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Fine Particle Emissions of small wood fired Furnaces

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Introduction

For several reasons, wood fired heating appliances have become increasingly popular over the last few years. Amongst their assets is the use of locally available fuel, their contribution in solving the "CO_2-problem" and also the "comfy atmosphere" they create when installed as an open fireplace in the living room. In recent years technical improvements helped to reduce the emission of CO and hydrocarbons significantly, both of which had been a major disadvantage of wood fired appliances. Furthermore major improvements have been achieved in regard of the maintenance.

There still are open questions concerning the emission of fine particles. Therefore we have started a series of investigations at the EMPA in order to gather information about the emissions of fine particles from different types of wood fired appliances.

Experimental

For the determination of number size distributions we are using SMPS and ELPI. Therefore we are able to look at a particle size range from below 10nm to about 10µm. The ELPI allows rather fast measurements of complete spectra (~ 50nm - 10µm) while SMPS spectra (~ 10nm - 1µm) take at least 60s and therefore are only useful during stationary combustion conditions.

With the help of a thermodenuder we had the option to strip the particles off their adsorbates. The sampling for ELPI measurements was designed to operate under isokinetic conditions.

Furthermore we did gravimetric measurements by exposing different kinds of filters to a defined flow of flue gas. This allowed us to compare those "classical" methods to the results of SMPS or ELPI measurements.

In addition to the particle measurements we also recorded the emissions of NO_x, CO, O_2 and hydrocarbons. This way we were able to determine the quality of the combustion and control the settings of the heating appliance.

The investigations included two types boilers, one open fireplace and boiler with pellet burner.

Problems

Apart from several practical problems like frequent clogging of the nozzle of our injector diluter upon starting the fire, we also faced some more serious problems. One was the instability of the dilution ratio, which probably was due to a slow contamination of the diluter nozzle. So far we dealt with this problem by recording the CO concentration in front and behind the diluter, deriving the actual dilution ratio from ratio of these CO concentrations.

When evaluating the ELPI measurements we found that the higher ELPI stages did not produce reliable results when trying to calculate the mass distributions. This became quite clear when we operated the ELPI as a "classical" impactor. This operation was achieved by not using the electrical detection but simply weighing the mass, which had be gathered on each stage.

The reason for this problem is the extremely low signal at the higher ELPI stages while there are much bigger currents at the lower stages. There is an interaction of neighbouring stages, which is taken into account by correction calculations. Because of the very small signals at the higher stages, the results for the higher masses are dominated by those correction calculations and therefore exhibit large uncertainties. For the evaluation we decided to neglect the ELPI results for the higher masses.

Results

So far, only preliminary results are available. We find quite a reasonable correlation between gravimetric measurements and ELPI results.

We did not see significant differences between measurements with and without thermodenuder. The concentration measured with thermodenuder was smaller by constant factor, which is due to usual diffusion losses.

First results also indicate that there is also good agreement between SMPS and ELPI results, when the total number concentrations are compared. This is understandable as the spectra show that the maximum of the number size distribution is roughly around 100nm. Only a very small number of particles is larger than 1µm.

The results for the heating appliances were obtained using the same methods and a comparable set-up as we have used for automobile engines. Therefore we are able to directly compare the different sources of particle emissions. According to our preliminary results we expect that the particles emitted from wood fired heating appliances tend to be only slightly larger than those emitted from diesel engines. The total concentrations probably are in the same order of magnitude. Final statements, however, will have to wait until our detailed evaluations have been finished.

