

NO_x abatement from the exhaust of a diesel engine with non-thermal plasma and Ag/Al₂O₃ catalyst

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Abstract—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 NO_x, ~4% of greenhouse gases, ~5% of black carbon and ~7% of global SO₂ 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 NO_x and SO_x 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/Al₂O₃ catalyst was used to convert NO_x (NO+NO₂) into harmless N₂. 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 Al₂O₃ 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 NO₂ in the NTP reactor followed by NO₂ conversion into N₂ in the catalytic chamber. The flow rate of the exhaust treated was 15 l/min and NO_x concentration was 550 ppm. Overall the NO_x 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% O₂ in addition to soot, CO, CO₂, HC and other unknown traces of gases.

REFERENCES

- [1] Balachandran, W., Manivannan, N., Belega, 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)