Flue gas cleaning for stoves & boilers

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Flue gas cleaning for stoves & boilers

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Background

Residential heating with wood (and coal) in small stoves and boilers emits about 50 percent of the total fine particle and black carbon emissions in Europe. Furthermore, many studies have confirmed a significant emission of ultrafine particles from residential heating. In other sectors, particle emissions have been successfully reduced by particulate filters. However, filters or other flue gas cleaning systems are still not standard equipment for small stoves or boilers. Even though new stoves and boilers still pollute much more compared to other heat sources and road traffic.

Purpose

The purpose was to investigate the removal of particles in an electrostatic filter and a condensing flue gas system with a bag filter adapted for small stoves and boilers.

Methods

This study investigates the removal efficiency in two filter systems adapted for stoves and boilers: An electrostatic filter and a condensing flue gas system with a bag filter.

Measurements were done with dilution tunnels to include condensates. Measurements were performed with P-Traks for ultrafine particles ($PM_{0.1}$) and traditional particle mass collection (quartz filters) concerning fine particles ($PM_{2.5}$). The collected particle mass was analyzed for elementary carbon (EC) equivalent to black carbon (soot) and analyzed for organic carbon (OC).

Removal efficiencies were found comparing measurements before and after both filter systems.

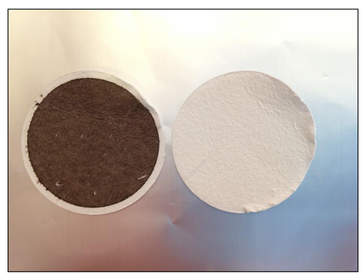
Electrostatic filter

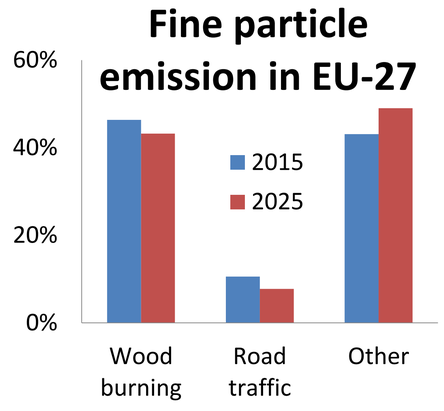
Condensing bag filter system

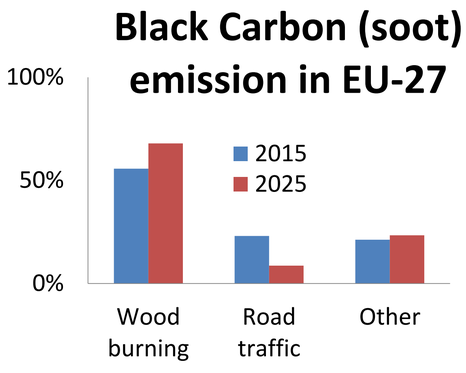
Results

Average removal efficiencies over a burning cycle (40 min.) are shown in table 1.

Both filters showed high removal efficiencies for both fine particles, elementary carbon and organic carbon, with the bag filter having highest efficiency. The bag filter showed a high removal of ultrafine particles as well. No net removal of ultrafine particles over a whole burning cycle (40 min.) was observed in the electrostatic filter: in the ignition phase (0-10 min.) the filter almost doubled the ultrafine particle emission, whereas it reduced the particle emission around 85 percent in burning phase (10-40 min.).