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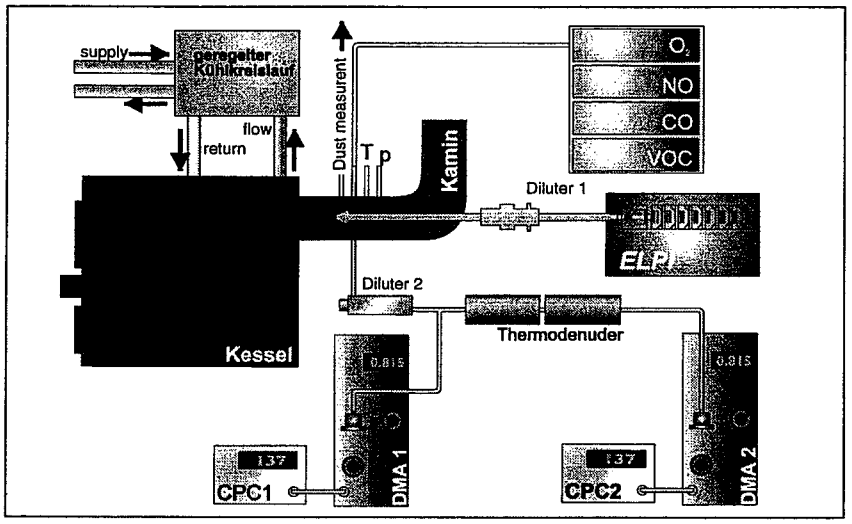
- *~30 kW heat input*
- *different combustion systems*
- *different measurement techniques*

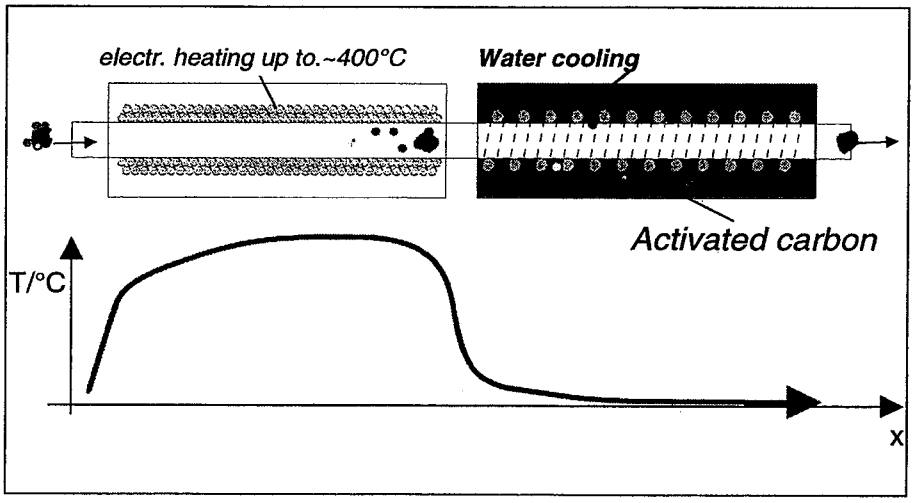
Fine Particle Emissions of small wood fired Furnaces

- measurement techniques
- experimental setup
- furnaces
- results
- conclusion

Experimental Setup



Thermodenuder



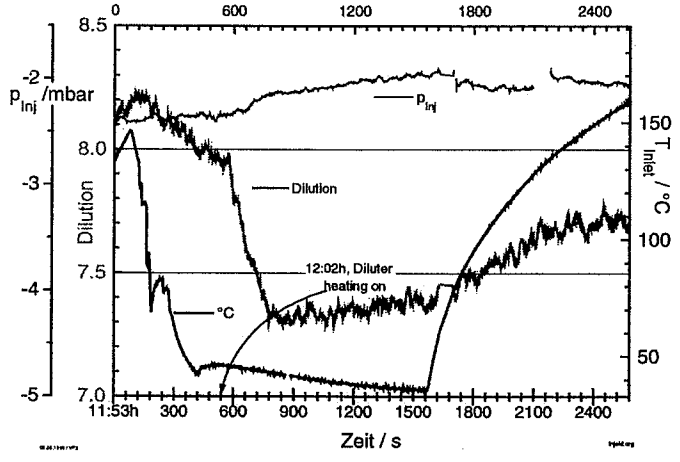
Furnaces

- appliances burning pieces of wood
  - –boiler with oberer Abbrand
  - –boiler with unterer Abbrand
  - –open fireplace
- boiler with pellet burner

