Help for designing and using FuranFlex RWV lining material

Content

This document contains useful information about wood heating, wood as fuel, the background of wood heating technology and the application of FuranFlex RWV lining. Furthermore, it provides theoretical and practical knowledge of flow calculation, sizing and installing the chimney liner as well as the wood heating process.

About wood heating in general

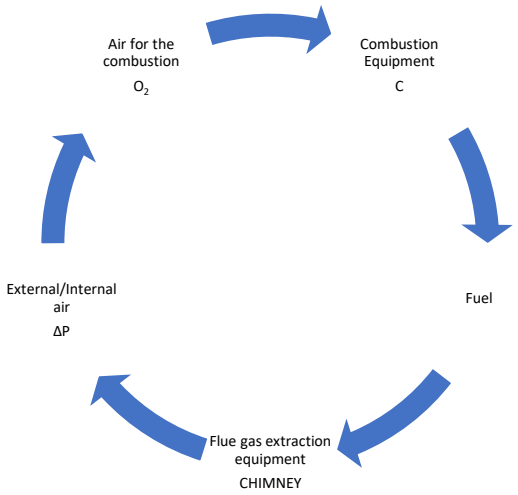
Burning wood is the oldest way heating. It still plays an important role in modern building engineering, with popularity changing country to country.

Wood heating has severe forms of application: from traditional open fireplace to the modern, closed, electrically controlled pellet combustion equipment.

Heating is a complex system, the elements of which need to by synchronized. This system is described the best with a chimney circle that needs to be designed for every case. Elements of the system must be checked right after installation and afterwards yearly by authorized chimney sweeper.

Elements of the chimney circle

Combustion equipment – Fuel –– Flue gas extraction equipment (Chimney) – External/Internal air – Air supply



The properly sized chimney provides the combustion equipment with the necessary pressure difference (draft) for efficient work (perfect burning and heat transfer).

The bad design however results in malfunction of the combustion equipment and the burning will be imperfect. The consequences are:

- Decreasing of efficiency of the heating – Higher costs
- Generating smoke – Pollution
- Soot deposition – Soot fire
- Flue gas backflow – Carbon monoxide (CO) – Danger to life

Conditions of burning

Burning establishes if the required 3 conditions are available:

1. High temperature (higher than the ignition temperature of the fuel)
2. Flammable material (fuel)
3. Oxygen necessary for burning (O_2)

Burning is a chemical process (oxidation) creating oxides.

What burns if not wood?

We tend to believe that during burning - wood burns, but it is not the case.

At higher temperature (100-200°C), a decomposition process starts in the wood, during which vapours and gases are generated and ignite (oxidize). The combustion (chemical process) involves the release of heat, which is accompanied by a light (flame).

This gives 5/6 of the heat, the remaining 1/6 of the heat is given off by the embers and glowing charcoal.

When burning wood, the gases released from the wood burn.

Wood as fuel

A tree is a perennial, woody plant with a crown that grows vertically with one or more trunks. The fuel made from such plants is firewood. It is also available in pelletized form.

Straw, hay, stems and seeds of fodder plants, energy grass, etc., as well as biomass of uncertain origin are not wood derivatives. The pelletized form of these is biomass pellet.

Chimney lining FuranFlex RWV is applicable for wood and wood pellet heating systems, but for biomass pellet it is not.

Quality of firewood

The quality of firewood is defined by its calorific value and moisture content.

Calorific value of wood

Calorific value of fuel is defined as its energy storage capacity, i.e. how much thermal energy we get by burning it.

The calorific value of the most frequently used fuels is as follows:

Fuel	Calorific Value, MJ/kg	Calorific Value, kWh/kg	Applicability of FuranFlex RWV
Freshly cut wood	6,8	1,9	✗
Dried wood	14,4-15,8	4-4,4	✓
Hay	17	4,8	✗
Wood pellet	18	5	✓
Peat	15	4,2	✗
Oilseeds	20	5,6	✗
Lignite	8	2,2	✗
Lignite briquettes	20	5,6	✗
Hard coal	27–32,7	7,5-9	✗

Moisture content of freshly cut wood: 40-50 $\%_m$, of dried wood: < 20$\%_m$

Fuel with a higher calorific value burns at a higher temperature, which results in a higher flue gas temperature.

At higher temperatures, thermal degradation in the liner is greater, i.e. damage may occur as a result of thermal stress. That is why you can only fire with wood in the case of FuranFlex-RWV liner.

If the flue gas temperature on the boiler is regulated by taking back the combustion air, tar formation may occur as a result of wet operation and imperfect combustion, which increases the risk of corrosion and the chance of a chimney fire.

