NOx abatement form the exhaust of a diesel engine with non-thermal plasma and Ag/Al_2O_3 catalyst

N Manivannan[1, 2], W Balachandran[1, 3], G Agozzino[1, 5], M Jayamurthy[1,4], D Brennen[1] and M Abbod[1, 3]

[1]Centre for Electronic Systems Research, [2] Department of Design, [3]Department of Electronic and Computer Engineering, [4]Wolfson Centre
College of Engineering, Design and Physical Sciences Brunel University, London UB8 3PH .

[5]Department of Chemical Engineering, Università di Napoli Federico II, Dip. di Ingegneria Chimica, dei Materiali della Produzione Industriale, Naples, Italy

Air pollutants generated by ships in both gaseous and particulate forms have long term effect on the quality of the environment and cause a significant exposure risk to people living in proximities of harbours or in the neighbouring coastal areas. It has been estimated that ships produce at least 15% of the world's NOx, ~4% of greenhouse gases, ~5% of black carbon and ~7% of global SO_2 output. International shipping traffic presents a major challenge in terms of environment and human health which entails severe economic consequences. During the past decade, the use of non-thermal plasma for the abatement of NOx and SOx has been gaining momentum [1]. Non-thermal plasma selectively transfers input electrical energy to the electrons and to not expend this in heating the entire gas stream, which generates free radicals through collisions and promotes the desired chemical changes in the marine diesel engine exhaust gas.

Abatement of NO from the exhaust of a 2 kW diesel engine was experimentally demonstrated in the work reported here. An AC corona based non-thermal plasma (NTP) followed by Ag/Al_2O_3 catalyst was used to convert NOx ($NO+NO_2$) into harmless N_2. A high frequency high voltage source ((~ 4.5 MHz and 30 kV) was used to generate the required NTP. In this set-up, the produced NTP was a streamer plasma [2], where no arc-discharge between the high voltage and ground electrode would be produced due to the fast switching of polarity between plates. Two percent silver (by weight) was impregnated onto the 3 mm Al_2O_3 beads using a rotary evaporator at 50˚C. Catalyst was heated to 350-400˚c to activate the catalytic effect during the abatement process. In a two-step process, firstly NO would be converted into NO_2 in the NTP reactor followed by NO_2 conversion into N_2 in the catalytic chamber. The flow rate of the exhaust treated was 15 l/min and NOx concentration was 550 ppm. Overall the NOx conversion efficiency was more than 90%. This technique has shown repeatable superior performance than the results reported by McAdams et al [3], whose study was only based on pre-mixed bottles gases, whereas this study was based on real engine exhaust which contained 12% O_2 in addition to soot, CO, CO_2, HC and other unknown traces of gases.

References

(1) Balachandran, W., Manivannan, N., Beleca, R., Abbod, M. F., Brennen, D., Alozie, N. S., & Ganippa, L. C. (2016). IEEE Transactions on Industry Applications, 52(3), 2496-2505.

(2) Omarov, O.A. & Rukhadze, A.A. Bull. Lebedev Phys. Inst. (2009)

(3) McAdams, R., Beech, P. & Shawcross, J.T. Plasma Chem Plasma Process (2008)