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EFFECT OF ANTI-CORROSION TREATMENT APPLIED TO DIESEL INJECTOR NOZZLES

BY

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Abstract. To comply with latest standards regarding emission regulations, diesel technology focuses on how to obtain a very good spray quality, by identifying the appropriate geometry for injector nozzles, the optimum size of injection holes and the best hydraulic parameters for efficient fuel spray evolution and dispersion. In practice, injectors are often subject to operating problems, mainly because inside the diesel fuel injector nozzle, accumulation of deposits might occur. To control the phenomenon, the scientific literature proposes anti-corrosion treatment. The present paper studies the effect of applying anti-corrosion treatment to a new diesel injector. The investigation method consists in using a Scanning Electron Microscope next to EDX Spectrometry. The results indicate that chemical treatment can lead to new deposits that also contaminate the nozzles. Concluding, the anticorrosion treatment must include monitoring and control of the process and as a final step, a method to remove detergent deposits.

Keywords: fuel injection; fuel spray; injector nozzle; deposit formation; anti-corrosion treatment.

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1. Introduction

In automotive industry, diesel engines are used especially in heavy-duty transportation. They have some advantages comparing to gasoline engines: good efficiency due to high compression rate, generation of high torque output in the low-speed range, very good reliability. The initial main disadvantage of diesel combustion was the generation of high rates of nitrogen oxides (NOx) emissions.

Current developments in fuels and emissions regulations are resulting in increasingly severe operating conditions of the injection system of auto vehicles. Lately, implementation of technological progress reduced NOx emissions of diesel engines from 970 NOx/km in 1992, to 80 NOx/km in 2014 (DieselInformationHub, 2021). Nowadays, new diesel passenger vehicles have NOx absorbers and Selective Catalysts Reductions (SCR), to comply with Euro 6 emission standard. The new approach opens the way to the development of this industry, which includes innovation regarding hybrid diesel engines.

The key diesel technology to improve efficiency focuses on how to obtain a very good spray quality (Pos *et al*., 2017). Intensive research work was performed to find the best geometry for injector nozzles, to establish the optimum size of injection holes and to identify the appropriate hydraulic parameters for efficient fuel spray evolution and dispersion (Pielecha *et al*., 2018).

Although research results on the topic are significant, in practice new and used injectors may operate in an unexpected way. Observations revealed that one cause is corrosion of the diesel fuel injector nozzle. To control the phenomenon, the scientific literature proposes to use cleaning by special detergents or adding of organic substances to the fuel.

The present paper studies the effect of cleaning a new diesel injector by an anti-corrosion solution. The study performed by using a Scanning Electron Microscope indicates that the immersion of new diesel injector nozzles in an organic detergent, might generate new kind of deposits that reverse the efficiency of the method.

2. Experimental Investigation

In an article published in SAE International Journal of Engines, Malbec *et al*., performed experimental investigation on the nozzle hole diameter, the rate of injection, the liquid and vapor penetrations, the auto-ignition delay and the lift-off length tested at different values of temperature, oxygen concentration and density (Malbec *et al*., 2013). The sources of variations of results for several injectors tested in similar conditions are analysed and recommendations regarding the importance of deep study on the aspect of the nozzle are provided.

Advanced investigation technics were performed by Algayyim S. J. M., Wandel A. and Yusaf T. to study the impact of injector hole diameter on macroscopic spray characteristics of butanol-diesel blends (Algayyim *et al.*, 2018). A Bosh (0.18 mm diameter) and a Delphi (0.198 mm diameter) injector were used in this study. The conclusions point out that controlling injection characteristics in compression ignition engines could lead to more efficient mixing between the injected fuel and spray propagation.

