HI-SMART

HI-SMART: HIGHER EDUCATION PACKAGE FOR NEARLY ZERO ENERGY AND SMART BUILDING DESIGN

MODULE #4

CHAPTER 5: BIOMASS

Co-funded by the Erasmus+ Programme of the European Union

MŰEGYETEM 1782 STU SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA TECHNISCHE UNIVERSITÄT KAISERSLAUTERN ENERGIAKLUB CLIMATE POLICY INSTITUTE APPLIED COMMUNICATIONS

4.5.1 BASICS OF THEORY

ENVIRONMENTAL DIRECTIVES

Our energy supply is declining day by day, which we need to replace and replace with alternative solutions. Nearly 40% of the energy used is used by buildings, in many cases with high CO_2 emissions and inefficient equipment. The European Union aims to reduce greenhouse gas emissions by 20% by 2020, increase the use of renewable energy to 20% and increase energy efficiency by 20%. These targets were set back in 2007, but 2030 will appear as an additional target date in the medium term. At that time, I want to reduce greenhouse gas emissions by 55% compared to 1990 levels. The goal is to achieve climate neutrality by 2050. [1] In the field of building services, the use of renewable energy equipment is the key to achieving the objectives. These include heat pumps, solar energy systems, biomass systems, systems, and so on. For solid and biomass fired plants, standard EN 303-5 provides guidelines for efficiency, emissions, safety and other parameters for plants of different capacities and designs. [2]

INTERPRETATION OF BIOMASS

In HVAC systems the use of renewable energy equipment is a solution to achieve the goals. These include heat pumps, solar systems, biomass systems, etc. It is necessary to clarify what biomass means. Biomass is our largest source of energy after coal, oil and natural gas, accounting for approximately 35% of energy consumption in developing countries. Based on the production of biomass, it can be divided into three groups:

• Primary biomass: natural vegetation (agricultural crops, forest, field, etc.),

• Secondary biomass: main and by-products of wildlife and animal husbandry,

• Tertiary biomass: a by-product of manufacturing industries, a by-product of human activity.

In comfort building engineering, we usually use primary biomass, the two most common types of which are pellets and wood chips, as they are highly automated, providing comfortable firing and operating conditions, but the logs burning fuel is often used.

In terms of agriculture, we can talk about the typical production and utilization of primary and secondary biomass, which is able to meet the fuel needs of comfort building services. Crop production for energy purposes provides an opportunity for producers, as they are still engaged in agricultural production, but the crop produced can be used as a renewable energy source.

Solid biomass is defined as plants grown for this purpose and intended for energy use, or as a set of by-products and waste from agriculture, forestry and the wood industry. As a by-product of arable crop production, cereal straw, corn stalks and cobs, as well as other plant stem residues can be used for firing purposes. Of course, the by-products of the plantations can also be utilized: vines, fruit trees, etc. Depending on the material, the waste generated is dried, baled, shredded, mixed and then finally briquetted or pelletized. The calorific value of the fuel thus obtained exceeds the calorific value of some lignite, with a low sulfur content. As it mentioned earlier, the care of energy forests is a special branch of agriculture. Typically, non-agricultural areas are used for this purpose, where special tree plantations are planted, which can be harvested in large quantities in the shortest time, cheaply, with good combustion characteristics. The shortest cutting round is 1-4, while the longest is 20-25 years. Excellent varieties for this purpose e.g. hornbeam, maple, linden, willow, acacia.

Of course, not only solid biomass can be produced, but it is also a liquid energy carrier and can be made from agricultural products. For this purpose, plants with a high oil or fat content are used, for example. canola, sunflower, or soybean. This type of fuel is lead and sulfur free with a high octane number. Typical fuel produced is bioethanol, biomethanol.

During the utilization of secondary biomass, biogas is formed during the decomposition, fermentation and rot of plant and animal residues. According to its composition, approx. 65-66% methane, 31% carbon dioxide, 3-4% other gases. Its characteristic odor is due to sulfur-hydrogen. Suitable feedstocks for biogas production include by-products of sugar beet processing, some grasses, etc. The produced biogas can be utilized in a form similar to LPG. In the point of view of HVAC systems the use of these materials is not so typical.

Almost all organic materials, such as manure, faeces, food by-products, household waste, etc., can be used to produce additional biogas. [3] [4]

As it mentioned above, the typically used biomass fuel for heating is primary biomass, which is one of the oldest forms of heating. Whether logs or pellet will be burned, there’s no difference between the processes that take place. Wood is a solid fuel, but it burns the majority (83% by weight) as wood gas. The percentage by mass burned in the gaseous form gives about 70% of its calorific value. Wood burning with a high flame of wood gas needs a large firebox. Excess oxygen-rich fresh air (preheated secondary air) heated around the gas flame must be provided, which is necessary because the energy-rich wood gas formed burns in this way. Because wood is a material grown in nature, the developmental stages of woodfire are not, or are only, very difficult to describe quite accurately. Rising temperatures and the combustion processes themselves are gradually pushing inwards from the surface of the wood. The moisture remaining in the air-dried wood is still 15-20% by weight. This moisture only leaves the wood at temperatures around 100 ° C. The components of wood begin to become liquid at the same time, their molecules begin to split and evaporate, and at 100-200 ° C the gases formed leave the wood very slowly. The earliest formed wood gases are ignited by the flame of the ignition paper, however, if the ignition flame is lost, the combustion process would stop. Up to 225 ° C, heat must be transferred to the wood so that the combustion process does not stop. This endothermic process is replaced by an exothermic process at an order of magnitude of 260 ° C, when excess heat is already generated. It decomposes completely and oxidizes to the reactive components of wood gas on the order of 1000 ° C to carbon and hydrogen. This means that perfect combustion requires a high temperature to prevent the release of imperfectly split hydrocarbons through the flue gas exhaust system into the environment. Perfect combustion produces CO2 and H2O. From an environmental point of view, therefore, wood burning is considered to be carbon neutral, as it releases just as much CO2 as it emits during its lifetime. Due to the fast-escaping wood gas, not enough oxygen reaches the surface of the piece of wood, so it is increasingly converted into charcoal, which heats up at 50-800 ° C, as pure charcoal burns practically without flame, so it is not suitable for fireplaces, but is excellent for garden grilling. Solid fuel can be divided into combustible and non-combustible components. Combustible components are carbon, hydrogen, and sulfur. Non-combustible components are oxygen, nitrogen, moisture, and ash. Combustion of combustible biomass is simplified as follows:

