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Quality differences in biogenic solid fuels

Database work

A database for natural biogenic solid fuels has been designed and established. The essential differences in the individual quality features (element contents, calorific value, ash content and softening behaviour) have thus been documented for the most important fuels. Mathematical estimation models have been examined and derived for the calorific value and ash softening behaviour as a function of the fuel composition.

Biogenic solid fuels are continually analysed anew and assessed in relation to the individual case under review, depending on the specific questions raised in research and practice. The large variety of influencing variables and the high number of analysis parameters make a general assessment difficult, especially since reliable statements can only be made when a sufficiently large database is available. Broad-based research and surveys were carried out to expand this database, and fuel types which have so far not been the major subject of examination were analysed specifically.

Structure of the database

A relational database model was used for systematic data survey. Its structure was designed in such a way that in addition to the actual measured variables, a large number of further properties and information data on the fuel and its origin features, as well as the analysis processes used, could be recorded [1]. Selective data queries can thus be linked with certain conditions. Altogether more than 1250 data sets have been compiled so far.

Evaluations on fuel differences

The database functions were linked with special evaluation routines on extreme value limiting, computation of frequency distributions and other statistical characteristic quantities. The purpose was to characterise those fuel types encountered most frequently in practice as exactly as possible.

Corresponding evaluations show the general advantages of the various wood fuels compared with most of the straw-type crops examined (grain straw, whole grain plants, meadow grasses, miscanthus). These advantages also include the higher calorific value, which is on average about 9% more, and an approx. 3 to 6 per cent lower ash content.

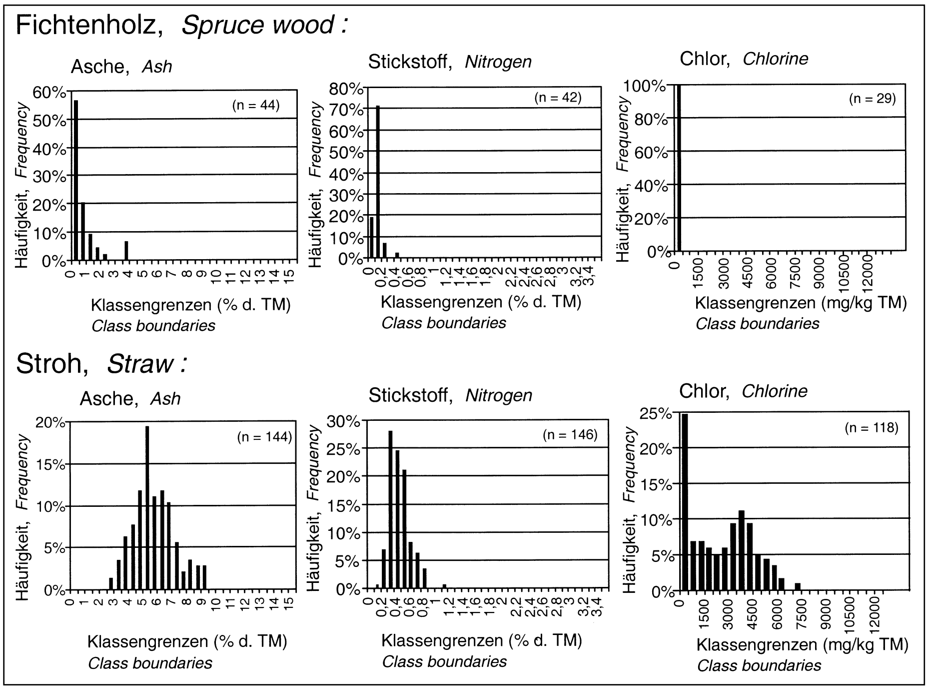

Fig.1: Frequency distribution of measurements for selected quality parameters of spruce wood (with bark) and straw (wheat, rye, triticale)

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Technical support for the work was provided by the Bavarian State Ministry for Rural Development and Environmental Issues and by the Bavarian State Office for Environmental Protection.

Keywords

Energy, fuels, data base, bioful, quality

Forest wood (plus bark component) shows the best values here with on average about 0.5 % in the dm, whereby major overstepping of this is attributable to secondary soiling/contamination. This can be concluded from the distribution curve for analysis values of spruce wood, which tends strongly to the left (*figure 1*).

There are disadvantages for straw-type fuels in connection with the ash softening behaviour according to DIN 51730 too. Whereas wood and bark are non-critical with temperatures of about 1200 °C (start of sintering) and 1300 to 1400 °C (softening point), the corresponding temperatures for straw-type fuels are nearly all below 1000 °C (start of sintering) and 1200 °C (softening point). Thus caking, faults and corrosion effects can occur during incineration.

