DANISH TECHNOLOGICAL INSTITUTE

Shipboard characterization of a particle filter during operation: Influence on particle number concentration, particle size distribution and gas emissions

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Introduction

Ultrafine particles are generally recognized to have an adverse impact on human health and as result, particle emissions from marine engines are under scrutiny. Although regulations on NO_X emission from ships have been implemented and sulphur content in marine fuel is limited to 1.0 % in emission control areas (ECA), and further reduced to 0.1 % in 2015, emissions from ship traffic is still a much debated subject, especially in harbour cities. Two mitigation strategies are being exploited: 1) lowering of the sulphur content in fuel and 2) implementation of emission reducing technologies such as filters and scrubbers.

In this study emission data from a Danish inland ferry with a retrofitted particle filter is presented. All measurements were carried out on-board the Danish inland ferry connecting the island of Ærø with Fyn. The ferry has two main engines (MaK M 20 C, 1020 kW 4-stroke diesel engine) both of them running on marine diesel, in which the sulphur content is limited to 0.1 %.

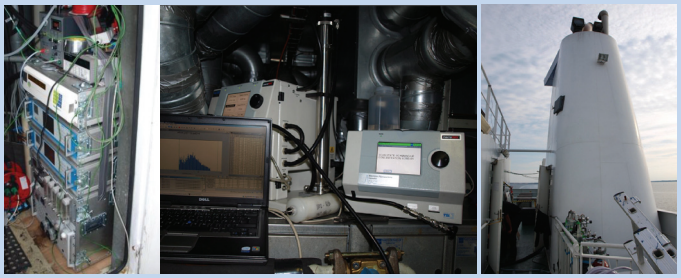

Figure 1: Experimental setup with measurement equipment and chimney

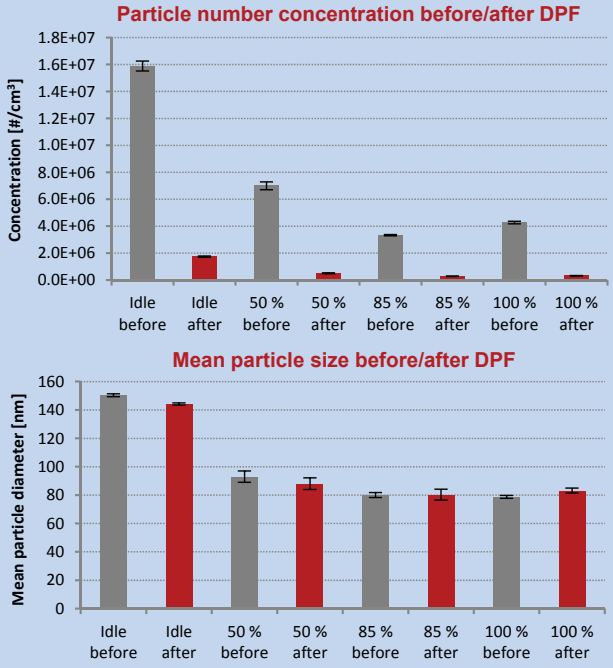

Figure 2: Particle number concentration and mean particle size for engine load: Idle, 50 %, 85 % and 100 % MCR, measured with SMPS during operation

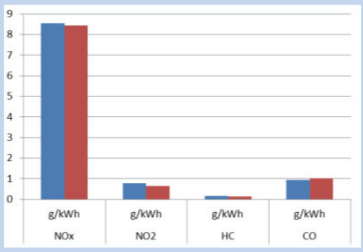

Figure 3: Average gas emissions before (blue) and after the particle filter (red)

Experimental

The emission was characterized at 4 points of engine load: Idle, 50 %, 85 % and 100 % MCR, and measured according to the ISO 8178 steady state method. The nanoparticle size distribution and number concentration was measured using a scanning mobility particle sizer (SMPS) (TSI) in connection with a rotating disc dilutor (Matter Engineering) and further connected with a thermal conditioner, heated to 300 °C (ASET15-1), which removes volatiles. Gas emissions (CO_2, CO, HC and NO_x) was measured using standard laboratory gas analyzer equipment.

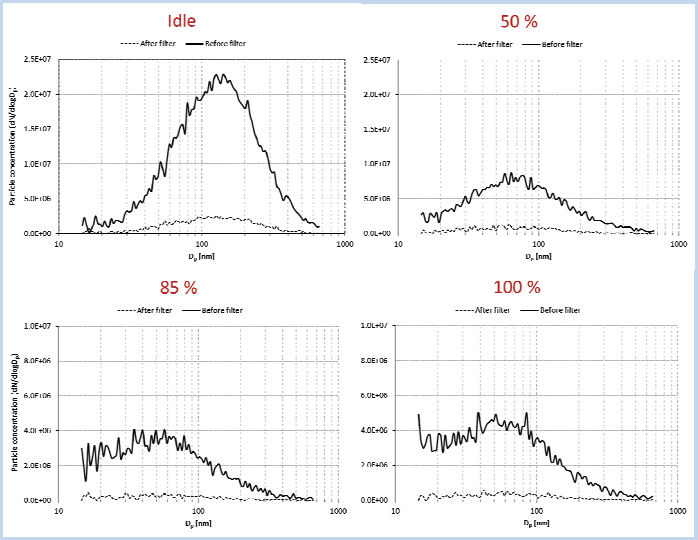

Figure 4: Particle size distributions for engine load: Idle, 50 %, 85 % and 100 % MCR, measured with SMPS during operation

Results and conclusions

The mean particle size depended on engine load, and was below 150 nm during all four engine loads tested. The largest particles were seen with the ferry operating in idle in the harbour during load and unload. Particle number concentration was in average reduced by more than 90 % by the filter.

The gas emission data show NO_x levels below the IMO TIER II regulation for ships and comparable to the EURO 2 norm for on-road heavy-duty diesel engines. CO and HC levels were found to be within the EURO 5 or 6 limit for on-road heavy-duty diesel .

In conclusion, the installed particle filter in average reduced the particle emission with minimum 90 % by number, measured in real-time during operation. The expected reduction was 99 % and the difference is very likely due to leaky bypass valves in the exhaust gas system. The visible smoke from the vessel's funnel, which is typically seen while manoeuvring in the harbour, is also reduced to a minimum.

This work is followed by implementation of a SCR catalyst (Dinex F-SCR technology), work expected to be carried out during autumn 2014.

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