$$C+O_2=CO_2$$

$$2H_2+O_2= 2H_2O$$

$$S+O_2= SO_2$$

DETERMINATION OF COMBUSTION AIR

To determine the actual amount of air needed for combustion, we need the amount of theoretical oxygen and the value of the excess air factor. A larger amount of air than the theoretical one must be used to burn the fuel perfectly. Excess air is expressed as an excess air factor (λ), which gives the number of times the air actually used is the theoretical air demand. The theoretical amount of air required can be determined from the following equation:

$$O2_{theo}=1,867C+5,6H_2+0,75S-0,7O_2\ [Nm^3/kg]$$

Theoretical air demand contains 21% O2 and 79% N2. Based on this:

$$L_o=1/0,21*O_{2theo}=4,76O2_{theo}\ [Nm^3/kg]$$

Knowing the theoretical combustion air and the excess air factor, we can determine the amount of actual combustion air:

$$L_v=\lambda*L_o\ [Nm^3/kg]$$

The standard cubic meter (Nm3) is the volume unit of gas at 0 ° C (273.15 K) and 1.013bar. The value of the theoretical flue gas quantity is also required to determine the value of the excess air factor. This is defined as follows:

$$1,86*C+0,683*S+11,1*H_2+O_{2theo}*3,72=CO_2+SO_2+H_2O+N_2\ [Nm^3/kg]$$

The diagram below shows the combustion air demand of a solid fuel appliance of different capacities for combustion air at different temperatures. [5]

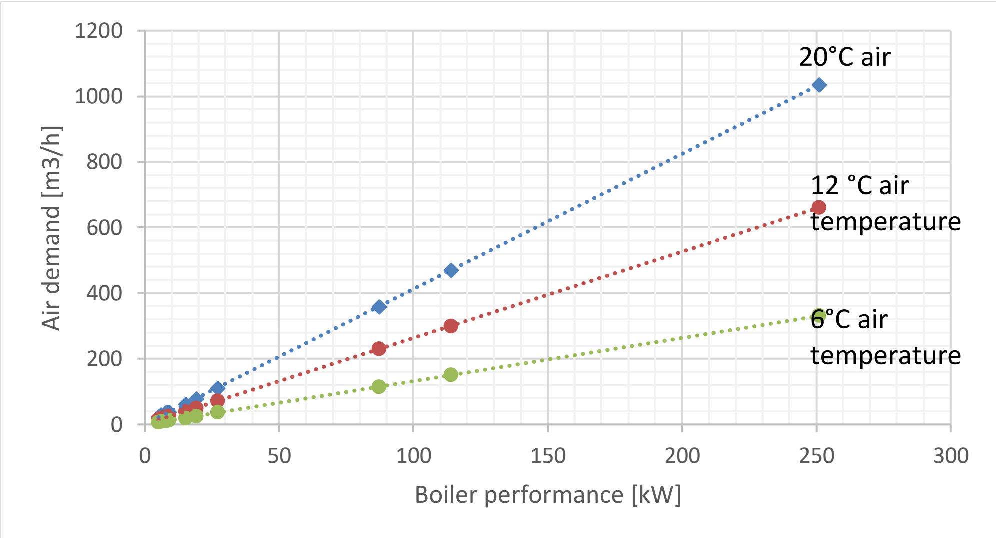


figure 4.5.1: Combustion air demand of solid fuel devices

It can be observed that the amount of combustion air required for a unit with the same power depends to a large extent on the room temperature, so a fireplace installed in a living space must provide more combustion air than a unit with the same power in an unheated room.

The use of proper combustion air is the most important parameter for operating the equipment. It affects not only the power that can be extracted, but also the amount of pollutants emitted, as the quality of combustion depends on it. Figure 4.5.2 is a diagram illustrating the burnout of a charge in a manual solid fuel boiler, with different amounts of combustion air provided to burn each charge.

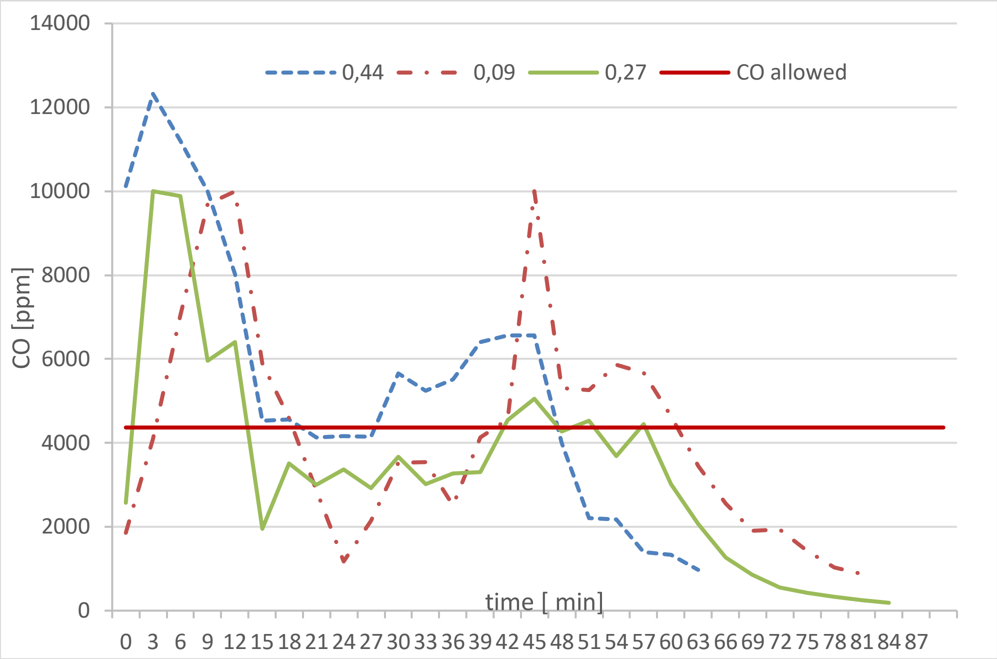


figure 4.5.2: CO emissions from a solid fuel boiler with different combustion air supplies

The dimensionless curves in Figure 4.5.2 indicate the combustion air for each plant with a flow rate. The flow rate is the quotient of the free combustion air inlet cross-section and the nominal air intake cross-section. It can be observed that the combustion process is characterized by high CO emissions even in the case of too high or too low combustion air quantities, which differs greatly from the emission limit value set in the figure as a constant line. With a properly sized combustion air supply, the emission values can be kept within the permissible range after the normal firing stage has been reached. In the case of automatic dosing boilers with adequate combustion monitoring (e.g. automatic dosing pellet boilers), the emission values are much more favorable in the normal firing phase. [6]

