ENGINE CARBON CLEANING AS THE WAY OF ENVIRONMENTAL PROTECTION

Dragan Adamović[1], Mirjana Vojinović Miloradov[1], Vojin Močević[2], Jelena Radonić[1], Maja Turk Sekulić[1], Savka Adamović[3], Sabolč Pap[1,4]

[1] Faculty of Technical Sciences, Department of Environmental Engineering and Occupational Safety and Health, University of Novi Sad, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia
[2]Hybrid Power System LLC, Zmaj Jovina 26, 21000, Novi Sad, Serbia
[3]Faculty of Technical Sciences, Department of Graphic Engineering and Design, University of Novi Sad, Trg Dositeja Obradovića 6, 21000 Novi Sad, Serbia
[4]Environmental Research Institute, North Highland College, University of the Highlands and Islands, Castle Street, Thurso, Scotland, KW14 7JD, UK
e-mail: draganadamovic@uns.ac.rs

Abstract
The paper points out the negative impact of air pollution on human health and the environment, caused by the emission of exhaust gases of motor vehicles. According to recent estimations published by the European Environment Agency, estimated traffic in Europe would be contributing more than 64% to air pollution (NOx, NO2, PM). Combustion chamber deposits are listed as one of the dominant causes of deterioration of the emission characteristics of motor vehicles. The primary reason for carbon deposits forming is a complex reaction that occurs between components, fuel, blow-by gas, and lubricant oil. Carbon deposit also has a negative impact on the heat transfer process in the combustion chamber, emissions, combustion and maintenance costs. The paper points out the possibility and importance of removing carbon deposits using H2E engine carbon cleaning (H2E ECC) system. The results of testing the emission characteristics of the engines on four randomly selected vehicles Euro 3 and Euro 4 classes before and after the treatment of vehicles using the H2E ECC indicate that the concentration levels of the toxic components in the mixture of exhaust gases are reduced. In this way, the emission characteristics of the treated vehicles have been improved.

Introduction
Ambient air pollution has a direct influence on human health. Air pollution alone poses the single most significant environmental risk factor in Europe today, responsible for more than 400,000 premature deaths [1]. Due to adverse health effects, air pollution has been marked as the top stressor regarding the environmental burden of disease [2]. Among various shared sources of air pollution in an urban setting, road traffic is considered to be the main contributor to pollution. According to the recent assessments published by the European Environment Agency, road traffic is estimated to contribute more than 64% to air pollution (NOx, NO_2, PM) in Europe [3].
The primary pollutants emitted from cars and vehicles are particulate matters (PM), carbon monoxide (CO), hydrocarbon (HC), nitrogen oxides (NOx), lead (Pb), sulfur oxides (SOx) etc. not only are these pollutants harmful to human health, nitrogen oxides and hydrocarbons are also sources of the formation of photochemical smog and ozone [4]. In Europe, the contribution of vehicle emissions to NOx and CO levels amounted to 40% and 26% in 2011, respectively [5]. Traffic-related emissions have become one of the significant sources of air pollution, in Chinese cities such as Beijing, Guangzhou, and Shanghai [6]. Therefore, the urban traffic problem, which encompasses exhaust emissions, congestion, and level of safety,

has become more serious. Due to their sizeable adverse impact to the environment and human health, vehicle pollutants emission reduction management has been an important topic in recent transport studies.

Regarding the environmental pollution, improving IC engine efficiency and emissions has become an important issue nowadays. Therefore, reducing vehicle pollutant emissions to improve the public's living environmental quality is a problem that government policies must deal with immediately; it is also an objective that industries and academics are working towards.

Carbon deposits

Carbon deposits (CD) can be defined as heterogeneous mixtures consisting of carbon residue, oxygenated resinous organic material and carbonaceous combinations [7]. The primary cause of CD is a complex reaction that occurs among the components, fuel, blow-by gases and lubricant oil. Most of CD originates from the fuel, while the remaining comes from the lubricant oil. The formation of CD may significantly affect the engine performance and drivability. Combustion chamber deposits are generally found on the top of pistons or the cylinder head in engines due to incomplete combustion and physical or chemical interactions between fuel or oil components and the hot chamber surface under the high-temperature, high-pressure heterogeneous mixing conditions. Carbon deposit also has a negative impact on the heat transfer process in the combustion chamber, emissions, combustion and maintenance costs.

Although fuel formulations and engine designs have both been significantly upgraded to provide the more stringent emission regulations and improve fuel economy, the formation of CD is still observed in the combustion chamber or the ring pack. The existence of CD is inescapable in internal combustion engines. Identifying the chemical composition is crucial in tracing the source of deposits. Based on statistical data and new data [8], the major elements in CD are C, O, H, N, and a small metal content level, possibly derived from the lubricating oil. Differentiating from traditional toxic and corrosive chemical substances for CD removal [9]. Mixed gas carbon removal is a new method of removing the engine carbon deposit, not only without stripping the engine, but also on the environment protection. Recently, the removing carbon deposition engine with mixed gas is widely used in engine maintenance.

Hydrogen carbon cleaning usin H2E technology

H2E engine carbon cleaning (H2E ECC) system in the process of water alkaline electrolysis, in the presence of potassium hydroxide (KOH), generates hydrogen and oxygen in a volume ratio of 2:1. The obtained mixture of gases is introduced into the engine cylinders through the inlet manifold, while the engine is operating in a mode set by the H2E application during the additivation procedure. In controlled combustion conditions, degradation of CD occurs in the cylinder and the exhaust manifold.

The increased internal oxygen proportion enhances combustion, and at the same time, the catalytic properties of hydrogen make it possible for the burning of carbon to be slowly broken down to clear the internal CD.

