Grouping Manipulation of Nanoparticles Emitted from ICEs

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Introduction

The new EURO-6 regulations requires for the first time to reduce PN. For that reason, there is a strong desire for new means and technologies to reduce the number of nanoparticles emitted from vehicles.

In order to reduce particle number we used the "Grouping" phenomenon: Small particles, in the nano scale range, have higher tendency to move as **groups** and cluster in an oscillating flow. In such conditions, particles may coagulate and increase their size, reduce the total particle number and comply with new EURO-6 regulations.

For similar total mass concentration, nanometer size particles are more harmful than micron size particles and that is due to both a much higher number as well as a much higher surface area that provides a surface on which catalytic chemistry can occur that favors the formation of free radicals that are responsible for driving oxidative stress, reduction of lung function and also mortality. We have already proven particle reduction in different engines. This time we investigated both PN and surface area reduction of nano-size scale particles.

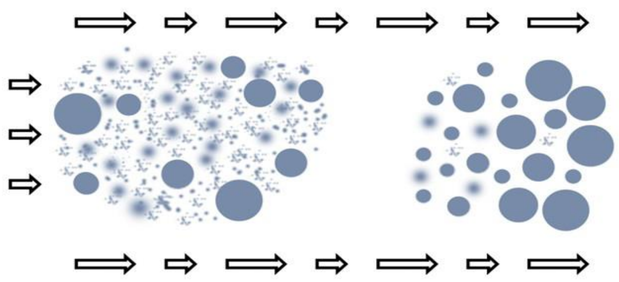

Figure 1. Schematic presentation of particles grouping in an oscillating flow field.

Experimental

The experiment was performed with a LDV Maxus 2L, Transit 75PS Diesel engine coupled to an engine chassis dynamometer.

The main objective of the current tests was to investigate the influence of the grouping pipe together with a DPF on the particle number and surface area reduction. The DPF is DOC+POC (Diesel Oxidation Catalyst and Particle Oxidation Catalyst).

Three different sets were assembled (Fig 2):

a) Original pipe

b) DOC+POC

c) "Grouping pipe" DOC+POC (Fig 3)

The three different systems were examined under two extreme European Stationary Cycle (ESC) engine operations:

ESC1 - 1,000rev/min, 15kW and

ESC10- 3,600rev/min, 100kW.

The particles number and surface area size distribution were recorded via Scanning Mobility Particle Sizer (SMPS).

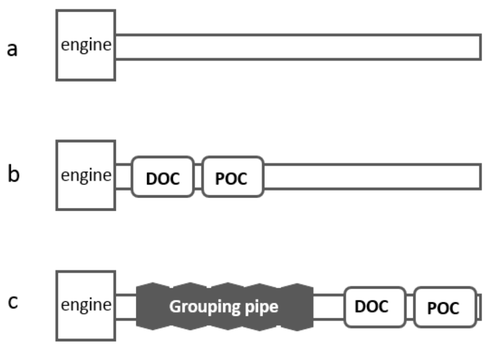

Figure 2. Schematic presentation of experimental setups.

Figure 3. picture of set number 3: Grouping pipe+DOC+POC.