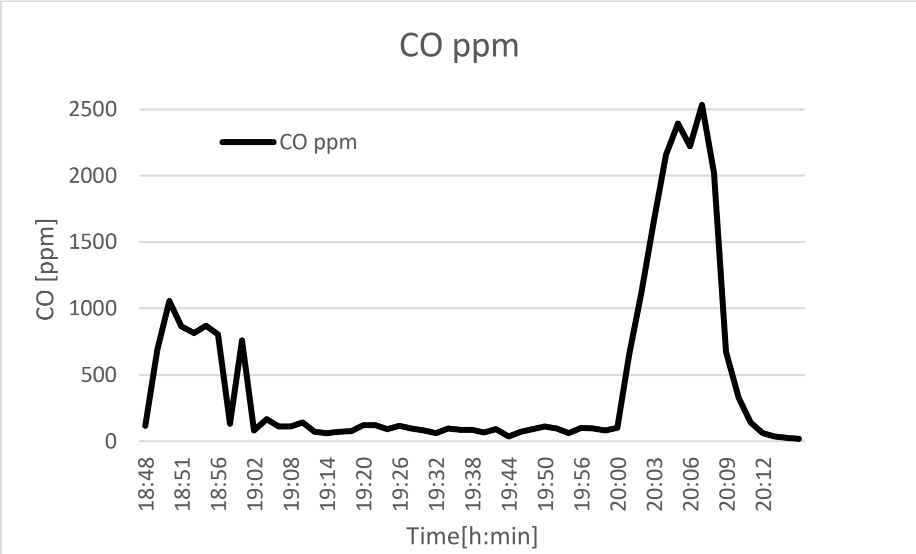


figure 4.5.3: CO emissions for automatic pellet boiler

It can be seen in Figure 4.5.3 that the carbon monoxide emissions are constant during the normal firing phase following the heating phase. This value is maintained by the boiler automation until the appliance is switched off. When switched off, a large amount of air is mixed into the combustion chamber of the appliance by the boiler fan, which suppresses the fire burning inside. High CO emissions indicate imperfect combustion entering the declining phase.

FIREPLACE AIR SUPPLY

In the case of fireplaces, the determination of the combustion air works on the same principle as described above. However, in the case of fireplaces, special needs means that they are placed in the living space. As these devices operate in long-term living quarters, an adequate air supply also plays a life-saving role. Modern residential building layouts are characterized by a central design of the kitchen-living room-dining room, in which these devices are placed. The operation of a fireplace based on the principle of gravity discharge is adversely affected by any forced flow generating equipment that can suck out the exhaust product. In the case of the aforementioned residential building arrangement, such a device can be e.g. the kitchen has a cooker hood. In the case of open-burning fireplaces, it is necessary to lock the devices that create the forced flow, independent of the operation of the fireplace, so that their joint operation cannot develop. A more modern solution is to use enclosed-type

figure 4.5.4: Closed combustion chamber fireplace (www.ecofire.hu)

fireplaces that suck combustion air into the firebox through a sized air duct. This air supply can also be implemented in the case of scaled, gravity-operated or flue-gas fan equipment. The essence of the plant is that the entire operation of the fireplace is independent of the room air. The interpretation of the complete chimney circuit is discussed in the chapter on flue systems.

4.5.2 MAIN ELEMENTS OF BIOMASS FUEL SYSTEMS

A systems approach is also important and essential for biomass fuel plants. It is not enough to simply inspect the equipment, the entire system must be designed together with the associated system components. Biomass fuel-based heating and domestic hot water production systems consist of four basic pillars. The main component of the system is the boiler, which is directly connected to a flue system. The air supply discussed above can be considered as the third system element and finally, but not least, the system becomes complete with the supplied heat dissipation and heat storage system elements.

BOILERS

In the case of heating residential and public buildings with a central biomass boiler, we can distinguish the combustion equipment from several perspectives:

- in terms of fuels used,
- in terms of firing technology,
- manual, or automatic dosing,
- with- or without automatic combustion regulator, etc.

In the following, we approach the main parameters and main operating characteristics in terms of manual or automatic dosing. In modern building engineering, energy efficiency, environmental awareness and outstanding comfort meet the most important requirements that an end user expects from a piece of equipment.

MANUAL-FED BOILER

figure 4.5.5
www.netkazan.hu

Conventional boilers are typically made up of three main segments. In the middle there is the firebox, below it the ash door, which is also the draft regulator of the combustion air, and above the firebox the secondary air inlet, which can also be used for maintenance and cleaning. For safety reasons, there is a boiler temperature limiting valve in the boiler that maximizes the flow temperature leaving the boiler. The valve is connected in a chain to the boiler's draft control door, which controls the amount of combustion air entering the firebox by continuously moving it. If the water temperature in the boiler approaches the set limit, it reduces the output by closing it continuously, preventing any overheating. This procedure is impeccable from a safety point of view, but it is unfavorable in terms of recoverable power or emissions.

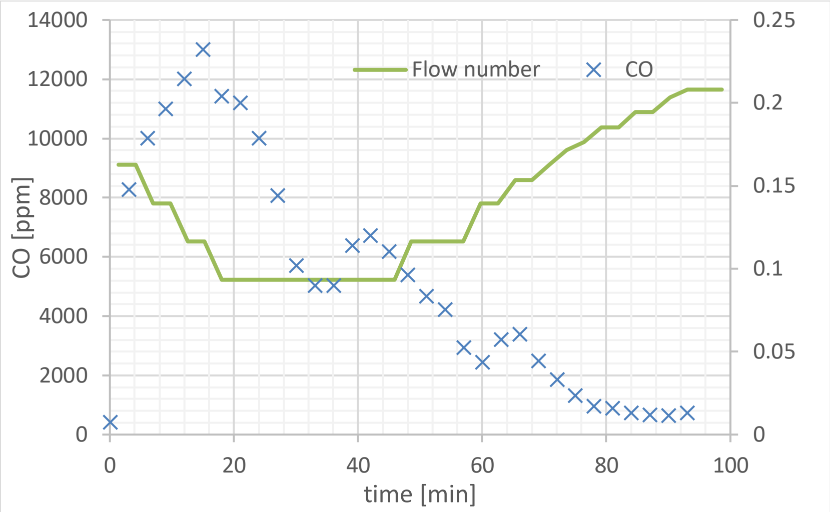


figure 4.5.6: Development of CO emissions due to draft control [6]

Figure 4.5.6 shows the effect of continuous movement of the draft regulator on the carbon monoxide emitted. Continuous movement of the safety valve "spoils" the firing, resulting in high CO emissions. Compared to Figure 4.5.2, it can be observed that with a properly adjusted air supply, the amount of CO emitted is demonstrably lower. The efficiency of these plants reaches around 75-80%, but is highly dependent on the quality of the fuel burned. When burning logs, the moisture content of the fuel can be a high risk, which greatly affects the efficiency of the boiler, its emissions and the output that can be extracted.