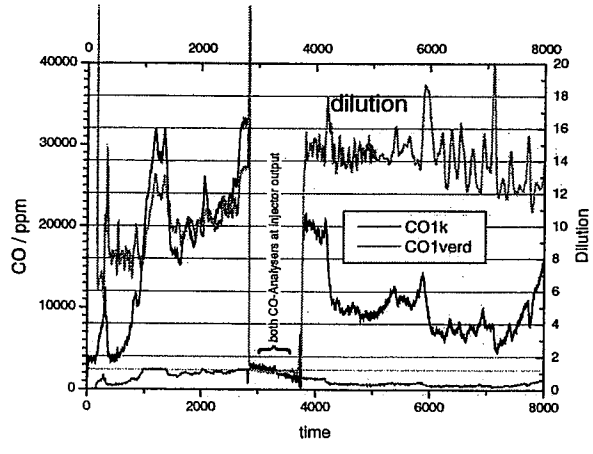
Problems

- Stability of dilution
- Saturation of Impactor
- Larger diameters by ELPI

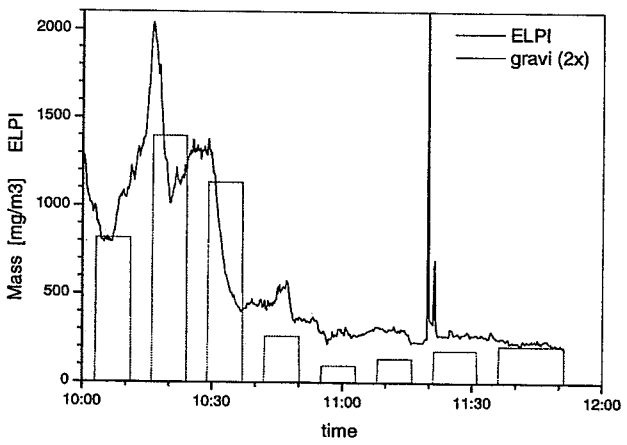
Temperature Influence on Dilution



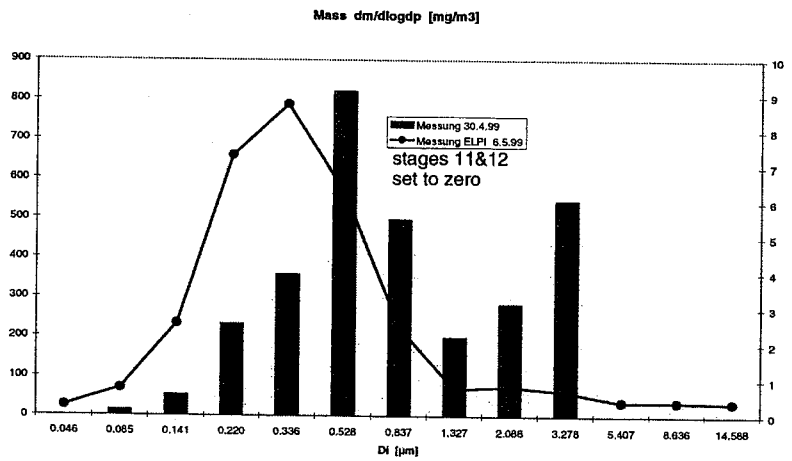
Dilution changing with time



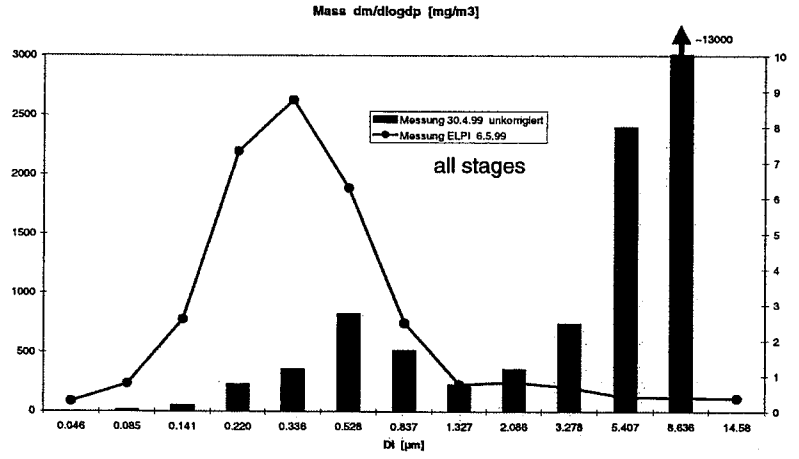
Total concentration



ELPI vs. ELPI as conventional impactor



ELPI vs. ELPI as conventional impactor



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Verbrennungsmotoren / Feuerungen

