European Commission TEMPUS

PROJECT 158989 - TEMPUS-1-2009-1-BE -TEMPUS-JPHES

"CREATION OF UNIVERSITY-ENTERPRISE COOPERATION NETWORKS FOR EDUCATION ON SUSTAINABLE TECHNOLOGIES"

Retraining and updating of PC universities staff in AT

TECHNISCHE UNIVERSITÄT WIEN Vienna University of Technology

Dust separation on bio mass combustion plants

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University Goce Delcev - Stip

Course development workshop 1 - Ohrid, MK

17th till 21st January 2011

Vienna University of Technology

The third training program was held at *TU Vienna*, Austria in period of 15-22, 11, 2010.

The TU Vienna is among the most successful technical universities in Europe and is Austria's largest scientific-technical research and educational institution.

Institute of Chemical Engineering

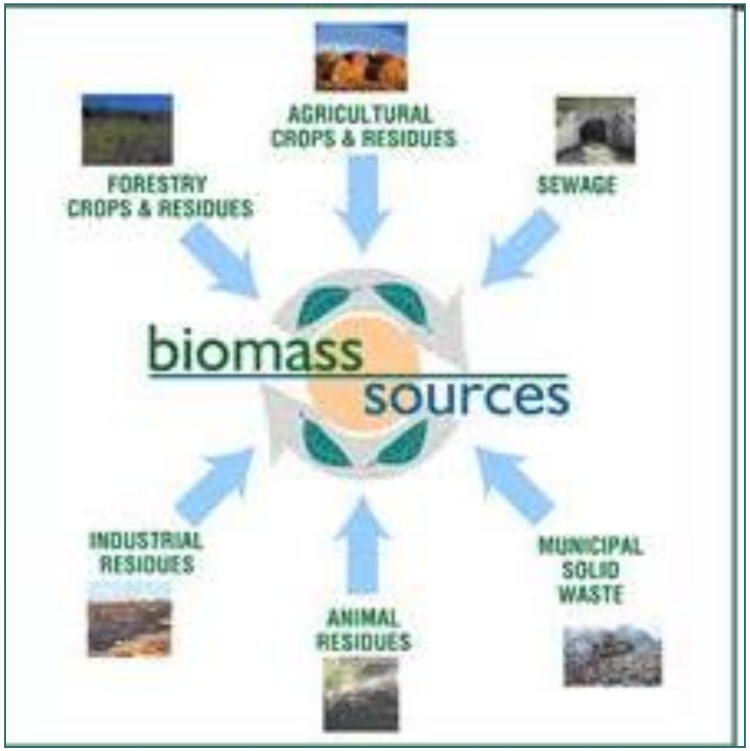
During the retraining session in Vienna, Austria:

- Air Pollution Control Techniques for Aerosol - and Dust emissions,
- Dust separators – types,
- Gasification of Biomass,
- Investigation of operating and engineering parameters of water spraying systems at figurative dust suppression,
- Standardized Filter Tests of Metal working fluid mist separators,
- Dust separation at biomass combustion plants. (was presented by Diominik Steiner from the company "Scheuch“)

BIOMASS

Biomass is material from vegetation, it can be used as a fuel in various boilers and combustor.

The main components: carbon, oxygen and hydrogen but it also contains nitrogen, sulphur, small amounts of chlorides and ash.
The main part of the ash comprises: Ca, K, Si, Mg, Mn, Al, Fe, P, Na and Zn.



- *Biomass can be clean* (wood chip), which contains cellulose, hemicelluloses, lignin and ash.
- *Biomass can be contaminated*, which is the case with, for instance, demolition material which, also even after sorting, often contains sulphur from gypsum board, chlorine from PVC and ash, mortar, sand, etc. The amount and composition of the impurities varies.

BIOMASS COMBUSTION

During combustion, various kinds of impurities are generated and some of them we find in the flue gas. Most of these are related to the composition of the biomass: particles from ash, NOx from nitrogen, SO2 from sulphur, etc. We can also find impurities related to incomplete or bad combustion e.g. particles such as soot and unburned matter, carbon monoxide and other gaseous organic compounds such as dioxin.

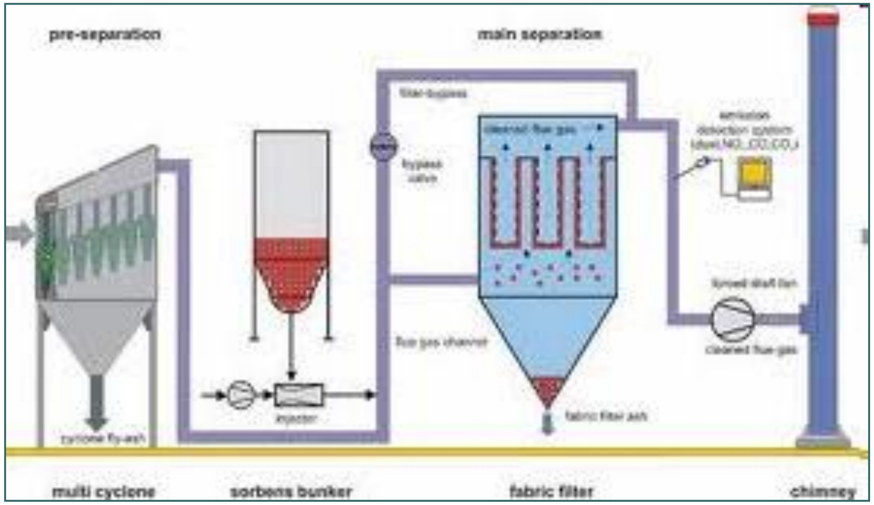
(Dioxin are aromatic molecules in which chlorine replaces hydrogen. Dioxin is very toxic.)