WOOD GASIFICATION BOILER

Compared to conventional solid fuel boilers, the operation of wood gasification boilers shows a more energy-efficient, modern solution. In the case of equipment operating on the principle of tradition, the charge placed in the firebox burns through simple control processes as described above. Much of the recoverable power is discharged through the flue. Thanks to the special design of wood gasification boilers, it can also burn gases that burn at higher temperatures, thus providing a much better efficiency for the equipment. This type of combustion can only be achieved with an adequate supply of combustion air. In the case of devices with a rudimentary design, this was controlled only mechanically by air dampers. In the case of more modern boilers, the combustion air is solved with combustion air fans controlled by an electronic controller. There are two technical solutions to this design. In one case, the combustion juice is pushed by the fan so that the colder air surrounding the boiler passes through the fan, extending its life. In the other design, the fan sucks the combustion air on the flue gas side, so that the very high-temperature combustion product also passes through it, which means a higher load on the system component. State-of-the-art wood gasification boilers can achieve efficiencies of 90-93%, and a full charge is used in the firebox for up to 12 hours. This not only gives us energy-efficient equipment, but is also much more convenient in terms of operation compared to conventional solid-fuel equipment!

AUTOMATIC FEEDING PELLET OR WOOF CHIPPED BOILER

The most efficient and most automated type of combustion equipment that can be used in single-family homes is the automatic feed pellet or wood chip boiler. The control of the combustion air of the device is similar to modern wood gasification boilers, here too it is done through a controlled fan. Thanks to the fine-grained fuel, the pellets or wood pulp can also be delivered to the unit via an automatic feeding system. There are several ways to dispense fuel, some examples of which are shown below. The lambda probe integrated in the flue gas nozzle is responsible for the combustion monitoring, which typically regulates the amount of oxygen in the combustion product. With the help of the oxygen sensor, the automation signals the fan and the fuel supply system. These devices can modulate a very wide spectrum depending on the product. More advanced products can operate in the power range of up to 30-100%. As a result, the equipment competes with modern gas boilers in terms of operation.

In the laboratory, we tested the combustion efficiency of the equipment with several different pellet compositions, at the same modulation level.

The composition of the fuels burned is given in Table 1.

Table 4.5.1 Types of fuels burned

	Fuel Type				
Characteristics	100% beech	100% pine	100% pine, w/ bark	50% beech -50% oak	30% beech, 30% oak, 30% alder, 10% pine
Heating value [MJ/kg]	20.00	19.00	17.69	17.45	17.53
Ash content [%]	0.50	2.35	2.42	0.98	0.77
Coal content [%]	44.0	46.2	47.1	46.34	47.2
Hydrogen content [%]	6.50	5.60	5.80	5.48	5.49

Nitrogen content [%]	0.75	0.31	0.34	0.83	0.356
Sulfur content [%]	0.05	0.062	0.086	0.053	0.055
Oxygen content [%]	42.0	39.2	39.32	39.07	40.25

The measurements lasted for 100 minutes for each of the different pellets, starting from the warm-up phase of the device until the device was switched off. The operation of the device can be divided into the following sections:

1. Ignition Preparation (Pre-ventilation),
2. Cold Start,
3. Heating Stage,
4. Normal Stage,
5. Burnout Stage.

From the pellet compositions shown in Table 4.5.1, it can be clearly seen that the various components differ slightly from each other, so the expected significant difference in terms of combustion efficiency did not occur (Figure 4.5.3). There was a difference of less than 4% between the highest and the lowest measured combustion efficiency. This result is also supported by international publications regarding boiler efficiency. [7] The moisture content of all pellet fuels was below 7%, which is well in line with the air-dry fuel criterion

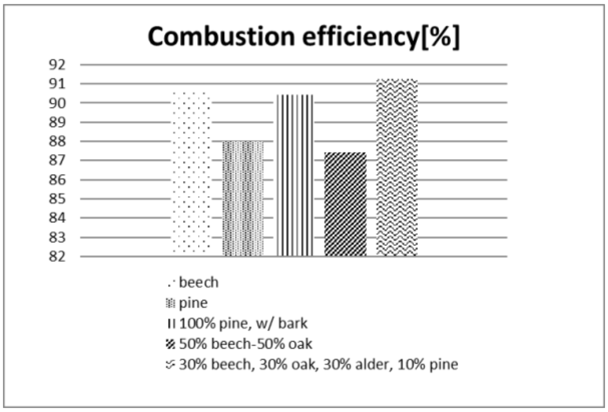


Figure 4.5.7: Combustion efficiency

Preliminary examination of pellet fuels with different compositions revealed that the basic operation of the boiler is not affected by the pellet composition. The bark-free 100% pine composition pellet was then selected and tested over the entire modulation range of the device with an expanded set of measured parameters. For the analysis of the flue gas, an MRU Optima 7 type flue gas analyzer was used to measure the flue gas components listed in

Table 4.5.2, and similarly to the previous measurement, the other characteristic values required for the measurement were recorded.

Table 4.5.2: Parameters measured

Sign of measured parameter	Unit	Name of measured parameter
O_2	%	*Oxygen content of flue gas*
CO_2	%	*Carbon dioxide content of flue gas*
CO	*ppm*	*Carbon monoxide content of flue gas*
NOx	*ppm*	*Nitric oxide content of flue gas*
SO_2	*ppm*	*Sulfur dioxide content of flue gas*
$\Delta p_{chimney}$	*Pa*	*Chimney draft*
t_{wood}	*°C*	*Combustion product temperature*
λ	-	*Excess air factor*
qA	%	*Flue gas loss*
m_{water}	*l/min*	*Heating medium mass flow*
t_{fw}	*°C*	*Flow temperature*
t_r	*°C*	*Returning medium temperature*

Measurement Results

The operating characteristics of the device are well characterized by the development of the temperature of the heating medium during the examined period, which is illustrated in Figure 4.5.4. After the short ignition preparation phase, an interval of about 15 minutes of the rapid warm-up phase can be observed. After this, the combustion enters a normal, controlled air supply phase, which is similar in nature to gas boilers. This is very different from traditional solid fuel boilers, as no sharpening, peak or declining fires can be observed in the firebox