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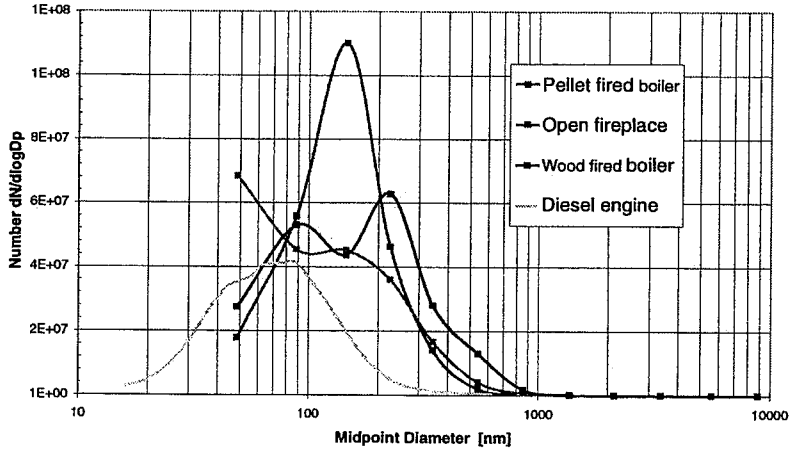
Diesel engine compared to Furnaces



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Verbrennungsmotoren / Feuerungen

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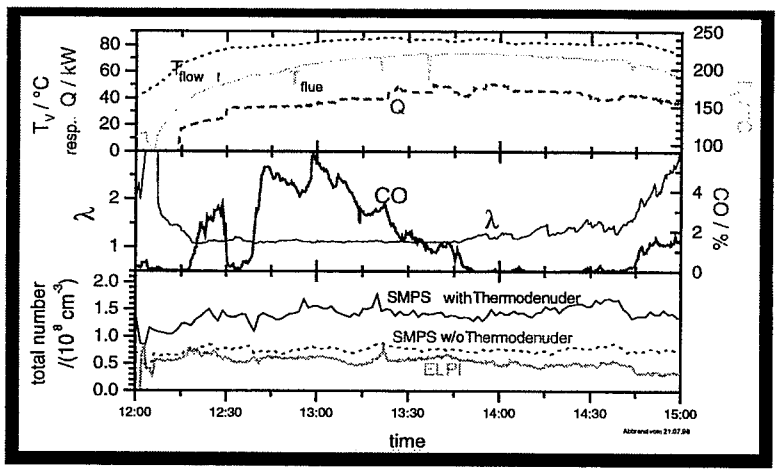
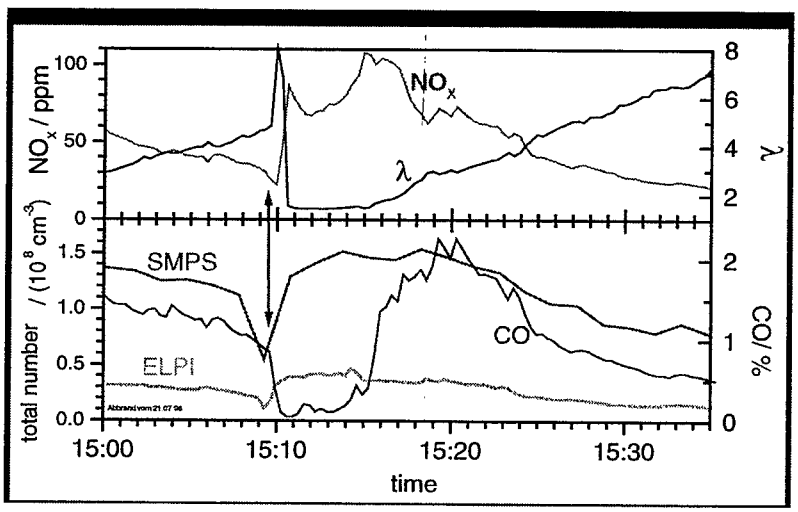
Number size distribution



Number size distribution



Conclusions

- wood: larger particles than diesel engines
- modern furnaces: lower emissions
- correlation between different particle measurement techiques
- Problems: stability of dilution, measurement of larger particles (~5µm)