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THE CURRENT STATE OF AUSTRIAN PELLET BOILER TECHNOLOGY

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1 AUSTRIAN PELLET MARKET

The market for pellets in the residential sector in Austria is presently expanding rapidly. About 30 manufacturers of small-scale pellet furnaces are currently active. The number of newly installed pellet furnaces per year has shown a clear increase since 1997 and levelled at 4,930 pellet furnaces in 2001 [1]. An overall number of 12,270 pellet central heating systems with an entire nominal boiler capacity of about 220,000 kW have been installed in Austria until the end of 2001. One reason for the strong increase were the investment subsidies granted at provincial level for new pellet furnaces and for the changeover to pellet furnaces (on average 25 % of the investment costs). Furthermore, the strongly increased price for heating oil contributed to the market growth within the last two years.

At present, the use of pellets in Austria is confined to small-scale systems with a power range below 100 kW_{th} (nominal boiler capacity), i.e. mainly the residential sector.

Regarding pellet production, currently 12 producers with a production capacity of about 200,000 t/a are active in Austria. The annual production has risen from 15,000 tons in the year 1996 to 120,000 tons in the year 2001. A pellet output of about 150,000 t is forecasted for the year 2002. Different prognoses for the year 2010 estimate annual pellet production to range between 200,000 and 900,000 tons [2; 3]. The raw material potential available for pelletisation is sufficient to cope with this increase but will meet competing markets.

2 REGULATIONS IN AUSTRIA

The pellet quality is regulated by ÖNORM M 7135 and the standard of the Austrian Pellets Association. The supply of pellets in Austria is assured throughout the country by a well organised distribution network.

The quality of pellet furnaces is regulated by ÖNORM EN 303-5. This standard is valid for heating boilers for solid fuels (biomass and fossil fuels), which can be fed manually or automatically, with a nominal boiler capacity up to 300 kW_{th} including furnaces fired by pellets. Type tests according to this standard are required by law. The standard comprises regulations regarding terminology, requirements, testing and marking.

The requirements regarding the boiler efficiency for heating boilers for solid fuels increase with increasing nominal boiler capacity from 76 % (nominal boiler capacity < 10 kW_{th}) to 86 % (nominal boiler capacity > 200 kW_{th}). The minimum thermal output where the emission limits can be kept must not exceed 30 % of the nominal boiler capacity.

Emission limits for heating boilers burning solid biomass fuels have been fixed for organic carbon (40 mg/MJ_{NCV}), carbon monoxide (500 mg/MJ_{NCV}), NO_x (NO_2) (150 mg/MJ_{NCV}) and dust (60 mg/MJ_{NCV}). These limits are valid for automatically fed systems.

3 PELLET BOILER TECHNOLOGY IN AUSTRIA

Pellet combustion systems used in Austria are mainly pellet central heating systems offered as total systems. Furthermore, pellet burners for use in existing boilers (replacement of e.g. old oil burners, common system in Sweden) are also applied in Austria but only to a small extent. Pellet single stoves placed in the room to be heated (with or without water jacket) are also in operation for room heating and for new houses with a low energy requirement. Pellet heating systems are also used in micro-district-heating systems (so called micro grids) and by smaller industrial consumers. The market for medium-scale pellet furnaces with a nominal boiler capacity between 100 and 1,000 kW_{th} is in an early development stage in Austria. Large-scale pellet fired systems are not applied in Austria at present.

Screw conveyors (flexible or inflexible) or pneumatic systems as well as combinations of these technologies are usually used for feeding the pellets from a storage room to the furnace.

The most common applications in the residential sector in Austria are storage rooms with a storage capacity of 100 to 150 % of the annual fuel demand (83 % of the users in the residential sector have such systems in operation). Stores integrated in the heating system are also used. Such stores must usually be filled manually once or twice a month, depending on the storage capacity and are used by about 17 % of the residential consumers. Underground storage tanks are of minor importance, but represent a space-saving opportunity.

Measures against the danger of a burn-back from the furnace to the storage room or tank are of great relevance and required by law in Austria. Such a protection can be provided by an automatic extinguisher system, a cellular wheel sluice or a fireproof valve. Moreover, systems with a fall shaft achieve this protection effectively through the separation of the feeding system and the glow zone.

Depending on the way how the pellets are fed into the furnace, three basic principles of wood pellet combustion systems can be distinguished, i.e. underfed burners, horizontally fed burners and overfed burners.

In underfed (also called "underfeed stoker" or "underfeed retort furnace") and horizontally fed burners a so-called stoker screw feeds the fuel into the combustion chamber from below. Depending on the design, the flame burns horizontally (as for the horizontally fed burner) or upwards.

In overfed burners the pellets conveyed from the storage tank by the conveying screw fall through a shaft into the glow zone at the grate. An advantage of this system is that a very accurate dosing of pellets according to the current power demand is achieved. A disadvantage is the

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impact of the falling pellets on the glowing bed of embers, leading to an increased release of dust and unburned particles as well as to an unsteady combustion behaviour on the grate. The separation of the feeding system and the glow zone prevents an afterglow when the furnace is turned off and furthermore ensures an effective protection from burn-back into the storage room, because the pellets in the screw have no direct connection with the glow zone.