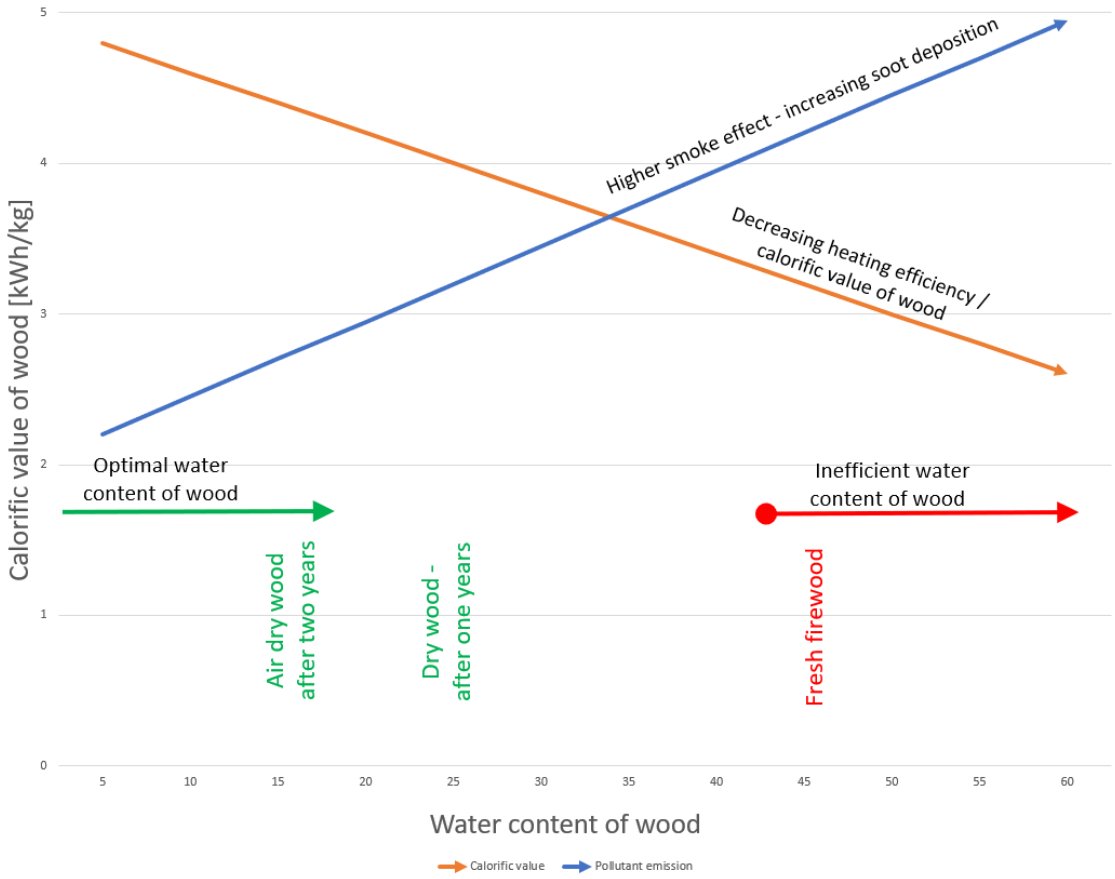
Moisture content

Combustion equipment should only be heated with dry wood!

Only untreated (free from paint, varnish, stain, adhesives, etc.), air-dried hardwood should be used for firing. The wood is air-dry if its moisture content is below 20%, which can be achieved by splitting the firewood and storing it in a covered, ventilated place for 1,5 to 2 years.

Freshly cut wood contains 40-50% water, and when it burns, the evaporation of the water takes away a significant part of the heat energy, i.e. the heat used for evaporation lowers the temperature of the flue gas. Due to the low combustion temperature, some of the gases released from the wood do not burn, but smoke, soot and wet tar are generated instead of heat.

If dry wood is used, however, these gases provide 5/6 of the energy in the wood.



The calorific value of dry wood is 15 MJ/kg, and that of freshly cut wood is around 7 MJ/kg, as a significant part of the energy contained in the wood is then used to evaporate the water. Burning wet firewood, which produces half as much heat, is wasteful and causes much more air pollution. If wet wood is used, the efficiency of burning can decrease by more than 50%.

Dry and wet operation

Depending on whether condensation continuously forms in the chimney / lining pipe and on the fittings connected to it during operation, we distinguish between wet and dry operating chimneys.

Condensation occurs in the chimney when the temperature of the chimney wall is lower than the water or acid dew point of the acid vapors in the flue gas.