A powerful electric current splits the water molecule into its component atoms producing an oxy-hydrogen mixture. The mixture is passed into the engine and burnt as the engine runs mixing the oxy-hydrogen with the fuel. As it passes through the induction system, combustion chamber, etc, the hydrogen reacts with the CD turning the carbon into hydrocarbons, this disposes the CD from the engine and the resulting gas exits the engine via the exhaust system. Using hydrogen technology, CD are removed from the inner workings of the engine, which naturally build up during the lifetime of the vehicle.

By removing unwanted CD, further engine deterioration and damage can be avoided.

The effect of carbon cleaning is dependent on how "dirty" the engine is. This is down to many different things: driving style, mileage, fuel used etc. If the engine doesn't get worked high load conditions, then it will most likely have more carbon build up. Taxis and buses are the worst as they are sat idling and often short stop-start journeys at low load conditions.

Experimental

In order to assess the impact of the H2E ECC process on the emission characteristics of the tested motor vehicles. The exhaust gas analysis were performed before and after the H2E ECC treatment. H2E engine carbon cleaning treatment is shown in Figure 1.

Figure 1. H2E engine carbon cleaning treatment

The quantification of the target components in the exhaust mixtures was carried out using the gas analyser Stargas 898 Global Diagnostic System (Serial No. 3156) and the "Smokemeter 495/02."

The measurements were carried out on randomly selected used vehicles that are in regular usage and where it was possible to test the emission characteristics using the exhaust gas analysers prescribed for control on technical inspections. The measurements were included a sample of ten vehicles, four of which were with diesel engines and six vehicles were with petrol engines. The analyses were conducted at the locations in Novi Sad (Serbia) and Ystad (Sweden). Measurements of exhaust gas emissions were conducted before and after treatment with the H2E ECC system, for each vehicle. Exhaust gas emission measurements were carried out according to the method described in the instructions of the exhaust gas analysers, while the treatments were carried out according to the procedure described in the directions of the H2E ECC system.

Results

The results of testing the emission characteristics of the engines on four randomly selected vehicles with diesel engines that fulfil the Euro 3 and Euro 4 standards indicate a decrease in the opacity by an average of 60%.

The results of the emission test for six randomly selected petrol engines that fulfil Euro 3, Euro 4 and Euro 5 standards indicate a decrease in carbon monoxide (CO) concentrations for an average of 77% and total hydrocarbons (HC) for an average of 84% in the exhaust gas stream.

Conclusions

It can be concluded that for all tested vehicles, emissions of exhaust gases (opacity on diesel engines) have dropped significantly, which is the result of more efficient combustion after performed the H2E ECC procedure.

The reduction in the concentration levels of CO and HC in the exhaust gas stream is the result of providing more favourable conditions for combustion of the air-fuel mixture after the treatment with H2E ECC system. This claim is supported by the data on the slight increase in carbon dioxide (CO_2) content, which generates as a result of complete combustion at the expense of the disappearance of HC and CO.

The significantly reduced CO and HC emissions in the petrol engine provide higher overall efficiency and longer service life of the catalyst in the exhaust system of the vehicle.

Reduced opacity in the diesel engine indicates on reduced particulate intake intensity within the particle filter (DPF), which diminishes many automatic regenerations of the filter, thereby providing a longer service life and higher efficiency of the catalytic converter of exhaust gases and particulate filters.

The reduced emission of gases in the exhaust section results in reduced accumulation of deposits in the inlet manifold to which it comes through the exhaust gas recirculation system (EGR)

Acknowledgements

This research was supported by Ministry of Education, Science and Technological Development, Republic of Serbia (III46009).

References

[1] European Environment Agency (EEA). Trends and projections in Europe 2015: Tracking progress towards Europe's Climate and energy targets. 2015. doi:10.2800/985234.

[2] O. Hänninen, A.B. Knol, M. Jantunen, T-A Lim, A. Conrad, M. Rappolder, et al. Environmental Burden of Disease in Europe: Assessing Nine Risk Factors in Six Countries. Environ Health Perspect 2014. doi:10.1289/ehp.1206154.

[3] EEA. Climate change, impacts and vulnerability in Europe 2012: an indicator-based report. 2012. doi:10.2800/66071.

[4] D. Brugge, J.L. Durant, C.Rioux Near-highway pollutants in motor vehicle exhaust: A review of epidemiologic evidence of cardiac and pulmonary health risks. Environ Heal A Glob Access Sci Source 2007. doi:10.1186/1476-069X-6-23.

[5] Eea. Air quality in Europe — 2013 report. 2013. doi:10.2800/92843.

[6] C.K. Chan, X.Yao, Air pollution in mega cities in China. Atmos Environ 2008. doi:10.1016/j.atmosenv.2007.09.003.

[7] A.K. Hasannuddin, W.J. Yahya, S. Sarah, A.M. Ithnin, S. Syahrullail, D.A. Sugeng, et al. Performance, emissions and carbon deposit characteristics of diesel engine operating on emulsion fuel. Energy 2018;142:496–506. doi:10.1016/j.energy.2017.10.044.

[8] C.J. Powell, A. Jablonski Microcharacterization of heavy-duty diesel engine piston deposits. Surf Interface Anal 2002. doi:10.1002/sia.1209.

[9] S.P. Yu, M.W. Lai, C.Y. Chu, C.L. Huang, C.Y. Lin, V.I. Borzenko, et al. Integration of low-pressure hydrogen storage cylinder and automatic controller for carbon deposit removal in car engine. Int J Hydrogen Energy 2016. doi:10.1016/j.ijhydene.2016.07.191.