Air staging is of great importance for a complete combustion and low emissions. This is possible by separating the combustion chamber into a primary combustion zone and a secondary combustion zone, each zone having a separate air feed. The splitting of the combustion chamber prevents the mixture of primary with secondary air and enables the operation of the primary combustion zone as a gasification zone with an understoichiometric air ratio. This is of importance for an efficient reduction of NO_x emissions. The ultimate oxidation of the flue gas takes place in the secondary combustion zone, therefore an optimised mixing of flue gas and secondary air is of great relevance. This can be achieved by an appropriate furnace geometry and air nozzle design. Moreover, a long enough residence time of the hot flue gas in the furnace (appropriate furnace volume) to achieve a complete burnout of combustible gases has to be ensured.

The combustion technologies used for pellet combustion must fulfil high demands in order to ensure a trouble-free operation and a high operational comfort for the consumer. In this context an automatic operation as well as appropriate and resistant materials for the combustion chamber are of great importance, because the service life of the furnace depends in particular on the material used. The combustion chamber can be made of stainless steel, firebrick or silicon carbide. Stainless steel is a cheap material with a low heat storage capacity, which allows quick start-ups and shutdowns, but has a limited residence regarding corrosion. The slagging hazard of stainless steel is lower than that of firebrick. Combustion chambers made of firebrick are more expensive and have a high thermal capacity. Silicon carbide is a material well suited for use in combustion chambers because it does not react with the ash and therefore is resistant to deposits but it is quite expensive.

An automatic operation of a pellet furnace can be achieved by a combined load and combustion control.

The load control is guided by the feed water temperature and determines fuel and primary air feed.

The combustion control can be guided by the O_2, the CO or the O_2 and CO concentration in the flue gas (lambda, CO or CO/lambda control) and determines the secondary air supply.

Proven lambda control sensors for measuring the oxygen concentration in the flue gas are available on the market. Sensors for carbon monoxide are very expensive, therefore usually cheaper sensors detecting the amount of unburned gaseous compounds are in use for small-scale heating plants.

The O_2 control is relevant regarding the efficiency and emissions, the CO control is relevant regarding emissions. The combination of these two control systems ensures low emissions at high efficiency. This CO/lambda control is the best approach, because optimal lambda values depend on load and fuel water content.

Temperature control should take place by flue gas recirculation or water-cooled furnace walls. Finally, the negative pressure control in the furnace usually takes place by an induced draught fan. In modern Austrian pellet combustion systems the whole process control is microprocessor based.

Vertical fire tube boilers (one or three-pass boilers) are usually used in small-scale pellet combustion systems. In fully automatic boiler cleaning systems the fire tubes are equipped with spiral scrapers driven by an electric motor, while semi-automatic systems use spiral scrapers operated from the outside by means of a lever. Some of the boilers presently used must be cleaned manually. Automatic boiler cleaning systems increase the efficiency and reduce dust emissions.

Various de-ashing systems are used in pellet furnaces. The ash from the grate or the retort as well as the fly ash settled in the combustion chamber is usually collected in an ash box. This ash box must be emptied periodically (depending on the size of the ash box, usually once or twice per month). Some manufacturers use ash compaction systems. In such cases the ash must still be emptied periodically, but over longer periods of time. Fully automatic de-ashing systems, where a screw conveyor discharges the ash in an external container, are also available on the market. Such external ash containers must be emptied only about once a year.

4 EMISSIONS

A comparison of emission factors for carbon monoxide, organic carbon, NO_x and dust measured both on test stands and in field measurements in Austria show that the emission factors determined during field measurements are usually higher than those from test stands. Furthermore, these measurements show that the emission factors mentioned above are below the corresponding limiting values, both for test stand and field measurements. A comparison of the emission factors for carbon monoxide and dust of old (1996 – 1998) and new (1999 – 2001) pellet furnaces shows a decreasing tendency of these emission factors (based on test stand measurements). No differences between old and new pellet furnaces could be detected in regard to organic carbon and NO_x emissions. The emissions of organic carbon are usually near the detection limit (due to the low CO emissions) and therefore no tendency could be found. The NO_x emissions mainly depend on the fuel nitrogen content and therefore no clear trends could be detected [4; 5; 6]. NO_x reduction by primary measures is possible, e.g. by air staging in combination with a sufficient residence time and temperature of the flue gas in the primary combustion zone.

5 FUTURE DEVELOPMENTS

In general, Austrian pellet furnace technology has already achieved a very high state-of-technology. Nevertheless, Austrian manufacturers are aiming at several future improvements. CFD-aided furnace development and optimisation is a promising future application in the small and medium-scale sector. Medium-scale pellet combustion systems with nominal boiler capacities up to 500 kW_{th} are starting to enter the Austrian market. Moreover, Austrian pellet boiler manufacturers also concentrate on the implementation of

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small-scale dust burners (utilisation of pulverised pellets), the combination of pellets and solar systems as well as on small-scale CHP systems (e.g. Stirling engines) as future developments. Further objectives cover R&D projects to reduce emissions, especially particulate emissions, and to utilise herbaceous / non-woody biofuels in small-scale applications.

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