An increase in the concentration of sulfur and hydrochloric acid in the flue gas significantly increases the dew point temperature and thus increases the risk of condensation in the chimney!

The dew point temperature of fuel with a high sulfur content can be 130-150°C. (In the case of natural gas, this is 60-65°C.)

The EN 13384 standard must be used to check the dry and wet operation of the chimney.

Corrosive effect of solid fuels

Little is said about the chemical composition of biomass as a fuel and its corrosion effects, although these are very important.

The sulphur (S) and chlorine (Cl) content of fuels can vary greatly.

In the case of vegetable fuels, the S content of hay is 12x and the Cl content is 30x that of wood derivatives.

A chimney or a liner is exposed to corrosion in both dry and wet conditions. The corrosion effect is caused by the sulphur (S) and chlorine (Cl) content of the firewood.

Acidic condensate generated in wet mode can initiate extremely aggressive corrosion processes, which causes rapid destruction of the chimney or the liner.

FuranFlex RWV can ONLY be used for flue gas exhaust of wood fuel.

In addition to sulfuric and hydrochloric acid, the CO/CO2 mixture in the flue gas results in the formation of carbonic acid in wet mode. This mixture also has an extremely aggressive corrosion effect.

Chimney fire

When an element of the chimney circle is not suitable, when burning wood, then strong soot, or worse, tar formation occurs in the chimney.

Due to the heat (between 100-200°C), gases are produced from the tarry deposit on the chimney wall, which ignite between 200-300°C. The flames intensify the gas formation and the chimney fire spreads along the entire length of the chimney in a self-stimulating manner.

In the event of a chimney fire, all (air)intake openings must be closed and the fire brigade must be called!

A soot fire is not a normal operating condition, but an emergency event, therefore the guarantee/warranty is void in this case!

The right way to burn wood

Before lighting the fire, the logs and the thin pieces of wood needed to light the fire (kindling) must be stacked according to the following arrangement:

The thick logs must be placed at the bottom, on which increasingly thin branches must be placed. With this method, overheating of the stove/chimney can be avoided, while at the same time efficient firing can be ensured.

Arrangement of the fuel from top to bottom:

touchwood

thin firewood (e.g. branches)

thick block of wood

The air opening must only be opened so that there is no backflow from the firebox, so that the smoke escapes through the chimney and the fuel burns with a flame of 10-20 cm.

Don't forget that the "gas formation" of the wood must be started and helped with heat/fire. At the same time, a draft develops in the chimney, which is the "air movement" resulting from the difference in density of cold and warm air. Due to the lower density of the warm flue gas, it "rises", thus starting the draft in the chimney.

During firing, the air opening must be adjusted so that the burner burns with a 10-20 cm flame. By adjusting the air opening, the amount of air passing through the combustion equipment can be controlled by the draft of the chimney. Too much air causes the wood to burn quickly (a strong draft carries the heat with it - poor efficiency); insufficient air supply leads to imperfect combustion, which leads to the development of carbon monoxide and the deposition of soot and tar.

Make sure that you never put more fuel in the heater than what is recommended in the manual.

Why should the chimney be cleaned?

When burning solid wood, ash is always produced, part of which leaves the combustion equipment through the chimney together with the flue gas. The escaping ash can settle in the chimney and form tar with moisture.

The sooty, tarry deposit reduces the cross-section of the chimney, which reduces the amount of draft and results in imperfect combustion. It is a self-stimulating, accelerating process. In extreme cases, the deposit can result in backflow, which in turn can lead to a decrease in internal comfort (smell) and a risk to life (CO poisoning).

The chance of a soot fire also increases with the degree of deposition, since the amount of gas-forming material required for the formation of a (soot) fire also increases.

By sweeping the chimney, the deposit is removed, which can increase the efficiency of the heating and reduce the probability of a soot fire.

Cross section of FuranFlex liner

The FuranFlex liner in the chimney can accommodate a wide variety of cross-sections. Calculation must be used to check that the size and shape properties of the liner ensure safe and technically adequate conditions (draft, temperature conditions) during heating.

For stoves, chimney sizes with a circular cross-section (diameter) are typically given.

In the case of a cross section other than a circle, the so-called circle equivalent diameter must be specified. Equivalent diameter indicates the flow resistance of pipes of different cross-sections of the same length or their ratio.

Incorrect cross-sections (for a given length of chimney) affect the functioning of the chimney as follows:

The effect of an oversized chimney

An oversized chimney means that its cross-section is larger than would be ideal according to the flow calculation carried out with the given combustion device.

A larger chimney cross-section results in a lower flue gas velocity, which can cause the flue gas to cool down and thus increase the chance of condensation occurring in the chimney.

