

Particle Agglomeration Inducer application in EURO-II Heavy Duty truck retrofitting

Avigdor Luttinger¹, Michal Ruzal-Mendelevich², David Katoshevski², Eran Sher³ and Hongjun Mao⁴

1. Introduction

China is confronted with millions of legacy EURO-II trucks, which due to economic constraints cannot be scrapped before several additional years of operation. Such “Yellow Label” trucks have circulation restrictions, which can be removed by retrofitting an after-treatment solution.



The Ningbo Port Authority (the second largest port city in China) is conducting a Yellow Label retrofitting project in order to reduce the emissions pollution of these trucks, starting with the Huizhong Container Truck.

This paper highlights the results and conclusions of a retrofit road trial in Ningbo, using the Particle Agglomeration Inducer to improve the performance of a DOC-POC after-treatment in EURO-II trucks using high-sulphur fuel (PAI-DOC-POC). That solution is entirely passive without any fuel additives.

2. Solution Alternatives

A popular initial choice for retrofitting is the Diesel Particulate Filter (DPF), known for its efficiency in modern diesel vehicles. Cost and complexity consideration nurture a continuing interest in alternative solutions.

A preliminary test of the operating conditions of the Huizhong truck concluded that it was incompatible with a passive DPF retrofit because the exhaust gas temperature is well below the DPF passive regeneration requirements, even with a fuel borne catalyst.

An alternative choice for this truck is Particle Oxidation Catalyst (POC). It requires a regeneration temperature of 300°C, which is compatible with the Huizhong truck. But the POC trapping efficiency is lower than that of a DPF - and that is where the Particle Agglomeration Inducer improves the standard POC efficiency. It enabled more efficient particle filtering while also reducing the ultrafine particle emissions.

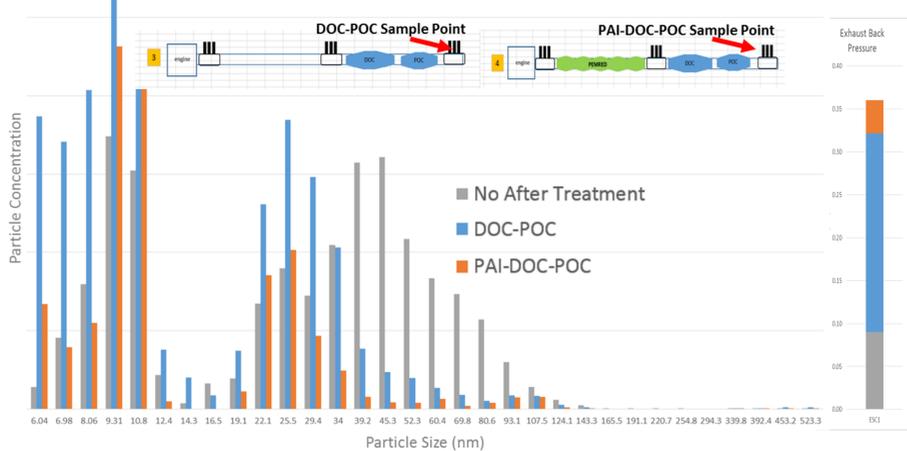
3. Validation Experiments

An initial validation of the PAI-DOC-POC configuration was conducted at Dinex labs in Middlefart, showing the increase in ultrafine particles emissions due to the installation of a DOC-POC device and subsequent reduction when the PAI is added.



This experiment was conducted on a bench with a 2.5L EURO-III diesel engine, using PMP compliant measurements.

Conventional vs PAI enhanced after-treatment
(EURO-III 2.5l Diesel, 1000rpm, 50Nm)



4. Road Test

The road test was conducted on the container tractor “China Shanghai Huizhong Automotive, engine model WD61550” (a 10L EURO-II power-train).

A PAI-DOC-POC configuration was designed and produced in collaboration with Ecocat China and Dinex. The system was installed in January 2015 and PM2.5 tests conducted by Sichuan University upon the installation (1 hour soot collection in idle speed) showed a high PM2.5 reduction efficiency.

By the end of April, the truck accumulated more than 19,000km with the system.

At that time, the elements was inspected visually and the number of particles emitted (PN) was also measured in collaboration with Nankai university, with their Pegasor Mi2 device (4 repetitive tests in High idle).

All the measurements were taken on a parked truck from the tailpipe.

PM2.5 Test (after installation)



PN Test (after 19,000km)

5. Results

The visual inspection of the PAI-DOC-POC showed a very efficient soot filtration result, without any change or damage to the filter.

While the inlet to the catalytic converter is blackened with a fine soot layer, the outlet of the particles oxidation catalyst is clean “like new”. That means that almost the entire soot was eliminated by the PAI-DOC-POC.

	Operating condition	Test period	Result: Original exhaust system	Result: PAI-DOC-POC system	% emissions reduction with PAI-DOC-POC
PM2.5 [µgr/cc]	Idle, 1 hour collection	Trial start (new unloaded trap)	9,253	2,646	-71.4%
Particle Number Concentration (particles/cc)	Full Throttle Governed Speed, 20 seconds,	After 19,000km	1,105,065	10,298	-99.07%



6. Conclusions

The installation of exhaust after-treatment devices increases the ultrafine particles emissions.

The addition of the Particle Agglomeration Inducer upstream of a standard DOC-POC device increases its trapping efficiency while also reducing the ultrafine particle emissions.

A Huizhong container tractor was retrofitted with a PAI-DOC-POC solution and drove more than 19,000km with an average of 400km per day at speeds up to 60kmh, without any operating incidents or noticeable increase in fuel consumption.

A PM2.5 test was conducted upon the installation (clean unloaded devices) and the reduction rate exceed 70%. A PN test was conducted after 19,000km and the reduction rate exceeded 99%. A visual examination of the POC outlet revealed an almost clean substrate, attesting to a high soot oxidation efficiency.

While the conventional POC trails behind a DPF due to its lower PM trapping and risk of spontaneous soot release in case of incomplete oxidation, the enhanced PAI configuration achieved in this road trial 99% PN reduction and excellent soot oxidation, and should be evaluated pragmatically in light of the alternatives.

Additional tests and trials are to be conducted to validate the consistency of the solution, which could significantly improve the air quality of transport intensive industrial, mining and port regions in China.

¹ PEMRED Particle Emissions Reduction; ² Aerosol Research Group, Ben Gurion University of the Negev, Israel;

³ Faculty of Aerospace Engineering, Technion Israel Institute of Technology; ⁴ Center for Urban Transport Emission Control, Nankai University, China