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Straw and grain fuels for residential heating

The use of straw pellets, grain kernels, and other non-wood fuels was investigated in a combustion test stand using two special residential boilers. With these fuels, an almost complete gas burnout was achieved, while ash burnout was usually lower than for wood fuels, which reduces efficiency in the end. Increased NOx emissions are problematic in the case of non-wood fuels. For both furnaces, a largely matching correlation with the fuel nitrogen content was observed. Similar conclusions can also be drawn with regard to total dust emission, which is clearly a function of the total content of aerosol-forming elements (K, Cl, Na, S) in the biomass fuel. Thus, grain-based fuels allow significant increases in total particle emission to be achieved.

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Keywords

Grain fuels, straw fuels, waste gas emissions

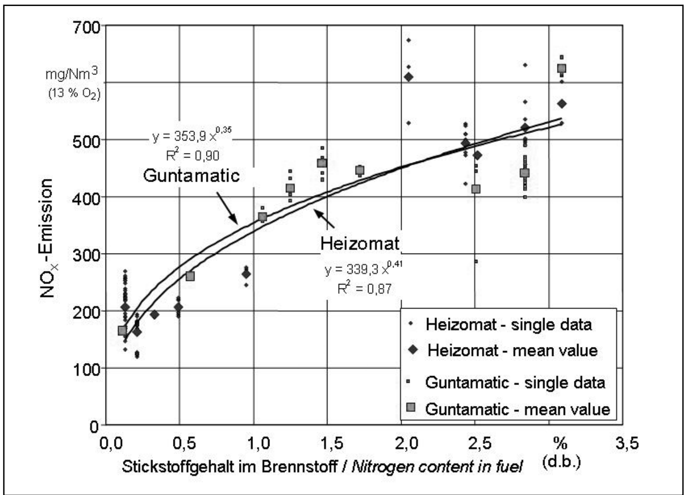

Fig. 1: NO_x emissions as a function of fuel nitrogen content, determined in two small scale biomass boilers (regression based on the mean values)

Due to unstable wood pellet prices and a beginning discussion about the availability of raw materials for pelleting, it seems appropriate to use agriculturally produced biomass also in residential boilers. For such non-wood fuels (straw pellets, grain kernels, energy plants), new boilers are currently being developed or are already being offered. In a research project, such kinds of utilization were investigated by means of practical combustion tests.

Method

Two different central boiler systems suitable for grain kernels were chosen for the trials. These were a pellet boiler from Germany (Heizomat RHK-AK 50) and a pellet and grain boiler from Austria (Guntamatic Powercorn 7-30). In these boilers, different grain kernels, straw pellets (6 mm in diameter), mill byproducts (waste, bran), chopped miscanthus, wood chips (in a pure form and as a mixture with grain kernels), as well as wood pellets were burnt. The grain kernels were used both with and without the addition of finely ground burnt lime (90% CaO).

Gaseous emissions

In almost all cases, difficult fuels, such as straw, grain kennels, or wheat bran can also be burnt relatively completely. If grain kernels were burnt in the Guntamatic boiler, for example, carbon monoxide (CO) emissions were generally below 100 mg/Nm^3 (at 13% O_2). With rye and wheat straw pellets, the 500 mg limit was never exceeded.

The emissions of unburnt hydrocarbons, which are a measure of the completeness of gas burn-out and generally ranged between 0 and 10 mg/Nm^3 here (at 13% O_2), were similarly unproblematic. Peak values of up to 65 mg/Nm^3 were only measured over a short period of time. The hydrocarbons are also responsible for the odour emissions of the boilers.

Only the NO_x emissions of the various kinds of fuel used showed clear differences. While wood fuels or miscanthus did not exceed an NO_x value of 200 mg/Nm^3, grain fuels caused emissions of approximately 400 to 600 mg/Nm^3 (at 13% O_2). Here, the main influencing variable is the nitrogen content in the fuel, which ranged between 0.1% (wood pellets) and 3.1% (wheat bran) (*Fig. 1*).

Dust emissions

Total dust emission is the most problematic parameter during combustion. Like in the case of NO_x, dust emissions also show a clear dependence on fuel composition. This can be explained as a result of different contents of aerosol-forming elements in the fuel (K, Cl, Na, S, Ph, Zn) [1]. Here, such a connection is proven with the aid of regression analysis (*Fig. 2*). Due to the individual content of these critical elements, the use of grain fuels often leads to higher dust emissions than the combustion of wood fuels. This is shown by *Figure 3*.

There is also a clear connection between the chlorine and sulphur content in the fuel and the individual pollutant emission during combustion (HCl and SO_2), which was proven here by means of regression analysis [2].