The relatively unfavourable assessment of straw-type fuels continues with regard to the nitrogen, chlorine and potassium contents. The chlorine content of these fuels is generally higher than that of wood fuels by a factor of 10 to 30 [1]. Connections with fertilising practice are evident here. Since data for washed out „grey“ straw are also considered, there is a strong „left-peaking“ course for the frequency distribution of the chlorine measurements (*fig. 1*).

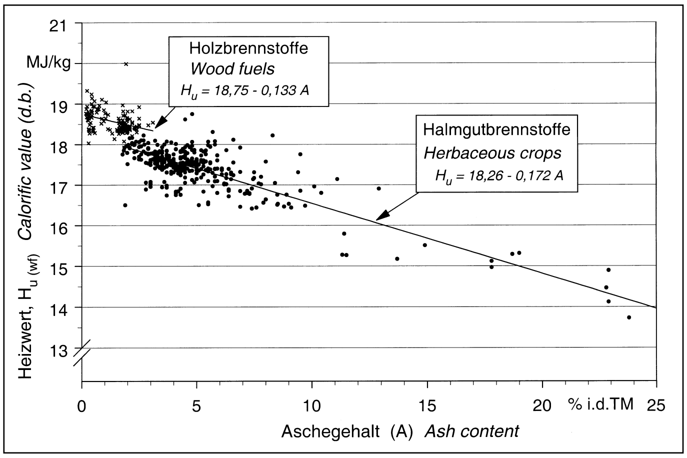

Fig. 2: Lower calorific value of the dry matter (H_u (wf)) versus ash content (A) of wood and herbaceous fuels

A converse picture is shown for the heavy metal contents, where the annual crops are at an advantage thanks to their lower accumulation period. Conifer bark in particular assumes a leading position with relatively high concentrations (for arsenic, cadmium, cobalt, iron, mercury, manganese, molybdenum, nickel and zinc). In the other woody fuels a distinction must be made between short rotation plantation crops and slow-growing forest timber. The latter nearly always have higher heavy metal contents – generally much higher – than short rotation plantation timber (poplars and willows), which do not have any disadvantages by comparison with straw-type fuel either. On the contrary, these have the lowest pollution values as regards nickel, chromium and above all mercury, lead and molybdenum.

General evaluations

The large number of data records also made it possible to examine different connections which apply for biogenic solid fuels in general. For example, the quantitative effect of the ash content on the calorific value is shown in *figure 2*, taking wood and straw-type fuel as an example.

The calorific value of anhydrous matter can also be estimated from a series of further ingredients, however. For low-oxidation fuels (coal) a series of approximation formulae are known. In a comparison nine of these formulae were examined with 295 data records from the database. The approximation formula according to BOIE [2] provided the best agreement with the analytically determined calorific value (in MJ/kg) here:

$$H_{u\,(wf)} = 34{,}8\,C + 93{,}9\,H + 10{,}5\,S + 6{,}3\,N - 10{,}8\,O$$

In this the element contents C, H, S, N and O are stated in % dry matter. When this formula is used a mean error of 4 % is to be reckoned for biogenic solid fuels.

The temperatures at the start of sintering (T_{SB}) and at the softening (T_{EP}) and flow (T_{FP}) points of the ash also depend on the fuel or ash composition. Corresponding estimate functions were derived from altogether 67 data records. According to the results, in the case of biomass the ash softening behaviour depends chiefly on the K, Ca and Mg concentration (in % of the fuel dry matter), while potassium and magnesium tend to lower the melt-point and thus have a disadvantageous effect.

Sintering start T_{SB} (°C) = 1159 – 58,7 K + 237,9 Ca – 743,8 Mg

Softening point T_{EP} (°C) = 1172 – 53,9 K + 252,7 Ca – 788,4 Mg

Flow point T_{FP} (°C) = 1369 – 43,4 K + 192,7 Ca – 698 Mg

Conclusion

Alongside special fuel assessment, the database also offers a variety of opportunities for identifying general connections and influences on fuel features. However it is only expedient to carry out many more in-depth evaluations once a sufficiently large data quantity is available. That is why the scope of the database is being constantly extended.

Literature

Books are signified with •

[1] *Hartmann, H., T. Böhm* und *L. Maier*: Umweltrelevante Eigenschaften naturbelassener biogener Festbrennstoffe sowie Möglichkeiten zu deren Beeinflussung. Bayerische Landesanstalt für Landtechnik (Freising) und Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen (Hrsg.), Selbstverlag, München 1999, Reihe “Materialien” (in Druck), 155 S.

[2] • *Netz, H.*: Verbrennung und Gasgewinnung bei Festbrennstoffen. Technischer Verlag Resch, München, 1982, 195 S.