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Influences on particle emissions from small wood furnaces

On the combustion test stand of TFZ fine particle emissions from modern residential wood furnaces were determined. Particular focus was set on the main options for primary reduction measures. Apart from the fuel quality (mainly moisture) several operational influences were identified as major reasons for increased pollutant emissions. In general, however, it was shown, that a furnace which is operated as intended using a suitable fuel can cause quite low particle emissions.

Keywords:
emission, pm10, wood furnace, dust reduction

Abstract
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Household furnaces for wood fuels contribute significantly with a participation of 10% to fine particle emissions (PM10) in Germany. In particular the large (estimated) number of 14 million fireplaces are of considerable importance as a source of emissions. Particles with an aerodynamic diameter of less than 10 µm are classified as fine particles; below 2.5 µm diameter they are lung incursive fine particles. Such particles are considered to be especially dangerous when they arise from combustion processes since they can carry adsorbed unburned hydrocarbons or heavy metals on the surface thus serving as a transport for irritant, toxic, carcinogenic or mutagenic contaminants.

Within the scope of the experiments the importance of several influences on the particle discharge under defined conditions was investigated. The measurements were carried out on five wood burning furnaces (pellet-fired boiler, log-fired boiler, woodchip-fired boiler, tiled stove heating unit, wood burning stove). In addition to the determination of the percentage by weight of the particle discharge in the size classes <1 µm, 1 to 2.5 µm, 2.5 to 10 µm and >10 µm, the particle samples were also examined with respect to their material composition in order to form a conclusion on the quality of the particles. The determination of the particle size distribution from the flue emissions was carried out by means of a cascade impactor; the determination of the total particle content in the flue gas was made according to the VDI-guideline 2066. For the measurements on the two fireplaces a dilution tunnel was used in which the flue gas was cooled to temperatures under 60 °C (median dilution ratio 1: 5.7) whereby measurements were made in both diluted and also in undiluted flue gas.

Technology status of modern wood furnaces

Wood burning furnaces representing state of the art technology were chosen for the investigations. In Figure1 the particle emissions from these units and the distribution of the four particle size classes are shown. The measurements were taken under conditions similar to practical situations using a variety of suitable fuels so that for each combustion 10 to12 individual tests were provided. The three boiler units produce dust particle emissions between 20 and 34 mg/Nm³ (at 13 % O_2), whereby the lowest value was produced from the pellet boiler. The dust particle emissions from the two fireplace stoves are substantially higher with 58 and 72 mg/Nm³. The generally low level of dust particle emissions indicates the high state of development now achieved for wood furnaces, especially when taking into consideration that these values are clearly lower than the presently applicable dust emission threshold value in Germany of 150 mg/Nm3 for central heating boilers over 15 kW nominal heat output.

The particle size distribution of the dust emission from the respective combustions shows little variation. Only small proportions of 2 to 12 % are allocated to the particle size class >10 µm and thereby not to be considered as fine particles. Hence further observations can be limited to the total dust mass.

Influence of fuels

The quality of fuels can have a decisive influence on the amount and quality of fine particle emissions from a wood furnace. The most important criteria are moisture and ash content as well as the preparation of the fuel. In contrast, the type of wood used has only a small influence. In Fi-

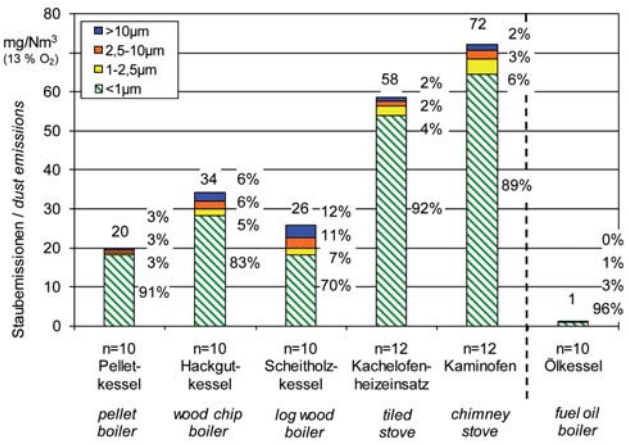
gure 2 the dust emissions from split log wood boilers using fuel with various moisture contents is shown. Whilst the increase in moisture content from 12 to 23 % has almost no effect, a further increase in moisture content to 31 % causes a considerable rise in dust emissions to over 400 mg/Nm³. In the combustion used here, fuels with water contents in this order of magnitude can no longer be burned with low emissions. In this respect the manufacturer's recommendations for maximum moisture content of 25 % are confirmed.