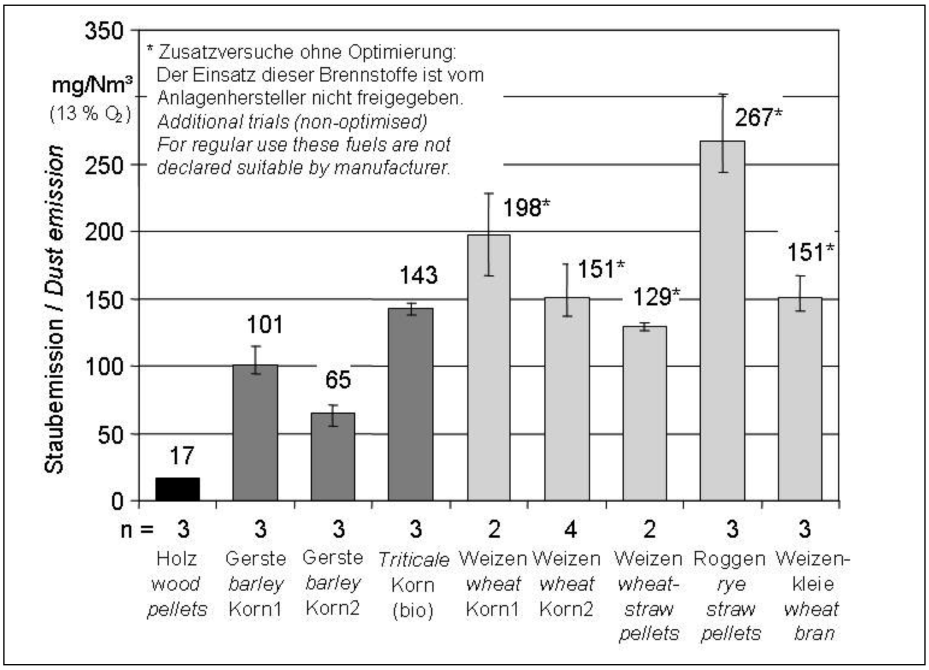

Fig. 3: Total dust emissions using various biofuels (without lime added) in a 30 kW furnace (Guntamatic Powercorn 30) at maximum heat load (n = number of measurements)

Ash burnout

Among the fuels used, gas burnout proved to be relatively inhomogeneous. While the reference fuels (chips, wood pellets) reached high burnout values of more than 90%, only approximately 30 to 80% of the grain kernel ashes burnt out. Straw pellets, however, burnt out almost completely. Ash burnout is described by the size of the ash residues as a result of ashing.

Conclusions

Difficult fuels, such as grain kernels or mill byproducts, also allow relatively complete gas burnout to be reached. However, ash burnout is often unsatisfactory, which leads to decreasing efficiency. The relatively high NO_x emissions also cause problems. The critical exhaust gas measurement value, however, is particle emission (total dust). Without secondary dedusting, it will be difficult to reach current and in particular future emission limits with grain fuels. Fuel adaptation with the aid of additives (burnt lime) or the production of mixtures with wood fuels only provide slight improvement [2]. Under the conditions of such difficult fuel applications, secondary measures (exhaust gas dedusting) are therefore desirable. Different recent developments in the field of electrostatic and filtering separators, which are intended to be available also for small boilers at low costs, however, provide positive prospects for the use of non-wood fuels even in smaller boilers.

Remark

These studies were financed by the Bavarian State Ministry of the Environment, Health, and Consumer Protection with funds from the European Fund for Regional Development (EFRD). The complete research report is available in the series “Reports from the TFZ” (issue 13). Free download: www.tfz-bayern.de

Literature

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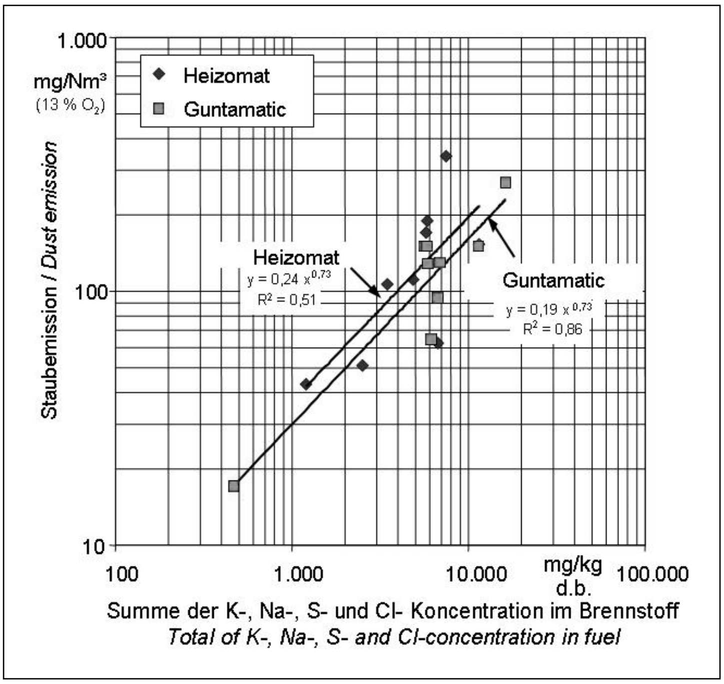

Fig. 2: Total dust emission in the fuels as a function of aerosol forming elements. Regression based on mean values from three to twelve replications per fuel