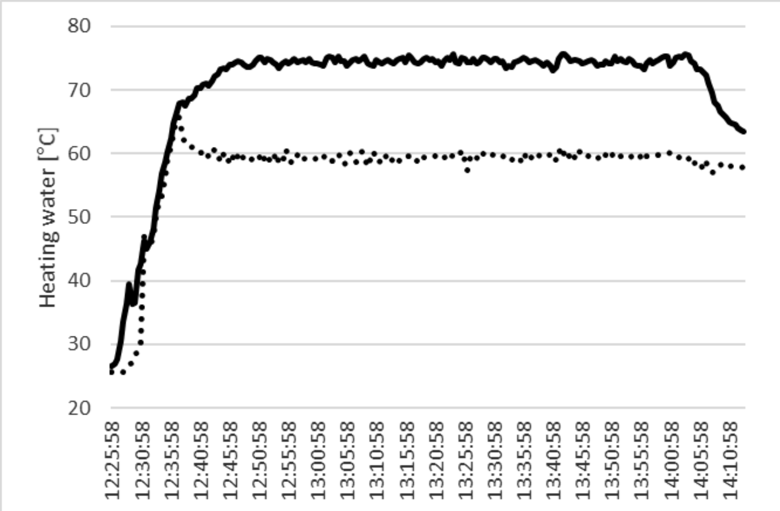


Figure 4.5.8: Characteristics of a controlled combustion stage

The load levels of the device were set between 50-100% in manual mode, with 10% increments. Figure 4.5.5 shows the combustion efficiencies thus obtained. As the load increases, the losses from the flue gas increase due to the rising flue gas temperature. However, it can be observed that even in the case of the highest combustion product loss, the qA loss term does not exceed an average value of 8% during the examined firing period. The results shown in Figure 4.5.5 refer to a normal firing stage and do not include the heating stage as well as the burnout stage. During the burnout phase, the flue gas fan of the appliance mixes a large amount of air into the combustion chamber, which is well reflected in the values of the excess air factor. At the same time, the qA flue gas loss term increases (Figure 4.5.10.).

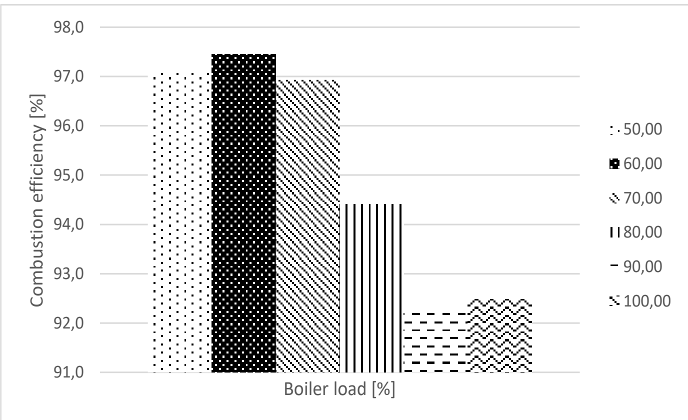


Figure 4.5.9: Combustion efficiency as a function of boiler load

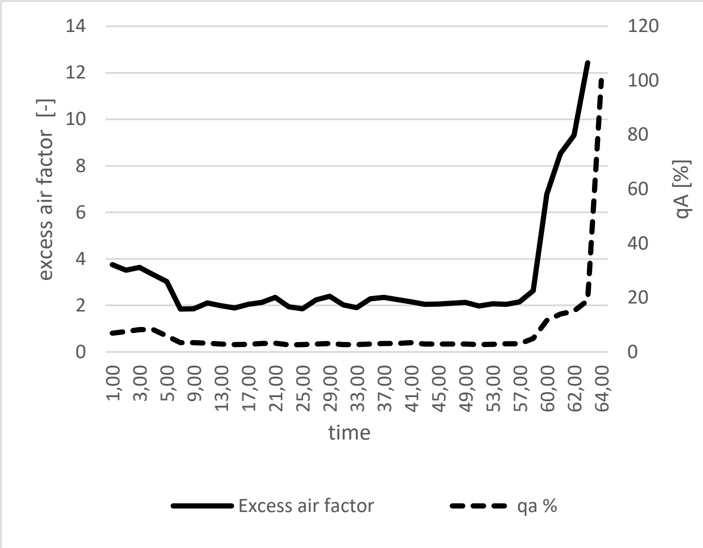
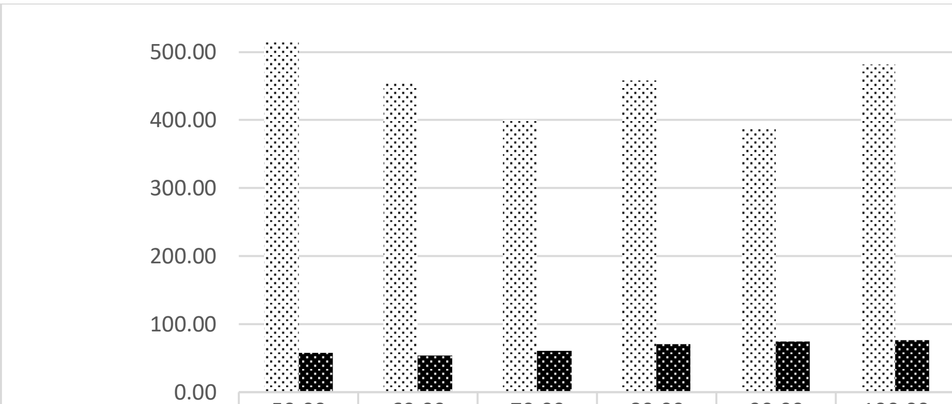


Figure 4.5.10: Burnout phase characteristics

Of the measured parameters, carbon monoxide and NOx emissions, which are of key importance according to the EN 303-5 standard, were included among the primary pollutant components to be examined. Figure 4.5.7 shows the values of CO and NOx emissions for different loads in ppm for the total firing time. In accordance with the limit value according to the standard EN 303-5, the limit values of 873 ppm CO for automatic feed biomass boilers classified in Class 4 are met at all load levels. The highest Class 5 436 ppm CO limits are met at 60 and 90% load.



	50.00	60.00	70.00	80.00	90.00	100.00
CO average ppm	514.21	455.02	400.12	458.07	386.42	482.19
Nox average ppm	57.61	53.91	60.59	70.43	74.52	76.63

Figure 4.5.11: CO and NOx emissions as a function of loads

For NOx emissions, the values measured in ppm are expressed as NO_2 according to EN 303-5, with a conversion factor of 2.05 for conversion to mg/m3. [2] For biomass fired plants, a limit value of 350 mg/m3 shall be taken into account. In our study, the maximum emission value for 100% load was found to be 157.1 mg/m3 , which is within the permitted limit. Since the evolution of NOx is temperature dependent, the results obtained are in line with theoretical assumptions. At 50% boiler load, an average firebox temperature of 444 °C was recorded in the normal firing stage, while at 100% load a firebox temperature of 623 °C was recorded.

