Reduction of Particle Emissions from Small Wood Fired Furnaces

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Usually wood fired heating appliances are considered to be environment-friendly sources of energy. Using a renewable fuel, they may contribute to a solution of the problems related to the greenhouse effect. Besides this and other positive qualities of biomass combustion, there is, however, the question of emissions. Over the years, significant improvements in this respect have been made. Nevertheless, estimations for the situation in Switzerland show that the contribution of small wood fired appliances to the overall pollution by particle emissions is not negligible.
In a first stage we have investigated the emissions of several wood fired heating appliances in order to characterise the particle emission under various combustion conditions. We used a number of techniques (SMSP, CPC, ELPI, gravimetrie, electron microscopy) for the measurement of particle concentration or size distribution. The typical particle size is between 80 nm and 180 nm.
In the project presented here, we build on the experiences from those previous investigations in order to develop a simple device for removing most of the particles from the flue gas of small wood fired furnaces. Looking at the inventory of existing filter principles it becomes obvious that this device should be based on the electrostatic principle. So far, we have achieved promising results with appliances fired with wood pellets as well as with logs.

Introduction

For the last few years, particle emissions of various sources have been of interest because particles in ambient air have been found to be the cause of a number of health problems. This has been shown by several epidemiological studies that have served as an important argument for the introduction of new regulations ("PM10 immission limits"). Besides transportation and industry, domestic-heating appliances are another important group of anthropogenic sources. Amongst these appliances small wood fired appliances, below 70kW, play an important role with respect to particle emissions. The importance is further underlined by the increasing popularity of small wood fired appliances. The use of a locally available and renewable source of energy is most remarkable among their merits. On the other hand, those small wood fired appliances still tend to produce rather high emissions, with particle emissions being most critical.
In the past, we have carried out several investigations about particle emissions of vehicle engines as well as of oil and wood fired heating appliances. A number of measurement techniques were applied throughout all of these projects in order to allow comparisons between those different emission sources. Based on these experiences, we wanted to address the problem of fine particle emissions from wood fired appliances. Comparing several filter techniques, we found the principle of electrostatic precipitation to be most suitable because of the small pressure drop. For small appliances of a few kW heat output this is an important argument.

Results & Future Prospects

First experiments checking the general suitability of this filter technique for small wood fired furnaces gave very promising results with filter efficiencies of well above 90%.
The objective of our project, however, was not necessarily highest efficiency. We wanted to develop a system which offers a reasonable reduction of particle emissions at low cost and easy maintenance. For this purpose we tested a variety of designs and especially different set-ups of the electrode. The constructions have been characterised with special focus on the filter efficiency, voltage and current.
The range of useful voltages is given by the begin of the ionisation around 10kV, depending on the geometry of the electrode, and the dimensions of the flue pipe and the rather harsh conditions within the flue gas. Voltages of 20kV are increasingly difficult to handle. A voltage around 14kV seems to be a suitable compromise.
The particles are deposited along the walls of the flue pipe. Most of the deposition, however, is found in the vicinity of the ionisation zone. This allows a local cleaning mechanism.
So far we have shown that a particle filter based on electrostatic precipitation can efficiently remove fine particles from the exhaust of small wood fired furnaces. The high voltage supply, a critical component of the system, can be realised at low cost. Presently, we are working at an easy cleaning mechanism and in next stages of the project a prototype will be built and tested in the field.

Acknowldegment
This project is funded by the Swiss Bundesamt für Umwelt, Wald und Landschaft (BUWAL).

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- **Introduction**
- **Conception**
- **Results**
- **Conclusions**

Wood Fired Furnaces: Pros & Cons

wood fired heating increasingly popular

BUWAL (Swiss Environmental Protection Agency): "Increase of wood consumption 1990-98": wood fuel+21%, energy + 25%

- **Sustainability**
- **„CO_2-neutral“**
- **Locally available**
- **Comfort**

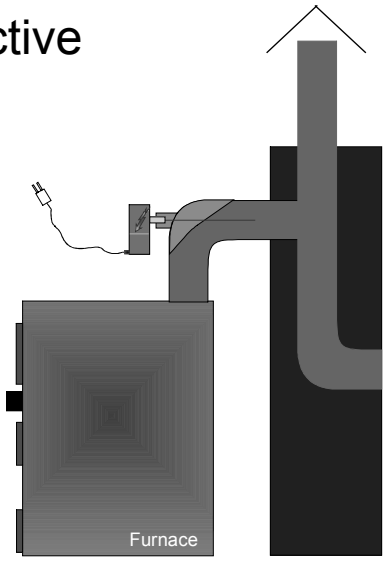
- Higher Emissions (particles)
- HC emissions („odor“)
- maintenance

