Supported by the European Commission under the Intelligent Energy - Europe Programme

2. Wood Energy and Environment

3 T's of combustion:

Time
Time means that the fireplace must be large enough for the particles and drops to have enough time to combust before they hit a cold surface (cool wall of fireplace, exhaust tube etc).

Temperature

The temperature in the end-combustion zone must be high enough to make the combustion complete.

Turbulence

Turbulence is needed to make the air reach all the combustible gases. This is secured by adding primary, secondary and sometimes tertiary air to the combustion chamber at high velocity.

Page and images by Markus Huhtinen

12.10.2006

2.3 **Dust and organic compounds emissions**

2.3.1 Organic compounds

The combustibles of solid fuels can be shared into two groups: volatile matters and components combusting as solid carbon. The combustion process begins with drying and is followed by pyrolysis (100-150 °C), a stage where volatile components start to evaporate.

The ignition starts at 225-300 °C depending on the type of fuel. The volatile components are burned first at 500-600 °C and they account for 75 % of the combustible substance. Finally the solid carbon is combusted at 800-900 °C along with tar.

A combustion is complete when all the combustible parts of the fuel have reacted completely with oxygen. If there is lack of air, the combustion is incomplete and there are carbon monoxide (CO) and different hydrocarbons (CxHy) left in the exhaust gases.

Organic gases and tar formed in an incomplete combustion cause dirt, smell and health problems. Some of the compounds are carcinogenic or mutagenic.

The complete combustion of wood fuels generally requires a minimum temperature of 900 °C. Low combustion temperature increases the possibility of for the formation of non-combustible substances. If the temperature is over 1200 °C the formation of so called thermal NOx gases starts.

It is sometimes difficult to reach the suitable combustion temperature and adequate level of oxygen especially in the small-scale ovens and boilers. High moisture content of the wood fuel or poor design of the fireplace might cause the flame temperature to remain low.

Recent technical development has made it possible to control the burning

Small ovens and burners may cause dust and hydrocarbon emissions especially in the ignition phase. (M. Huhtinen)

process better. Extensive research of the small-scale burner emissions has taken place especially in Austria and Denmark. In Finland and Sweden the research work has concentrated more into large-scale boilers.

2.3.2 Dust

When solid fuels are combusted, fine particles of dust are always formed. These emissions consist of of three components: inorganic ash, coke and fine-particle coal (soot) that is that is formed due to incomplete combustion of pyrolysis gases. Most of these particles are harmful to health.

Dust emissions are typically more problematic in small houses and heating units especially in the cases when the small-scale boilers are used at partial loads.

Modern automatically stoked boilers have much better performance also with partial loads. The amount of dust and other emissions can be affected by controlling the fuel and air supply with sensors.

In the boilers that use very homogenous fuels such as pellets, the combustion process can be controlled better.

In general, the dust emissions of the modern wood-burning medium and large-scale heating units are at the same level as in boilers of similar size using coal, oil or peat (0.01-0.08 g/MJ). The ash forming is inevitable, but the amounts are actually quite small.

Dust and hydrocarbon emissions are easier to control in larger 30-200 kW burners (M. Huhtinen).

2.3.3 Heavy metals

All solid fuels contain some amounts of heavy metals. Wood biomass has, however, much lower heavy metal content than coal or peat. Recycled wood may form an exeption, sice it can be polluted with residues from paints, glues, wood reservatices etc. Therefore the heavy metal content may rise to a notable level. This kind of wood may not be burned in conventional boilers.

Table 2.3.1. The average heavy metal content of coal, peat and wood, mg/MJ (Swedish EPA, Nilson and Timm 1983)

Heavy metal	Coal	Peat	Wood
Arsenic (Ar)	150	100	5
Cadmium (Cd)	10	10	10
Cobalt (Co)	150	100	10
Chrome (Cr)	400	250	50
Copper (Cu)	500	500	100
Mercury (Hb)	4	5	1
Manganese (Mn)	2000	4500	5000
Nickel (Ni)	400	300	50
Lead (Pd)	500	250	200
Vanadium (Vn	900	450	100
Zinc (Zi)	1000	900	1200

2.3.4 Conclusions

The amount of organic compounds and dust in the emissions of wood burner is mostly dependent on the control of the combustion process. It is important that the combustion temperature is high enough and there is enough oxygen to complete the burning process.

The automatic control of the fuel and oxygen supply makes it possible to control the combustion process also on partial loads. This technology is naturally easier to apply in large-scale burners, but has found its way to household-size boilers as well.

If the fuel is moist or inhomogenous, the dust and hydrocarbon emissions may become a problem especially in small-scale units. The combustion of homogenous fuels such as pellets is easier to control.

The following figures show, that the emissions during a life cycle of a heating system favor the use of wood fuels compared to oil or gas. Only the amount of ash is unavoidably higher, but various ash recycling methods can be an answer to the problem. The ash content of wood biomasses ranges from 0.08 to 2.3 %.

Table 2.3.2 Average emissions of modern 300-400 kW range burners using different fuels (The Austrian Energy Agency, 2002)

Emissions, mg/m3	SO2	NOx	Ash	CO	NMVOC
Oil	130	78.2	0	2.3	<3
Gas	0	44.5	0	14.8	0
Cas (condensing)	0	12.2	0	7.5	0
Pellett	27	81	24	6	<1

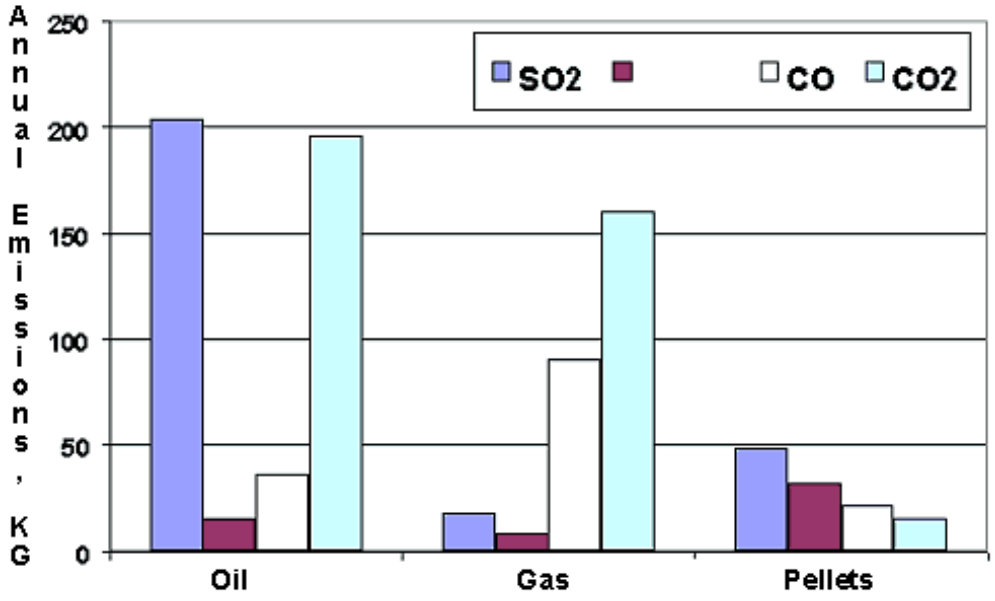

Figure 2.3.1 The annual emissions during a lifecycle of a 400 KW heating plant using different fuels. Emissions kgs, tonnes CO2 (The Austrian Energy Agency, 2002)

2.4 Nutrient loss of forests

2.1 Greenhouse Effect and Wood Fuel

2.2 Emissions from Wood Fuels