Experimental Results

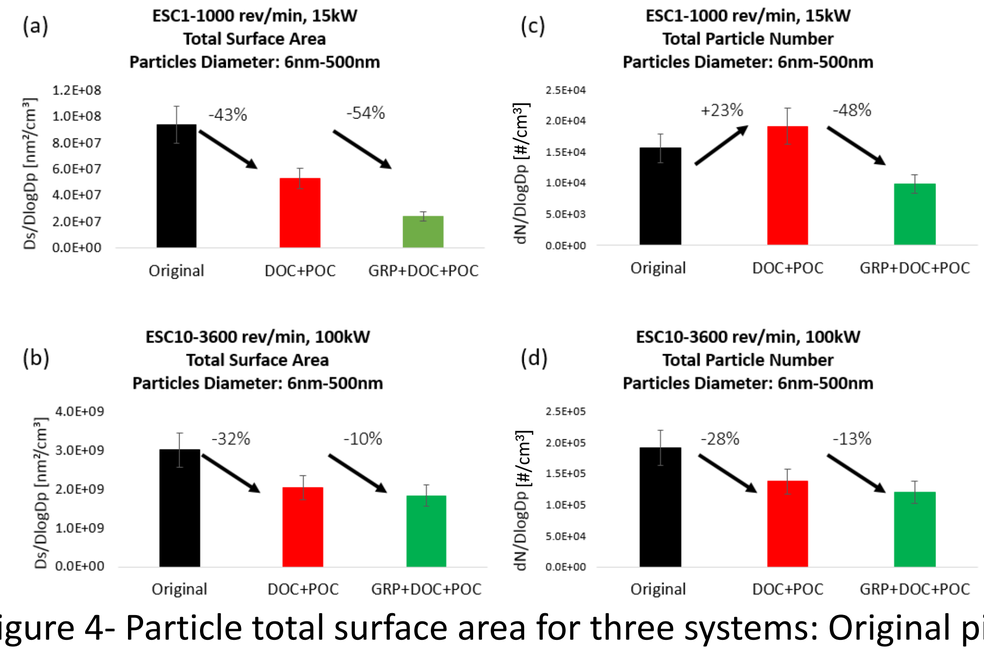

Figure 4- Particle total surface area for three systems: Original pipe, DOC+POC and GRP+DOC+POC for 2 different engine conditions

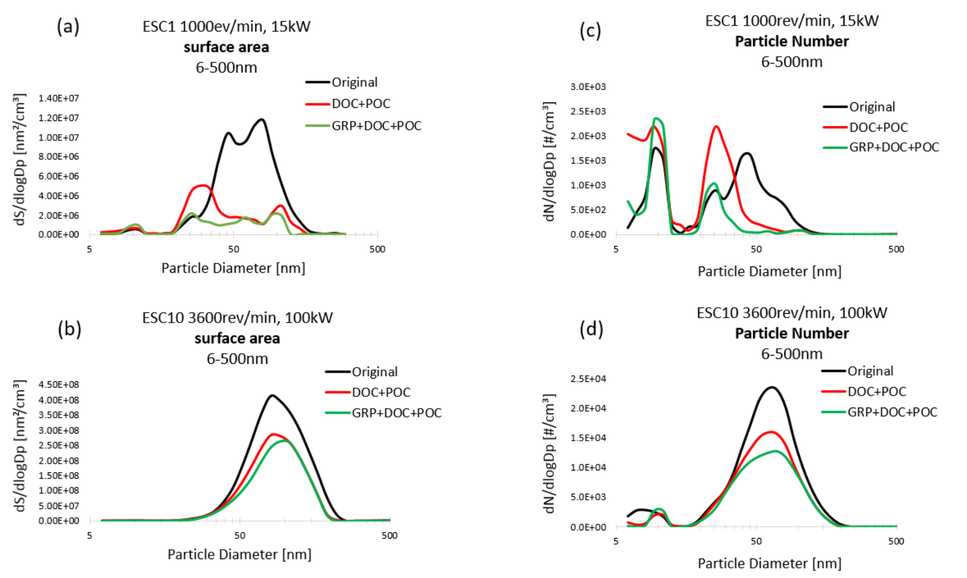

Figure 4- average of particle total surface area size distribution for three systems: Original pipe, DOC+POC and GRP+DOC+POC for 2 different engine conditions

Along the high engine operation a significant PN reduction occurs with the third system GRP+DOC+POC both in surface area and particles number. Moreover, there is a small shift towards the larger diameters as a result of coagulation/agglomeration. At low engine operation (Fig 4(a) and 4(c)) one can notice on one hand the reduction of the surface area but on the other hand an increase of particle number at the nuclei mode (6-11nm) collected from the tail pipe of the third system that is longer in length (longer time residence) and the average temperature along it is lower in comparison to the other systems, conditions that can lead to the formation of nuclei mode particles. According to the size distribution and together with a focus on the surface area that nuclei mode particles contain, we can refer the growth in total particle number (Fig 4(c)) not only to backpressure but also to nucleation.

Conclusions

The current research focuses on particles surface area, where its total reduction is due to the clustering of nanoparticles with themselves or with larger ones.

To summarize, using a well-designed grouping exhaust pipe in vehicles, based on engine specifications, without or with DPF will lead to a reduction in particle number emissions due to coagulation promotion and greater efficiency of filtration systems, thus reducing health risks associated with exposure to combustion generated nanoparticles.

References

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