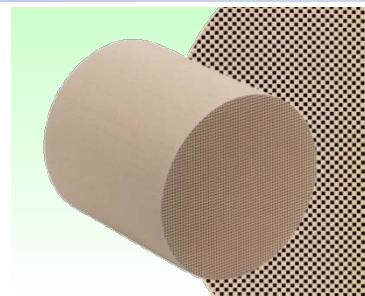


GPF Concepts for Low PN Emissions, Backpressure and CO₂ Emissions

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Definition



Background: Engine Technology and Legislation

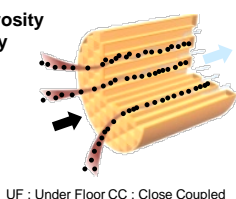
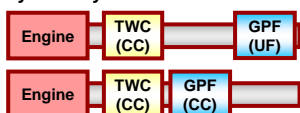
Gasoline Direct Injection (GDI) engines cope to meet the CO₂ certification limit from 2021, but have the drawback of increased Particle Number (PN) emissions. On the other hand, PN legislation limit will be 6.0E+11 #/km from September 2017. In addition, certification of Real Driving Emission (RDE) including PN limit will be implemented. Gasoline Particulate Filter (GPF) is a strong candidate to cope with the future legislation limits.

Objective of this study:

The GPF made of Cordierite is based on the well established ceramic Diesel Particulate Filter technology. It's working principle and several results based on non-catalyzed and catalyzed GPF were presented in past ETH conferences. For this paper, NGK conducted several tests under different boundary conditions and checked PN, CO₂ emission and power output of the engine to determine the GPF performance under future real driving conditions.

GPF : Non-catalyzed : 45-55% porosity
Catalyzed : 60-65% porosity

System layout for tests

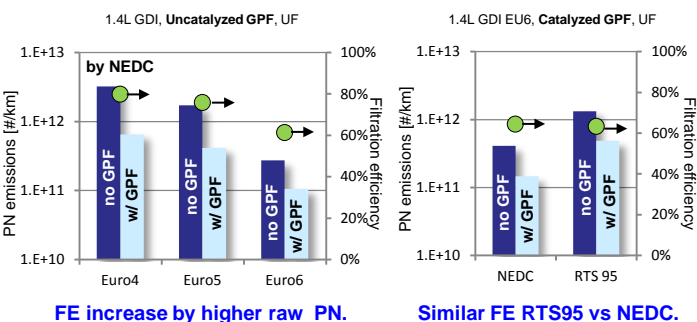


UF : Under Floor CC : Close Coupled

Evaluation contents

Filtration efficiency	CO ₂ emissions / power
Engine PN raw emission : low – high	Driving cycle : NEDC, WLTC and RTS
Driving cycle : NEDC, WLTC and RTS 95	Engine bench full load test
Filter position : UF, CC	Vehicle mileage : 0 km – 160,000 km
Vehicle mileage : 0 km – 160,000 km	(Size optimization for dP reduction)

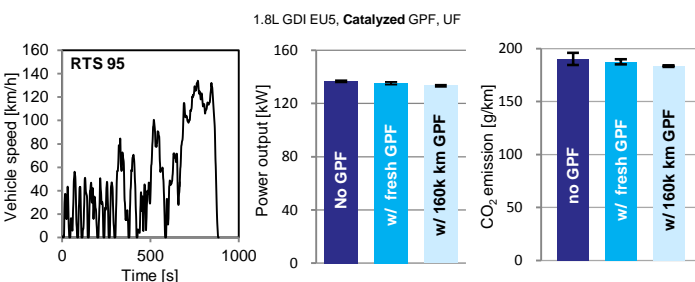
Results ✓ Raw PN and filtration in NEDC, RTS 95



FE increase by higher raw PN.

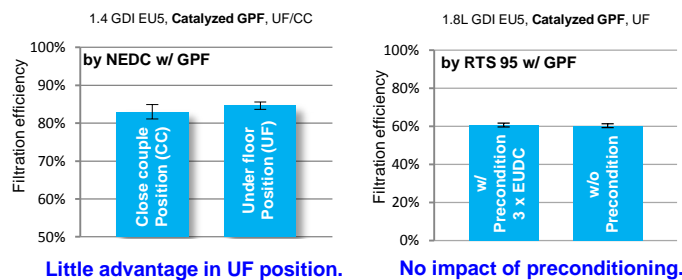
Similar FE RTS95 vs NEDC.

✓ RTS 95 – CO₂ and power output influence by GPF



Only 2.5 % power loss by aged GPF and no influence on CO₂.

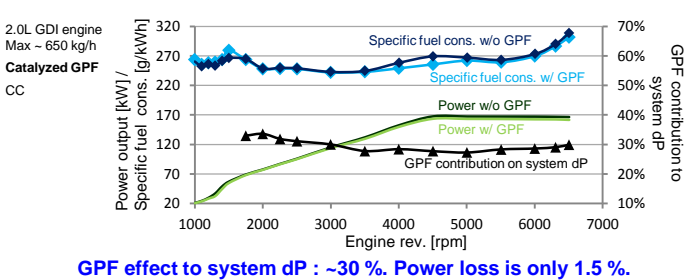
✓ GPF position and precondition impact on filtration



Little advantage in UF position.

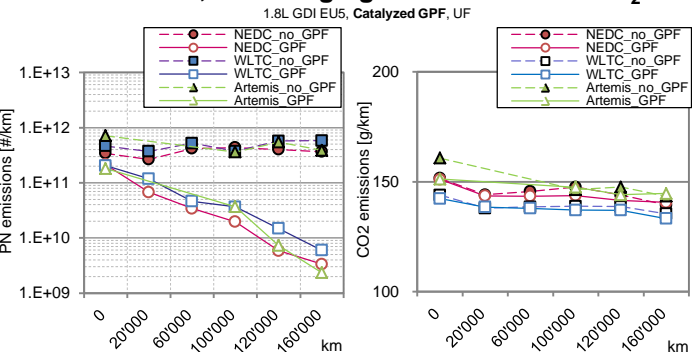
No impact of preconditioning.

✓ Full load test – fuel consumption and power



GPF effect to system dP : ~30 %. Power loss is only 1.5 %.

✓ Effect of 160,000 km aging on filtration and CO₂



GPF FE is increased to > 99 % after 160 km run.

There was no measurable impact to CO₂ emissions during each cycle.

✓ GPF influence on system dP and GPF optimization

GPF size	Diameter	GPF volume / engine displace.	GPF contribution to system dP	
			Fresh	22 g ash (160k km)
Small	4.66"	0.84	30 % measured	40 % *
Medium	5.20"	0.84	22 % *	29 % *
Large	5.66"	0.84	16 % *	23 % *

Optimized GPF dP : less than 1/4 of system dP
* Calculation value

By rightsizing the GPF, the effect on system dP is smaller (~16%).

It is only ~23% even after aging (Engine with 22g ash : 160k km).

Conclusion of GPF technology

- Raw PN emissions of vehicle decreasing from EU4 to EU6
→ Requested filtration efficiency of EU6 b/c is reduced in comparison to EU4/5 vehicles
- Under EU6 RDE conditions (e.g. RTS95) GPF provides sufficient filtration efficiency
- GPF has no measurable influence on CO₂ emissions: Neither under NEDC, WLTC, Artemis, RDE / RTS95
- The CO₂ impact at full load is hardly to detect and might be optimized by calibration work
- The impact of a coated GPF on power output is small (~ < 2.5 %) at nominal power

Sufficient Filtration Efficiency for RDE

No measurable CO₂ impact

Only small impact to power