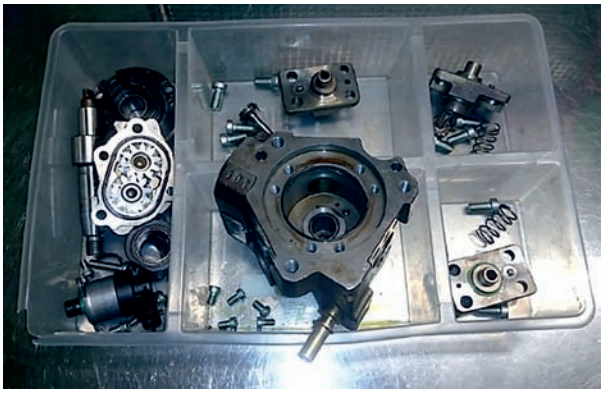

Fig. 3. High pressure Bosch CP1H fuel pump disassemble on spare parts
Rys. 3. Wysokociśnieniowa pompa wtryskowa Bosch typ CP1H zdemontowana na element składowe

There are three types of CP1 high pressure pumps: CP1S (standard), CP1K (compact) and CP1H (reinforced). Piston radial high pressure fuel pump CP1H is reinforced version of CP1 family pumps. It is adapted to higher pressures (160 MPa) because of increase main body strength, changes valve units and reinforces pump propulsion [7]. It was improved energy efficiency through adjustment fuel dosage to section by dispenser valve. Figure 1 presents CP1H high pressure pump [5]

3. Influence the fuel quality on high pressure pump work

The first sign of defect high pressure pump is problem with supporting system pressure in maximum load dosages range [4]. There is perceptible drop engine power in that range. The reason of this is to low system pressure because fuel pump is not able to generate it. The reason of this is defect the high pressure sections. Figure 4 presents high pressure pump divides on two modules: A – propulsion, B – high pressure section. The propulsion module contains propulsion shaft with bearing and eccentricity, efficiency valve and initial fuel pump. High pressure module is responsible for bank up fuel. It contains head with piston, bearing and valve. Figures 5 – 8 present elements depend on high pressure pump parameters. Elements were observed under microscope. There is noticeable considerable their usage.

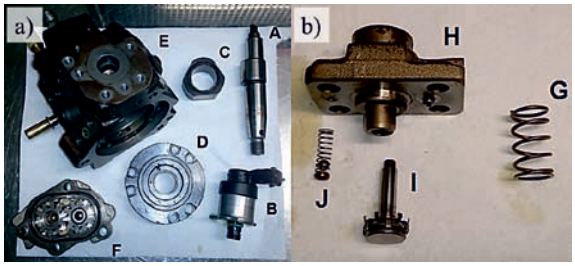

Fig. 4. A – main body with steering and propulsion section, B – high pressure section: A – propulsion shaft, B – efficiency valve, C – eccentricity, D – main bearing, E - main body, F – initial fuel pump, G – piston in high pressure spring, H – high pressure section head, I – high pressure section piston, J – high pressure section valve
Rys. 4. A – korpus pompy wtryskowej z regulatorem wydatku oraz sekcją napędową, B – sekcja wysokiego ciśnienia: A – wałek napędowy, B – zawór wydatku, C – łożysko ślizgowe napędzające sekcje wysokiego ciśnienia, D – pierścień z łożyskiem głównym, E – korpus pompy wtryskowej, F – pompka przetłaczająca, G – sprężyna w sekcji wysokiego ciśnienia, H – głowiczka sekcji wysokiego ciśnienia, I – tłoczek sekcji wysokiego ciśnienia, J – zaworek wysokiego ciśnienia

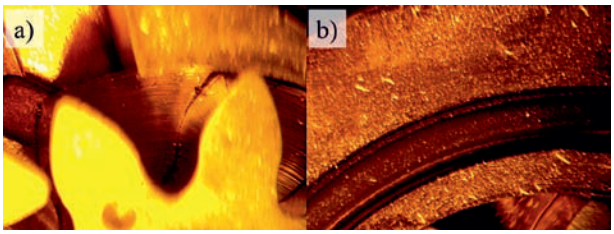

Fig. 5. A – low pressure pump inside, B – polluted area of low pressure pump
Rys. 5. A – wnętrze pompki wysokiego ciśnienia, B – zanieczyszczona powierzchnia pompki przetłaczającej

Figures 7 - 8 present work diagrams of researched high pressure pump. Figure 7 shows the magnitude of fuel

efficiency. There is noticeable that faulty pump has lower fuel efficiency but figures 8 presents that in spite of lower fuel efficiency this pump has higher functionality. During high pressure researches the most important factor is fuel efficiency. Only when fuel efficiency parameters are correctly it is possible to counting fuel pump functionality. There is possibility to calculate practically functionality of fuel pump. The efficiency of correct working pump is 573 mm^3 (1000 rotation of pump) by system pressure 0 MPa. Efficient fuel pump has 523 mm^3 by 100 MPa system pressure. Pump functionality is 91%. Faulty pump has by 100 MPa 150 mm^3 fuel efficiency by 100 MPa. Its theoretical functionality 93% but practical only 26%. It means that high pressure pump is damage.