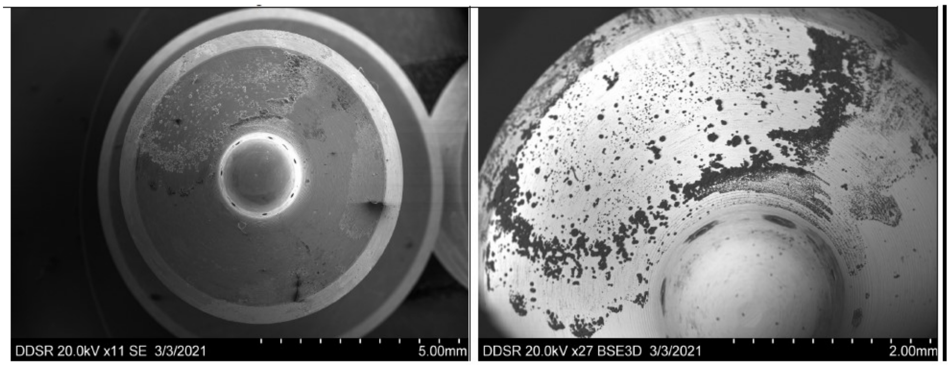

Fig. 1 – Nozzle after anti-corrosion treatment.

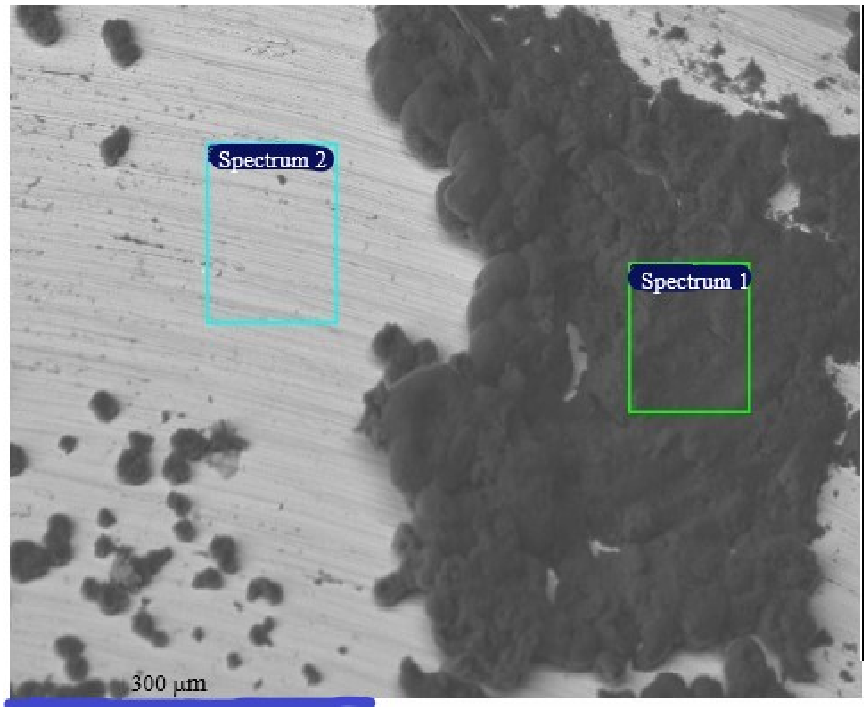

Fig. 2 – Nozzle surface after anti-corrosion treatment.

Both new and already used nozzles were in the focus of the research developed by Caprotti (Caprotti *et al*., 1993). Several factors, including climate factors were found to be responsible for corrosion of the nozzle, but also normal aging process can lead to similar consequences. The main effect of formation of deposits, especially in the inner region of the nozzle holes is the reduction of the fluid flow rates of the fuel injected into the combustion chamber. In this case, the combustion becomes less efficient, which leads to the increase of fuel consumption and diminishes the power of the engine.