Particle Filter Techniques

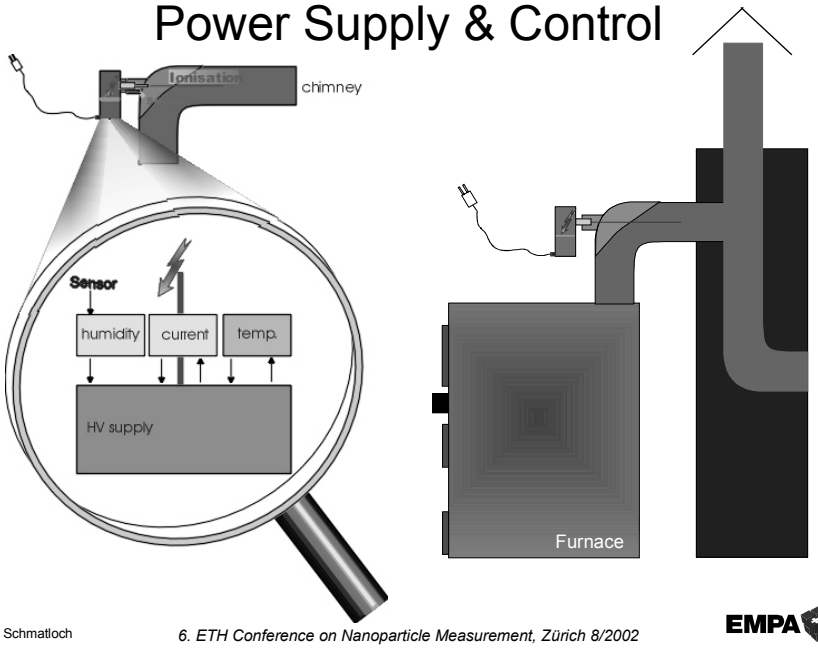
	Cyclone	Filter	El. Precipitator
Efficiency	high	very high	high
Pressure Drop	medium/high	high	low
Cost	low	medium	high
maintenance	medium	high	low

Objective

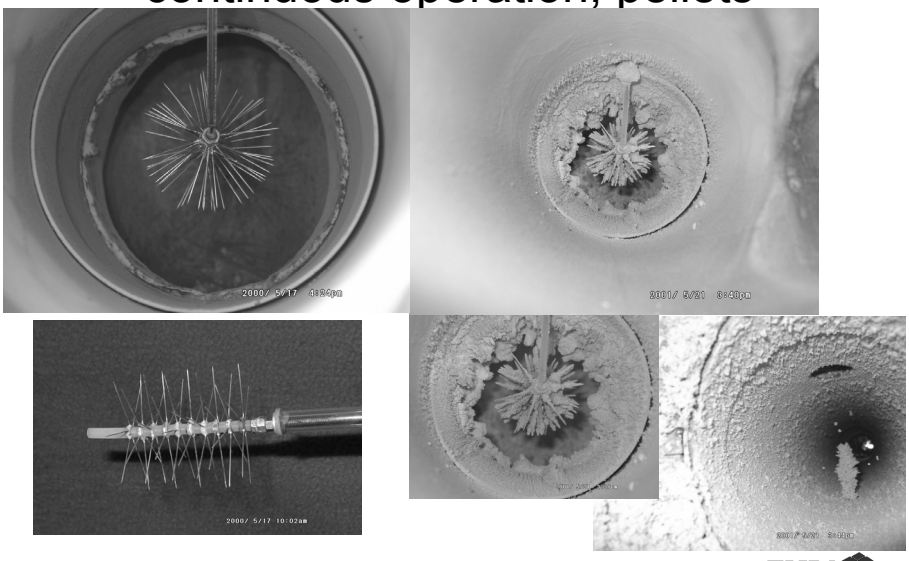
- **low cost**
- **small size**
- **easy handling**
- **low maintenance**
- **reasonable efficiency**