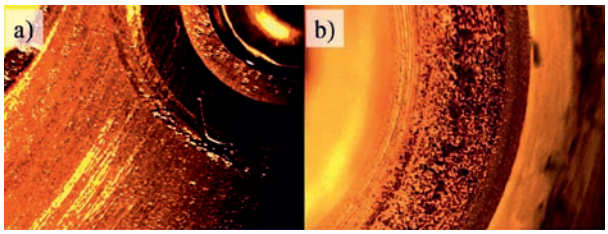

Fig. 6. A, B – high pressure section head
Rys. 6. A, B – głowiczka sekcji wysokiego ciśnienia

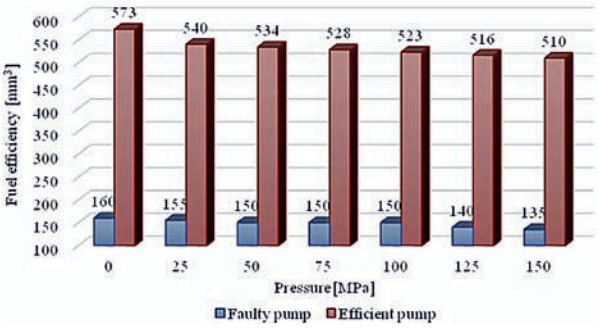

Fig. 7. High pressure pump fuel efficiency [mm^3] diagram
Rys. 7. Wydatek pompy wysokiego ciśnienia [mm^3]

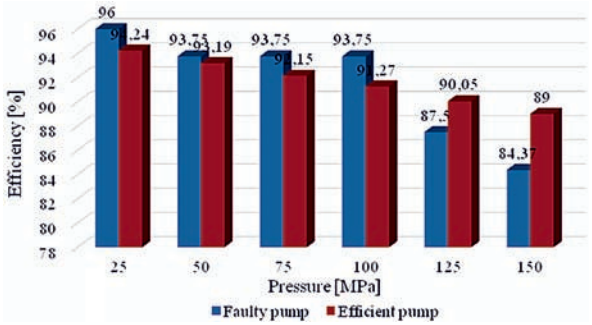

Fig. 8. High pressure pump efficiency [%] diagram
Rys. 8. Sprawność pompy wysokiego ciśnienia [%]

4. Conclusion

The main work parameter of high pressure pump are fuel efficiencies and practical functionality. High pressure pump is functional in huge range of fuel pressure from 25 to 160 MPa. The elements depend on make pressure are sections. Technical conditions of precision elements sections pistons influence on efficiency magnitude. Bad quality fuel damages friction areas in low pressure initial fuel pump. There are produce metal filing between spinning pump elements and pump area. Metal fillings are very dangerous. These damage not only high pressure elements but fuel pump propulsion shaft, main bearing, eccentricity and sealers. Metal filings move with fuel in high pressure system to injectors damaging them. There is in fuel water in spite of air humidity. It causes local corrosion in various high pressure pump elements especially on precision elements (fig. 7). Practical high pressure pump functionality is use full method of diagnosing. It is calculated from efficient pump fuel efficiency without system pressure and research pump fuel efficiency by 100 MPa system pressure. Fuel rotation speed is 1000 turns per minute. So calculates efficient determines usage degree of fuel pump. The range of correctly working high pressure pump efficient is 80 – 100%. Researched pump has of efficiency higher than 80% but fuel efficiency were low. It means that high pressure section were uses similar to turbines elements [11, 12].

5. References/Literatura

[1] Stepniak D., Surwilo J., Skarpetowski B. Badania eksperymentalne silnika spalinowego zasilanego paliwem płynnym typu diesel wzbogaconym wodorem // Mechanik. – 2016. – N 7. – S. 827-829.
[2] Balyts'kyi O.I., Abramek K.F. , Shtoeck T., Osipowicz T. Evaluation of the losses of hydrogen-containing gases in the process of wear of pistons of an internal-combustion engine // Materials Science. - 2017. – Vol.53, N 2. – P. 289 -294.
[3] Ambrozik A., Ambrozik T., Łagowski P.: Fuel impact on emissions of harmful components of the exhaust gas from the ci engine during cold start up. Eksploatacja i Niezawodnosc – maintenance and realiability, 2015, 17(1), 95 – 99.
[4] Günther H.: Common Rail – Systeme in der Werkstattpraxis. Technik, Prüfung, Diagnose. Bad Wörihofen. Krafthand Verlag Walter Schultz GmbH, 2012.
[5] Osipowicz T., Abramek K. F., Stoeck T.: Testing of modern common rail fuel injectors. Combustion Engines. 2015, 162(3), 688-694.
[6] Osipowicz T.: Diagnosing common rail fuel injectors using fuel micro – doses. TEKA. Commission of Motorization and Energetics in Agriculture. 2015, 15(1), 61 – 64.
[7] Osipowicz T.: Analysis of the costs and cost – efficiency of regeneration of modern fuel injection systems in ci engines. Econtechmod. An international quarterly journal. 2016, 5(2), 45 – 50.
[8] Osipowicz T., Lisowski M.: The influence of corrosion phenomena on operational parameters of modern fuel injectors CI – engines. Combustion Engines. 2017, 171(4), 17 – 23.
[9] Olszewski W.: Paliwa i materiały smarowe. Badania i pomiary laboratoryjne podstawowych własności fizykochemicznych. Politechnika Radomska Wydawnictwo, 2009.
[10] Zasobnikowe układy wtryskowe Common Rail. Informator techniczny sterowanie silników ZS.Robert Bosch GmbH. WKiŁ,2005, 2009.
[11] Balyts'kyi O.I., Chmiel J., Krause P., Niekrasz J., Maciag M. The role of hydrogen in cavitation fracture of C45 steel in lubricants // Materials Science.– 2009, Vol. 45, N 5, p. 651-654.
[12] Balitskii A.I., Ivaskevich L.M., Mochulskyi V.M. Temperature dependences of age-hardening austenitic steels mechanical properties in gaseous hydrogen // 12th International Conference on Fracture 2009, ICF-12,Vol. 8, 2009, p. 5786-5792. Ottawa, ON; Canada; 12 July 2009 through 17 July 2009; Code 93954.