A method to overcome deposition problems is to immerse the injector into an anti-corrosion solution. To study the effects of the procedure, the investigation method applied in this paper relies on using a Scanning Electron Microscope (SEM). The main advantage of SEM over conventional optic devices is the increased magnification possibilities using electrons instead of light. Afterwards, the electrons released by the interaction on a certain region, determine the amplitude of the signal using a specific detector. In the present paper, the nature of deposits was studied by EDX Spectrometry and comparison to the clean surface area was done.

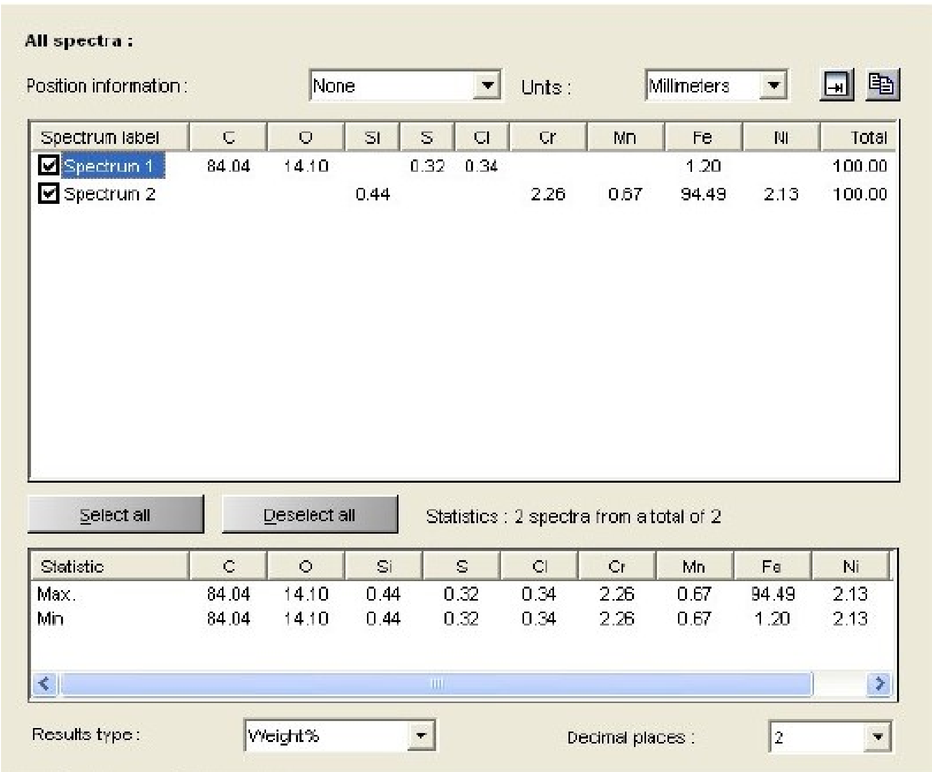

Fig. 3 – Spectrometry results.

In Fig. 1, a nozzle that was immersed 5 hours in an anti-corrosion solution is presented. The scale presented on the bottom of each photo indicates, the accuracy of the image. A closer look on the nozzle is presented in Fig. 2, that represents less than 1 mm^2, surface area, as it can be deduced from the scale positioned at the bottom of the figure. Two regions were analysed by spectrometry. The results are presented in the table from Fig. 3 and in Fig. 4 and 5. In Fig. 3, the notations are: C-carbon, O-oxygen, Si- silicon, S- sulphur, Cl-chlorine, Cr-chromium, Mn- manganese, Fe- iron, Ni- nickel. The results indicate that the surface area of the nozzle was contaminated by the anti-corrosion solution.