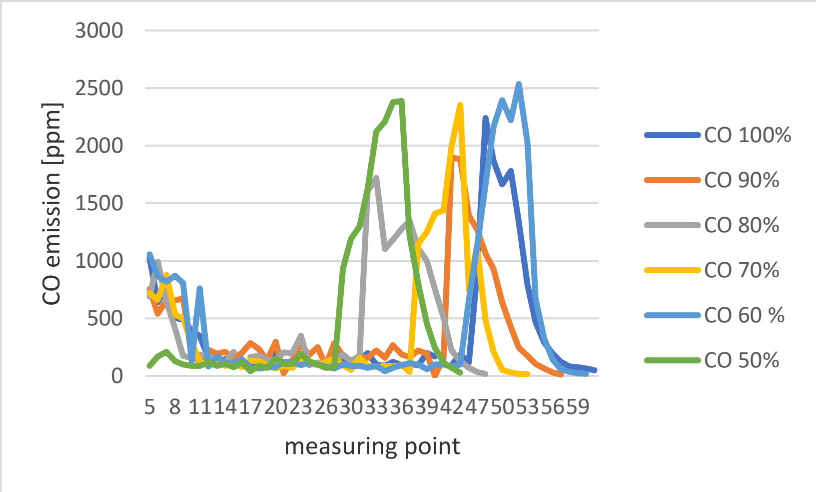


Figure 4.5.12: CO emission trajectory during the firing period

Figure 4.5.12 shows how CO emissions develop from the ignition preparation stage to the end of the burnout stage. In the first stage of the measurement, fluctuating values close to 1000 ppm characterize the uncertain, imperfect combustion, which is not yet typical of the normal stage, and which occurs after approximately 15 minutes. After that in the normal stage the boiler operates with substantially constant emission values. The slight increase of every 8 minutes indicates the operation of the automatic feed screw, as it carries fuel into the firebox at these times. After perfect ignition of the freshly loaded pellet, the carbon monoxide emission values return to the characteristic values for that load. This process is repeated periodically until the boiler is switched off, and then, due to the large amount of air entering at the beginning of the burn-out phase, the quality of the combustion deteriorates, leading to imperfect combustion. This results in an outstanding CO emission value for the 15-minute interval of the burnout stage, which is also much lower than the emission values for the normal operation of conventional manual dosing boilers.

Condensing pellet boilers are also available for pellet boilers in single-family homes and public buildings. The principle of operation is similar to gas-fired condensing boilers. At return temperatures below 55 ° C, the condensation process starts, where the moisture content of the combustion product condenses. In this process, we can utilize the heat hidden in the phase change, due to which the high efficiency is due. At the same time, due to the low-temperature combustion product, the combustion efficiency is also high, as low-energy combustion products leave through the chimney. Condensate is an acidic material, so the interior of the devices is made of acid-resistant material. Of course, the condensation process also occurs in the case of equipment operating independently of the device, but in these boilers the temperature of the low return temperature heating medium must be avoided and, if necessary, raised. For this purpose, it is necessary to install return temperature raising mixing valves, which, at a preset limit temperature, mix the heating medium from the flow heating medium into the return line with a temperature dangerous for condensation. In the case of conventional boilers, operation in condensing mode leads to boiler corrosion, which causes the unit to puncture. Figure 4.5.13 shows an example of a solution for raising the temperature of the return medium.

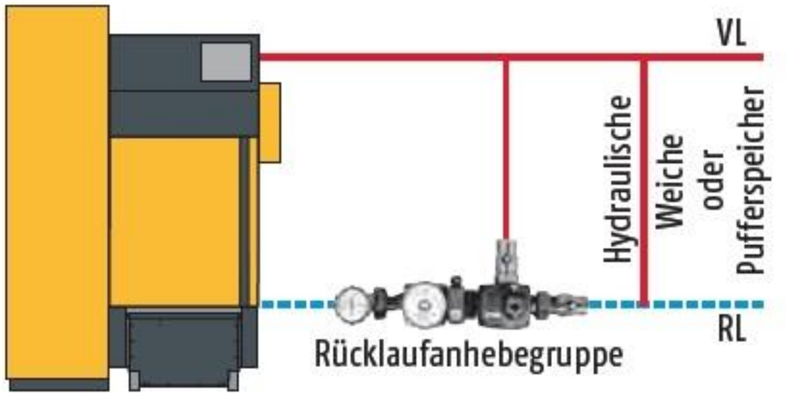


Figure 4.5.13: Temperature raising of the return water (www.eta.co.at)

MODERN BOILER LAYOUT EXAMPLES

The automatic fuel dosing of modern pellet or wood chips fired equipment greatly facilitates the use of biomass fired boilers. Several important rules must be observed when arranging the boiler room. For fire protection reasons, we can only store enough fuel for one day in the same space as the boiler. This is true for all solid fuel equipment. As a result, the scaled fuel storage is located in a separate room from the boiler house. This should be seen in essentially the same way as the connection between a gas boiler room and a gas metering room. The boiler room must have a door that opens directly into the open air, through which by-products formed during combustion can be carried out. The fuel tank must also be serviceable. There are several types of fuel packaging, it makes sense that the design of the tank must be adapted to the way the fuel is packed. The storage follows a special design, typically the room slopes to the lowest point of the room, so that the fuel is added to the feed auger. The auger is connected to the boiler housing, where it is connected to the boiler via a fixed or flexible feeder. There is a damper on the boilers that closes in the event of an emergency, so that in the event of a burnout, the fire cannot spread into the fuel storage room. There are also vacuum systems where the system draws fuel into the boiler via a duct network. This is typically the case where it is difficult or impossible to build a screw system. The fuel tank can be placed either in the attic or next to a building, with a tank sunk into the ground. Each of the examples below is an illustrative system solution for Herz Pellet Boiler and its components.