User influences

Together with the fuel quality there are also many possibilities to influence the harmful emissions through furnace operation. The piece size of wood used plays an important role here since this parameter is on the one hand a quality factor for the fuel and on the other hand the preparation of the wood fuel is often influenced by the user himself. Particularly in fireplaces the split log size has a decisive influence on dust particle emissions. Figure 3 shows that both small and also large pieces (with the same length and the same total mass) lead to an increase in the particle emissions, whereby too large pieces are rated as more critical than too small.

This is particularly noticeable in the values for diluted emissions. The use of large pieces of logs leads to an incomplete combustion with a high content of gaseous organic compounds in the emissions. Under these conditions there's high potential for condensable substances in emissions. These gaseous substances in the hot emissions condense during dilution and the accompanying cooling and are recorded as additional particle mass. From measurements in diluted emissions the differences between the individual variants are even more distinct and to some extent substantially higher dust particle emissions are detected. That is especially the case when the combustion process is relatively incomplete.

Fig. 1



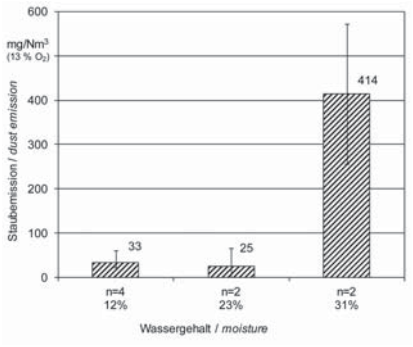
Dust emissions and particle size distribution of modern wood stoves and boiler types

The largest influence of the operator with fireplaces concerns choice of amount of fuel. In Figure 4 the dust particle emissions from a tiled stove heating unit with different load quantities are shown. The medium quantity of 4.5 kg corresponds with the manufacturer's recommendation. The dust particles measured in the undiluted emissions rose with increasing load quantities from 29 mg/Nm³ to 51 mg/Nm³. Observing the measurements in the diluted emissions, however, reveals another picture. Here both the smaller and also the larger fuel loads lead to higher emissions.

Summary

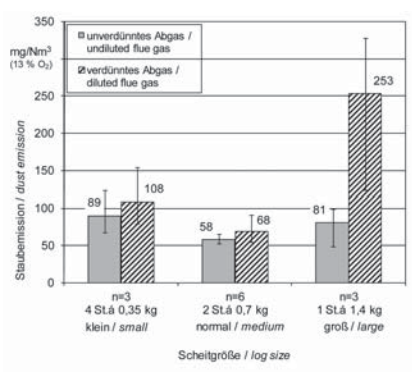
Especially with hand charged fireplaces, even without secondary control (dust separator), a considerable reduction in particle emissions is achievable by exploiting all the available possibilities. For instance by the use of suitable devices for combustion ad-

Fig. 2



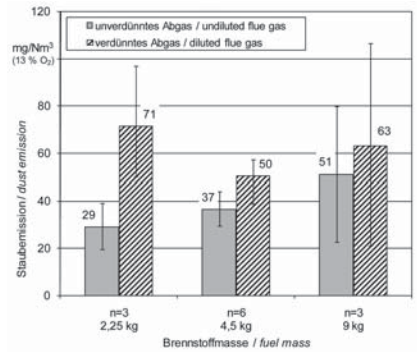
Dust emissions from a wood boiler at different fuel moisture contents

Fig. 3



Dust emissions from a chimney stove operated with different log sizes

Fig. 4



Dust emissions from a tiled stove operated with different fuel loads

justment and monitoring of fireplaces, dust-causing operator errors can be avoided. Further reductions are attainable by specific improvements in fuel quality. Low water and ash content in the fuel as well as suitably adjusted log piece size similarly lead to a reduction of dust particle emissions. The same applies to strict compliance with the manufacturer's instructions with respect to fuel loading quantities.

Authors

Peter Turowski is member of the scientific staff at the Technology and Support Centre for Renewable Raw Materials (TFZ). The relevant discipline "Biogenic solid fuels" is headed by **Dr. Hans Hartmann** and includes also **Frank Ellner-Schuberth**.

Note

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