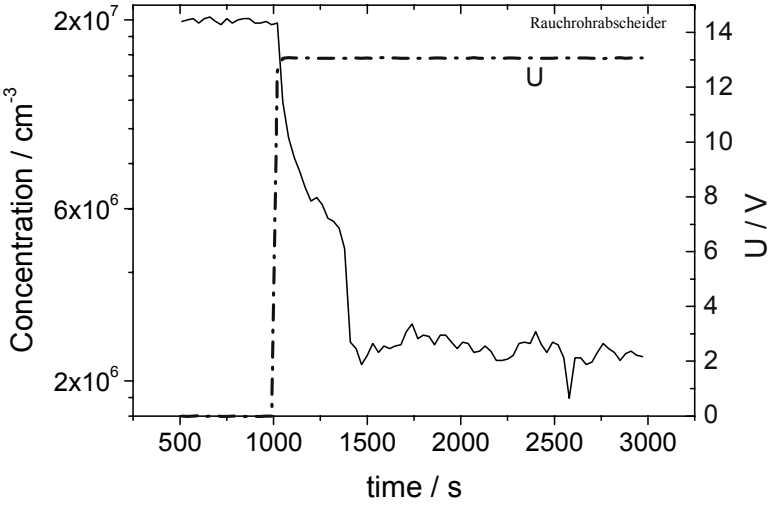
Power Supply & Control



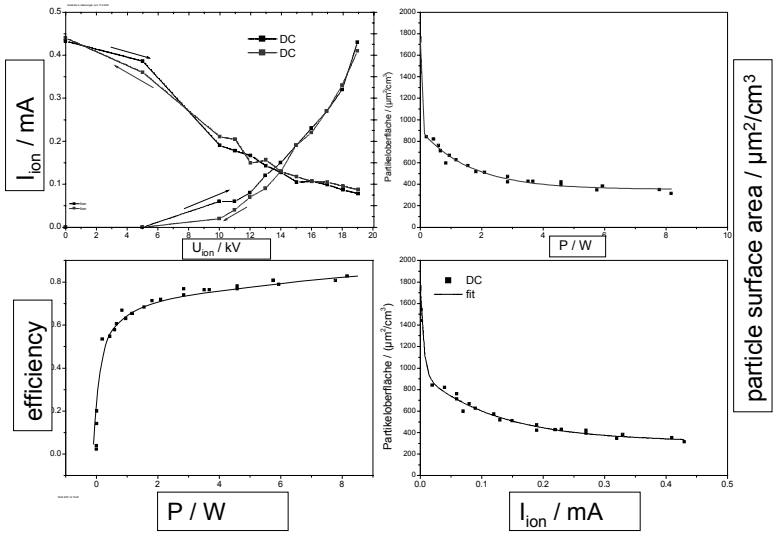
continuous operation, pellets



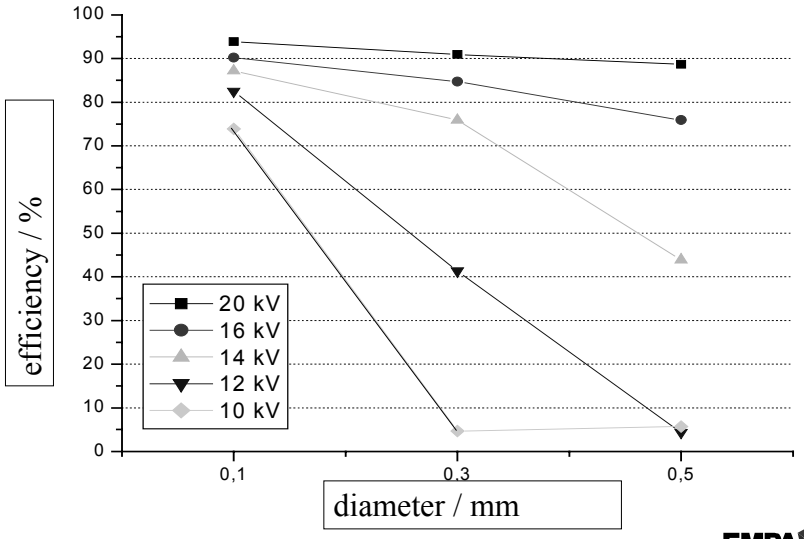
Filter Efficiency



Electrical Characteristics



Effect of electrode diameter



Conclusion

Wood combustion = important source

- ☑ **Feasibility**
- ☑ **HV supply**
- ☒ **cleaning principle**
- ☐ **prototype & field tests**
- ☐ **production**
- ☐ *other applications*

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