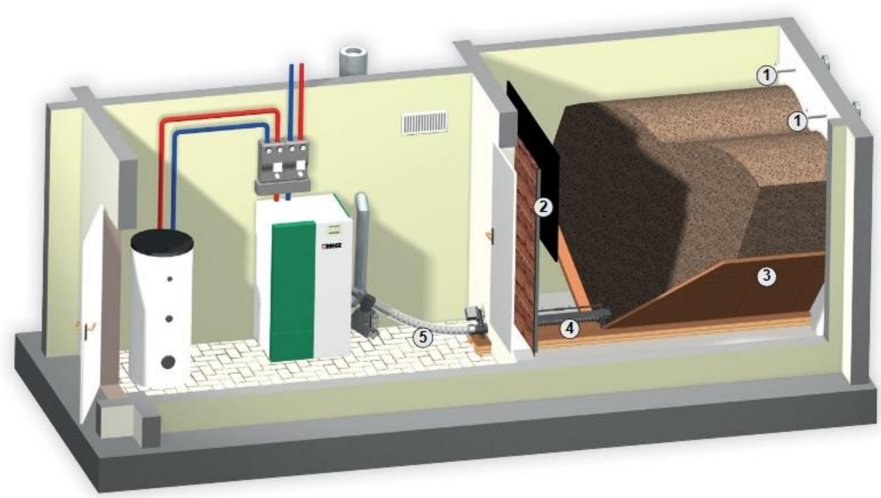


Figure 4.5.14: Flexible feeding spiral system

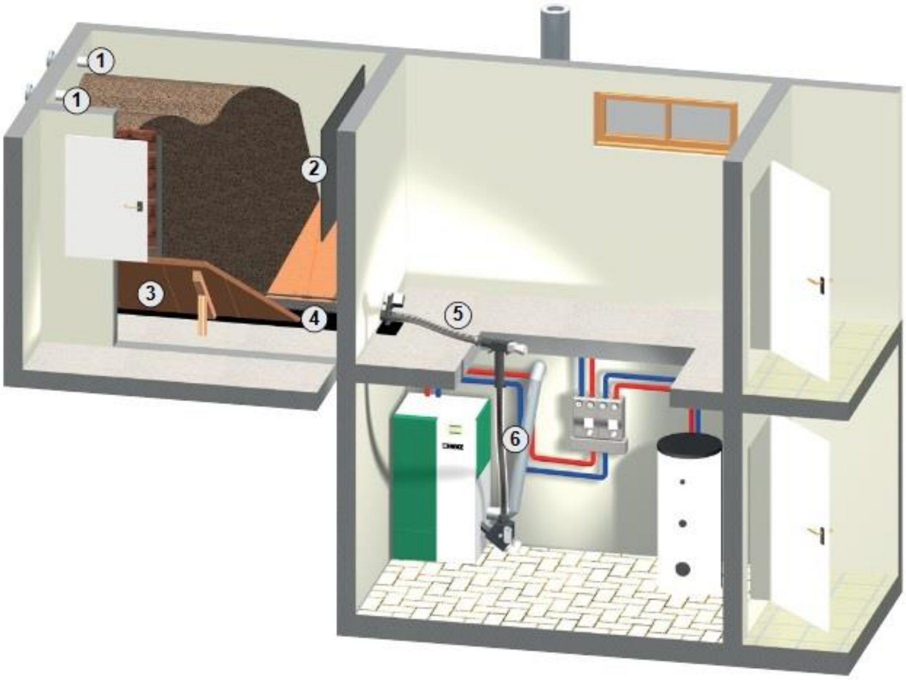


Figure 4.5.15: "Dropped" feeding spiral system

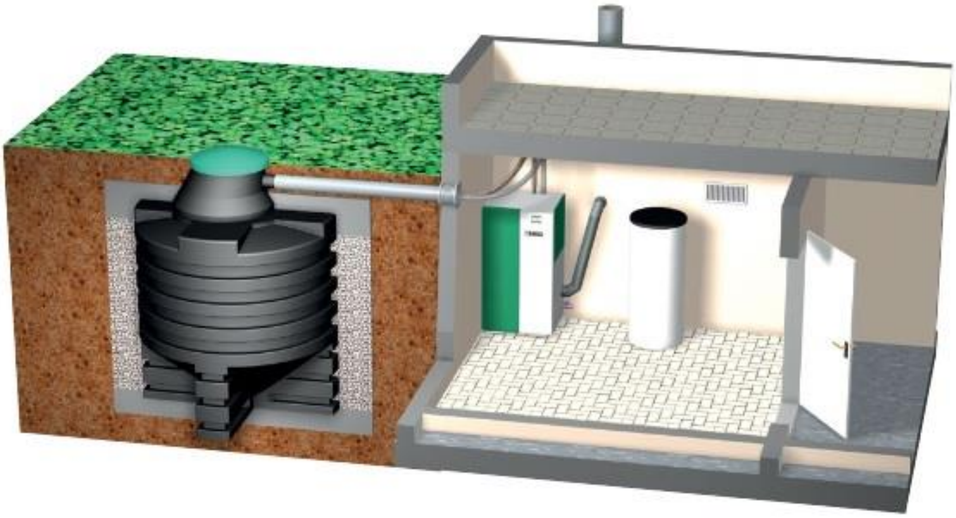


Figure 4.5.16: Underground storage arranging

4.5.3 FLUE GAS SYSTEMS

As mentioned above, a proper system approach is also essential when installing biomass-fired plants. The heart of our system is the boiler or fireplace, but the boiler is inoperable without proper combustion air and a precisely sized flue system.

To understand how chimneys work, these three parameters need to be considered together. Typically, a combustor is located in some interior space. It could be a boiler room or, in the case of a fireplace, the living space. As in the case of gas boilers, in the case of solid combustion we distinguish between combustion plants operating on a purely gravity principle or with a fan. As mentioned above, modern biomass boilers and fireplaces use a fan for proper combustion control, but most of the older equipment or fireplaces and stoves operate on a purely gravitational principle. The entire combustion process, including the corresponding flue gas discharge, is illustrated in Figure 4.5.17. [6]