It is more difficult to develop the draft conditions necessary for operation (draft).

When the chimney heats up, the large draft reduces the efficiency of the boiler. (It "pulls" hot flue gas out of the stove.) The higher flue gas velocity that develops at higher temperatures increases the heat transfer between the flue gas and the chimney wall, which in extreme cases (over 450°C) causes the lining pipe to fail.

The effect of an undersized chimney

An undersized chimney means that its cross-section is smaller than would be ideal according to the flow calculation carried out with the given combustion equipment.

An undersized chimney can result in a smaller chimney draft, which leads to flue gas backflow and imperfect combustion (lower efficiency).

Effect of overheating

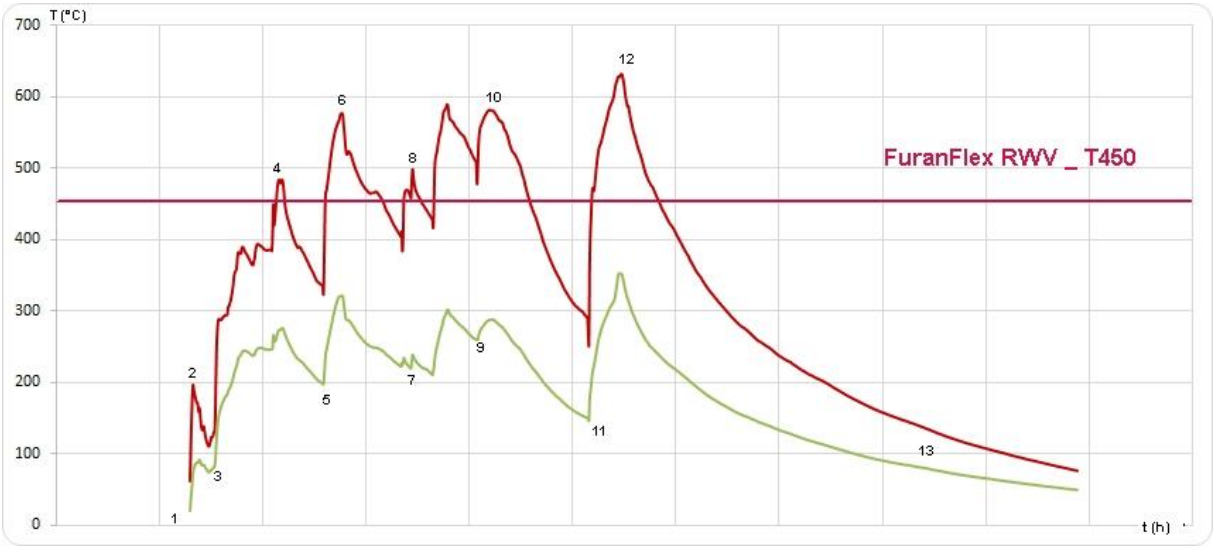
It is called overheating when flue gas coming out from the flue pipe of the heating device is of higher temperature than the one allowed in the heating device or in the chimney.

In such a case, the structure of the boiler is damaged (e.g. seals, heat storage medium is damaged), the smoke pipe is deformed, the chemical structure of the steel elements changes (corrosion damage), and the liner is damaged in terms of structure and material.

Overheating can result from the wrong sizing of the chimney or from inadequate heating (e.g. more firewood than allowed, excessive combustion air, etc.)

Description of the wood burning cycle

When operating a wood-burning stove, the following typical temperature changes can be experienced during a 10-hour heating period.



The figure shows the temperature conditions of a 9 kW wood-burning stove.

Flue gas temperature markings:

GREEN when burning the amount of fuel allowed in the user manual;

RED when burning 2x the permitted amount of fuel allowed in the user manual

According to the stove's user manual (catalogue value), the maximum temperature of the flue gas is 350°C.

Ignition	1	Ignition of fuel	Air inlets fully open	Cycle # 0 Time period: 15"
	1-2	Fuel catches fire		
	2	Fuel burns	Narrowing of the air inlet	
	2-3	Fuel burned	Embers provide the heat	
Burning	3	Fuel load		Cycle # 1 Time period: 60"
	3-4	Fuel burns	Wood pile ignites, temperature increases, draft increases	
	4-5	Glow	Fuel burned; embers provide the heat	
	5	Fuel load		Cycle # 2 Time period: 60"
	5-6	Fuel Burns	Wood pile burns, temperature increases	
	6-7	Glow		
	7	Fuel load		Cycle # 3 Time period: 50"
	7-8	Fuel Burns		
	8-9	Glow		
	9	Fuel load		Cycle # 4 Time period: 60"
	10	Fuel Burns		
	10-11	Glow		
	11	Fuel load		Cycle # 5 Time period: 240"
	11-12	Fuel Burns		
Shutdown	13	Glow	Embers burn down and the stove cools down	

The combustion parameters of open-burning wood burning (amount of fuel, amount of combustion air, changes in draft, etc.) are difficult or impossible to control and change over time (they change continuously during heating). This means that the temperature conditions can change and thus the way the chimney works.