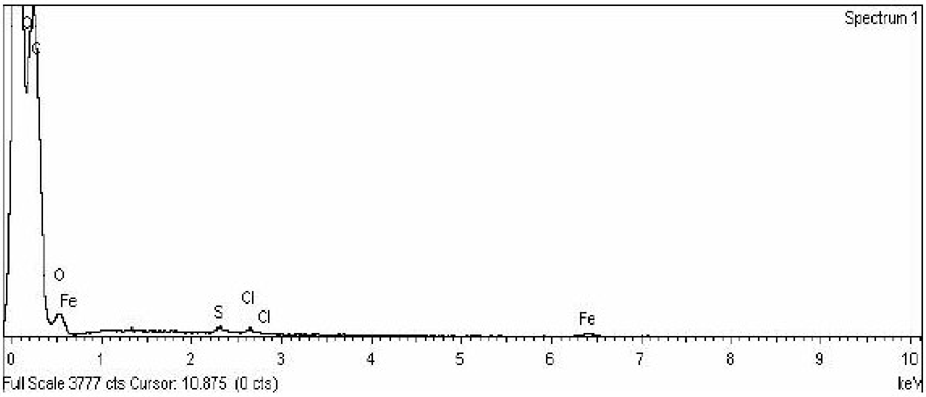

Fig. 4 – Results of spectrometry regarding zone 1.

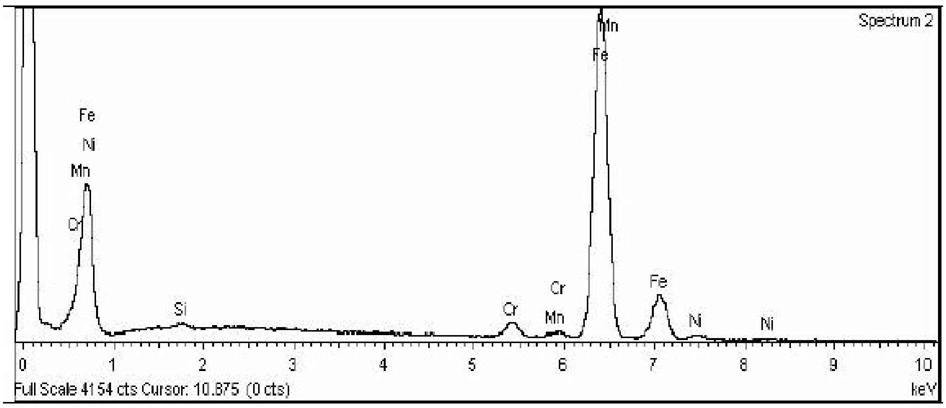

Fig. 5 – Results of spectrometry regarding zone 2.

3. Conclusions

Due to corrosion phenomena, diesel injector nozzles are subject to deposition of materials that can obstruct good dispersion of the spray in the combustion chamber of the engine. One method to overcome this problem is application of anticorrosion treatment. Based on investigation performed by SEM and spectrometry technologies, the results presented in the present paper point out that such chemical methodology can lead to new deposits that also contaminate the nozzles. Concluding, the anticorrosion treatment must include monitoring and control of the process and as a final step, a method to remove detergent deposits.

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EFECTUL TRATAMENTULUI ANTICOROZIV APLICAT
INJECTOARELOR DIESEL

(Rezumat)

În vederea alinierii la noile standarde privind emisiile de gaze, noile tehnologii de fabricare a injectoarelor diesel urmăresc obținerea unui spray de calitate, prin identificarea geometriei optime a diuzei, a dimensiunilor orificiilor de injecție și a parametrilor hidraulici aferenți. Practica de exploatare a reliefat faptul că în injectoare pot apare depozite de material provocate de coroziune, depozite ce înrăutățesc procesul de combustie. Literatura de specialitate propune utilizarea tratamentelor anticorozive pentru a rezolva problema. În acest articol este studiat efectul aplicării de tratamente

anticorozive, unui injector nou. Metoda de investigare utilizează un microscop electronic și analiză spectrală. Rezultatele indică apariția de depozite de soluții anticorozive, post tratament. În concluzie, metodologia de aplicare a tratamentului anticoroziv injectoarelor diesel implică o monitorizare atentă și o etapă finală de îndepărtare a depunerilor de substanță anticorozivă.