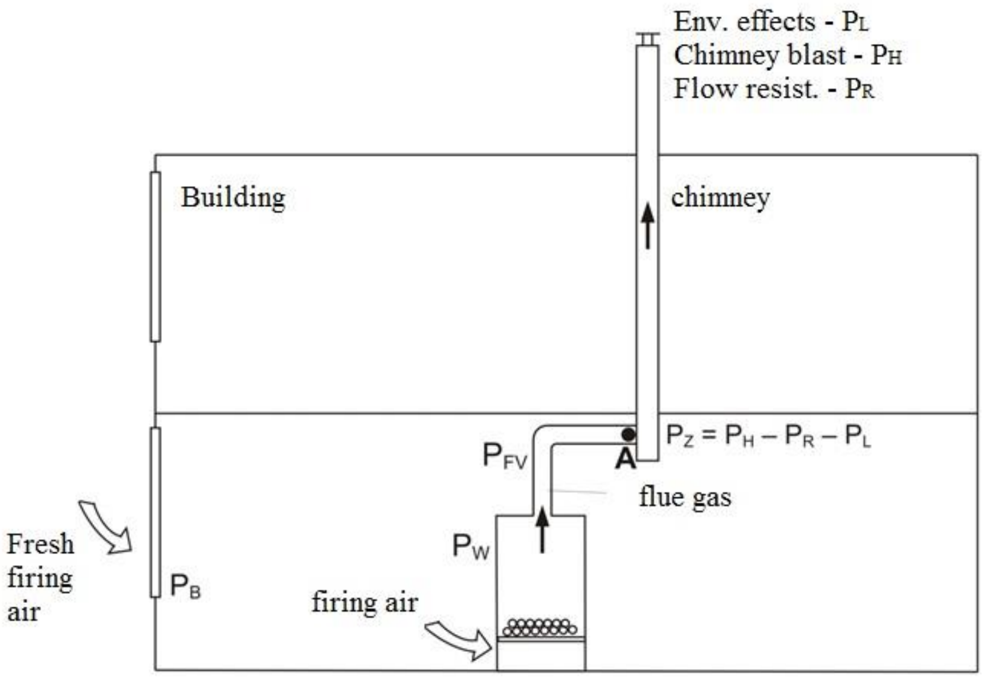


Figure 4.5.17: Chimney circle

For the operation of the system, we introduce the so-called a chimney circuit where the combustion air, the combustion plant and the flue gas are treated together. The flue system has an effective pressure and draft. This cover must overcome the inlet resistance of the combustion air, the resistance of the appliance, the frictional and shape resistances in the chimney and, last but not least, the environmental effects, e.g. the wind pressure acting on the chimney. In the case of fan-operated combustion plants, the same principle is followed, only in that case the desired available pressure difference must be provided to the fan operating in the unit.

Symbols in the figure:

p_W – Draught for the heating installation

p_b – Air resistance flow resistance

p_{FV} – Flue pipe resistance

P_r – Flow resistance of the flue gas passage

p_H – Theoretical draft of the flue gas flight

p_L – Wind pressure

p_Z – Cover for the introduction of the combustion product of the vertical section of the flue system [6]

In order for the process to be self-sustaining, the introduction of combustion air must be ensured in all cases. If this is not the case for some reason, the flue gas discharge process will be stalled and backflow may occur. The phenomenon can be thought of as moving the plunger of a syringe. When the flow cross-section is free at the end of the syringe, the plunger can move freely. If the end of the syringe is gripped, the plunger cannot be moved. In the case of combustion plants, the air in the room is consumed in this form, and in the absence of adequate replenishment, the boiler begins to use the CO2 content of the flue gas for combustion, leading to imperfect combustion, which produces large amounts of CO. The same is true for open-fired gas boilers. This phenomenon is especially true for equipment operating in long-term living spaces, such as fireplaces or stoves. Section 1.4.1. When dimensioning the combustion air supply system in Chapter II, the flow and shape resistances of the air supply system of the closed combustion chamber fireplace into the chimney circuit system must also be taken into account. This air intake system can also be implemented with a built-in flue system with a ventilation chimney.

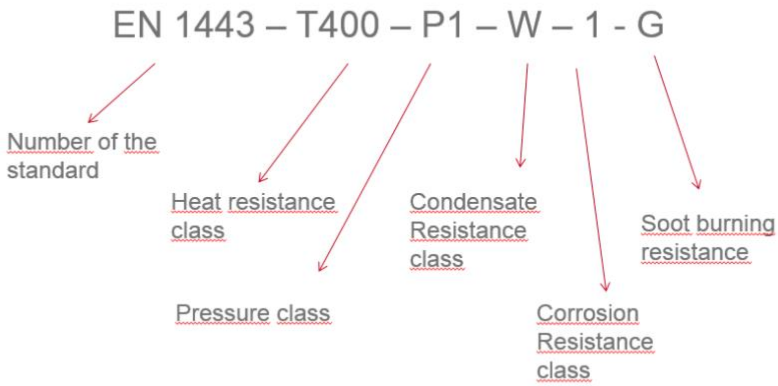


Figure 4.5.18: Standard marking of a flue gas system

In the case of systems using solid fuels, flue systems have special requirements. Figure 4.5.18 shows the designation of a chimney element for use in a solid fuel system. The first term indicates the number of the relevant standard, followed by the temperature class. In the case of wood burning, if a non-condensing pellet boiler is used, our flue gas temperature is characterized by a high flue gas temperature. In the case of conventional boilers, a temperature of 200-250 ° C can be reached. In the case of pellet or wood gasification boilers, this temperature is around 100-150 ° C. The next term indicates the pressure class of the system. In the case of class P, the chimney is suitable for pressurized flue gas discharge, i.e. for receiving boilers with a fan. In case of rating N, only gravity flue discharge can be realized! The following parameter shows the resistance to corrosion, and last but not least the last member illustrates the class of resistance to soot burning. According to the presented standard, it is clear that even in the case of flue systems, only system-type chimneys should be implemented with qualified components.

REFERENCES

[1] „European Commission," 2021. [Online]. [Retrieved: 01. 2021].

[2] *EN 303-5 Standard,* 2013.

[3] P. Dr. Tóth, M. Dr. Bulla és G. Dr. Nagy, „A biomassza energetikai hasznosítása, energiatermelés biomasszából," 2011.

[4] European Union, „Útmutató a biomassza lépcsőzetes hasznosításához a fás biomassza felhasználásának válogatott bevált gyakorlatait szemléltető példákkal," Luxembourg, 2019.

[5] N. Érces, *Biomassza tüzelés - BSC épületgépészeti mérések felkészülési segédlet,* BME ÉPGET.

[6] N. Érces és L. Kajtár, „Szilárd tüzelésű kazán üzemviteli vizsgálata különböző tüzelőanyagokkal," *Magyar Épületgépészet,* 2020.

[7] B. Lajos, Szerző, *7. Gázkészülékek égéstermék- elvezetése Természetes huzatú, nyitott égésterű gázfogyasztó berendezések.* [Performance]. BME ÉPGET , 2019..

[8] D. J., C. M. és A. J. L. T., „Test of a small domestic boiler using different pellets," *Biomass ans Bioenergy,* %1. kötet27, pp. 531-539, 2004.

[9] N. O.K., P. M. S., W. M., M. M. H., N. M., G. S., F. P., A. R., H. K., B. H. G. és T. M., „Annual dansih informative inventory reoprt to UNECE," Danish Centre for Environment and Energy, 2016.

[10] K. P.-K. Kristensen, „Air pollution from residential combustion," The Dansih Ecological Council.

[11] S. Clara, P. Henar és M. Esperanza, „Pine chips combustion in a 50 kW domestic biomass boiler," *Fuel,* pp. 564-573, 2013.

[12] S. Bram, J. De Ruyck és D. Lavric, „Using biomass: a system perturbation analysis," *Applied Energy,* pp. 194-201, 2009.

The views and opinions expressed in this publication are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission.

Co-funded by the
Erasmus+ Programme
of the European Union