In the case of wood burning, the chimney does not have an "equilibrium state" similar to gas heating. As a result, the operating power range of the boiler is between 50 and 150 % compared to the nominal heat output.

50% - when the fuel burns down and the embers provide the heat

150 % - when the fuel burns and a larger than ideal draft develops due to the excess air.

These parameters also apply to modern stoves with good efficiency (i.e. low flue gas temperature). The flue gas temperature for these devices is much lower. Due to the low flue gas temperature, the risk of condensation is greater.

Stove manufacturers specify the performance ranges as follows:

Heating power levels*

Minimum: 3.9 kW

Nominal: 6.0 kW

Maximum: 9.0 kW

*Example: Manufacturer data in the catalog of the JØTUL F361 Advance CB combustion equipment.

It follows from the above that

• Overheating is a real danger in practice

• Partial load is due to the nature of wood burning

• Heating and cooling takes place quickly

• Even at high flue gas temperatures in the chimney, a wall temperature can develop when condensation occurs.

Design recommendations

Before installing the FuranFlex liner, we always recommend sizing the flue gas exhaust system in terms of flow technology.

Software according to the EN 13384 (Combustion exhaust systems. Thermal and flow engineering dimensioning procedure) standard is available for planning. (Ex.: CHM-Bau, Kesa-Aladin, Easy-Calc, etc.).

These programs can be used to check whether the FuranFlex liner meets the parameters of the given heating system (boiler, flue piping). Most important parameters:

• Maximum flue gas temperature

• Dry mode along the entire length of the chimney in all power ranges (avoid condensation)

The design programs calculate with the standard design basic values (fuel properties, safety factor(s), boiler data, etc.).

For the data of combustion devices, the **performance range values** in the technical description of the device must be examined. Otherwise, the **operation of the boiler must be checked at 50%, 100% and 150% power levels.**

In the case of heat exchange equipment, which is used for hot water production or heating, due to the low temperature of the flue gas, they can operate in wet mode during the entire period of operation of the chimney. **Heat exchanger data must be provided for sizing**.

In the case of **tiled stoves**, data on heating performance and flue gas **data must be requested from the builder.**

Local and European regulations, standards, and directives must be observed during sizing.

Standard designation and interpretation of FuranFlex-RWV liner

The FuranFlex-RWV liner is a lining material that can be used for depressing (40 Pa) discharge of combustion products with a temperature of up to 450°C with wood-burning combustion equipment, which must operate in dry mode. Resists soot burning.

Marking according to EN 1443: **EN 1443– T450 N1 D 2 G**

T450:	**Temperature class**
	It is suitable for exhausting flue gas at a temperature of up to 450 °C
N1:	**Pressure class**
	It leads the flue gas into the lining pipe on the principle of draft (negative pressure).
D:	**Resistance to condensation**
	Dry mode flue gas removal equipment. Under steady operating conditions of the boiler, no acid condensate (from flue gas) can settle on the chimney wall.
2:	**Type of fuel**
	It is suitable for exhaust gas from wood or wood derivatives.
G:	**Resistance to soot burning**
	Resists soot burning.

The liner can only be installed for dry flue gas exhaust, which means that continuous condensation cannot form in the chimney during operation. The existence of a dry operation must be verified by sizing the given flue gas flow in accordance with the EN 13384 series of standards.

The liner must be protected from precipitation with a rain protection disc at the chimney outlet (as a mandatory requirement).

When installing the FuranFlex-RWV lining pipe, the (technological) specifications of the FuranFlex manual must be observed.

General findings

Only the fuel specified by the manufacturer may be burned in solid-fuel burning devices, not household waste. Burning household waste might even destroy the combustion equipment. In addition to carbon monoxide, other highly toxic gases, vapours, and acid effects can also be produced, and deposits can increase in the chimney passage (in the flue and in the combustion equipment as well), which results in a chimney fire, as well as premature failure of the system and deterioration of the conditions for safe operation.

Fuel must be stored in a well-ventilated place protected from rain and moisture.

When using an open combustion chamber stove (until the embers/ashes cool down) DO NOT OPERATE AIR EXTRACTION EQUIPMENT. The flue gas and CO entering the air from the stove/chimney is dangerous to life.