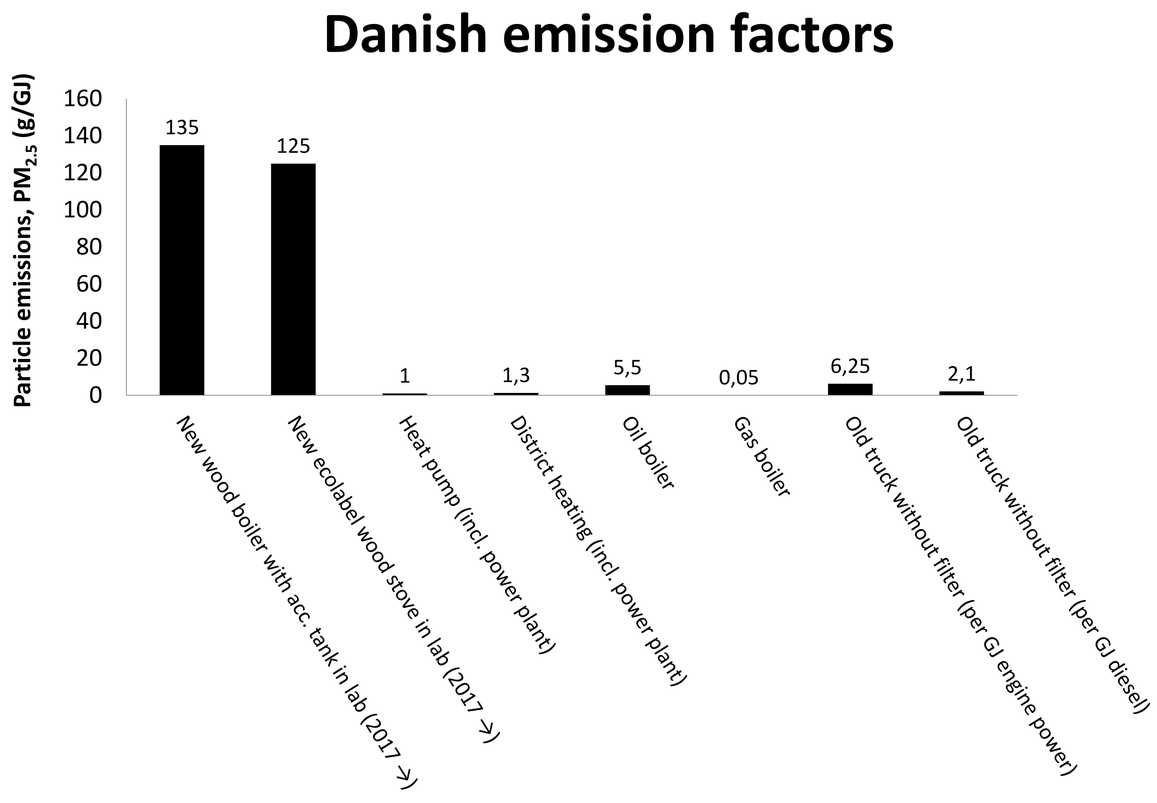


Table 1: Average removal efficiencies over a burning cycle (40 min.)

	$PM_{0.1}$	$PM_{2.5}$	EC	OC
Electrostatic filter	0 %*	87 %	98,5 %	74 %
Bag filter	98,7 %	94 %	99,6 %	85 %

*In the ignition phase (0-10 min.) the filter almost doubled the ultrafine particle emission, whereas it reduced the particle emission around 85 percent in burning phase (10-40 min.).

Discussion

If all stoves and boilers were fitted with these filters it would reduce the total emission of fine particles and black carbon in Europe by 40-50 percent. Furthermore, the bag filter would significantly reduce emissions of ultrafine particles as well as dioxins and PAHs adsorbed to their surfaces.

The prototypes of both filter systems (incl. regeneration) have now been successfully tested for several years on chimneys for small stoves operated under controlled conditions at test facilities. Next steps are crash testing the filter systems and testing under real conditions in private households.

Even if the filters are reliable in use and maintain the high efficiencies, next challenge will be to get filters installed on chimneys. This will either require legal filter requirements or high taxes on residential heating without filters since the filter price is believed to be around 3,000 euro in mass production.

Conclusion

The two investigated filter systems efficiently remove particles, both fine particles, elementary carbon and organic carbon. The bag filter has the highest efficiency and showed a high removal of ultrafine particles as well.

Acknowledgement

We would like to acknowledge Danish Centre for Environment and Energy at University of Aarhus and the Technical University of Denmark for providing sampling equipment, ultrafine particle measurement devices and performing the chemical analysis. We could not have performed these investigations without their support and contribution.

Further info:

Clean Heat website: www.clean-heat.eu

Danish Ecological Council: www.ecocouncil.dk

Deutsche Umwelthilfe: www.duh.de

LIFE program of the EU: ec.europa.eu/environment/life/

Main author:

Kaare Press-Kristensen has a master degree and a Ph.D. degree in environmental engineering from the Technical University of Denmark. He has been teaching air pollution for 16 years at the university (recent years as external). His work is focused on wood burning, road traffic, shipping, non-road machinery, aircrafts & indoor pollution sources. He works with emissions, ambient air concentrations and the connected risk to public health as well as work related exposure and public information.

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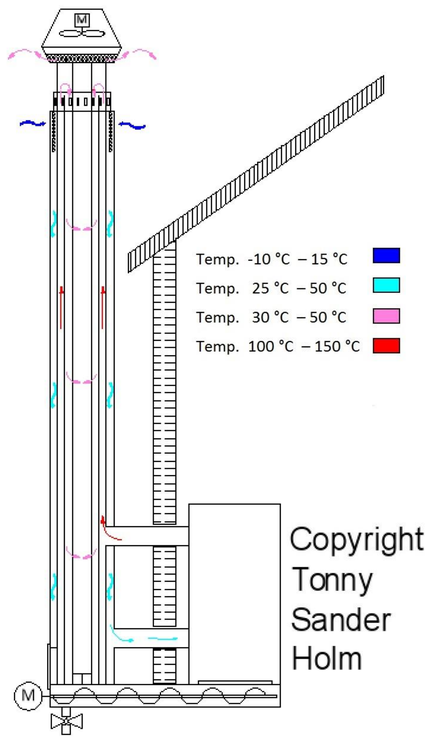

Condensing bag filter system