The impurities in the flue gas are harmful if they are emitted to the atmosphere.

Flue gas cleaning - must be installed !!! - eliminate or reduce this problem.

The degree of cleaning depends on regional and local regulations, but regional and local authorities, organisations and individuals have often an opinion on an actual plant due to its size, location, etc.

GAS CLEANING



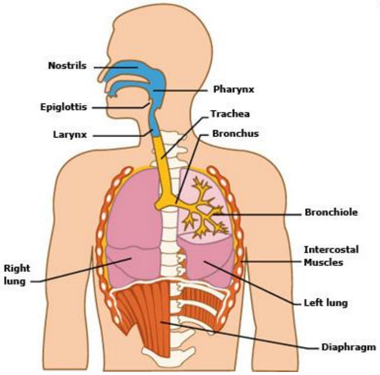
The gas cleaning systems can be divided as follows:

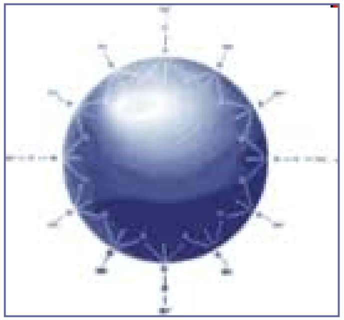
1. Removal of particles or dust collection;
2. Removal of water soluble gases: SO_2, HCl, HF and NH_3;
3. Removal of NO_x, mainly NO;
4. Removal of the very toxic substances: dioxin and mercury (Hg);

One equipment or system can be specific for a certain pollutant or can, sometimes with some additions, take care of the whole gas cleaning.

There are often several possible solutions for an actual plant with respect to emission limits, performance, reliability, costs, etc.

REMOVAL OF PARTICLES





Particles in the atmosphere have a great influence on climate, weather, human health, corrosion, vegetation, etc. Particles smaller than some microns are particularly harmful for man as these small particles penetrate down to the smallest lung alveoli.

The properties of the particles in the flue gas and flue gas itself influence of course the behaviour of the particles during the particulate removal process.

The most important parameters in the removal are:

Particles

Physical properties

· *Phase of particles – solid or liquid*

· *Particle size, particle size distribution and concentration*

· *Particle density and particle shape*

Chemical properties

· *Chemical composition*

· *Hygroscopicity, agglomeration properties.*

Electrical properties

· *Resistivity*

· *Electrical strength*

Flue gas

· Composition and temperature

There are in principle three available forces for the separation of particles from a gas:

1. Mass or inertia force

2. Surface or adhesion force

3. Electrical force

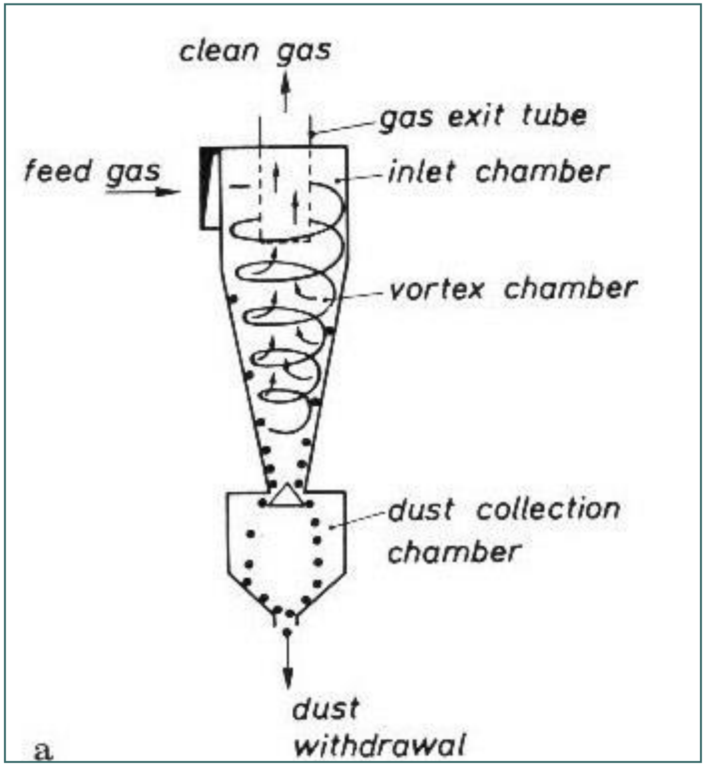
Cyclones and conventional wet scrubbers are typical mass force separators.

Fabric filter is a typical adhesion force separator.

Electrical is the dominant force in an electrostatic precipitator.

Cyclones

Cyclones are totally dependent on mass for the removal. Flue gas and particles are introduced tangentially into a cylinder so that a rotational movement is obtained.
Centrifugal forces carry the particles toward the wall of the cylinder, to the vortex chamber and then to the dust collection chamber.

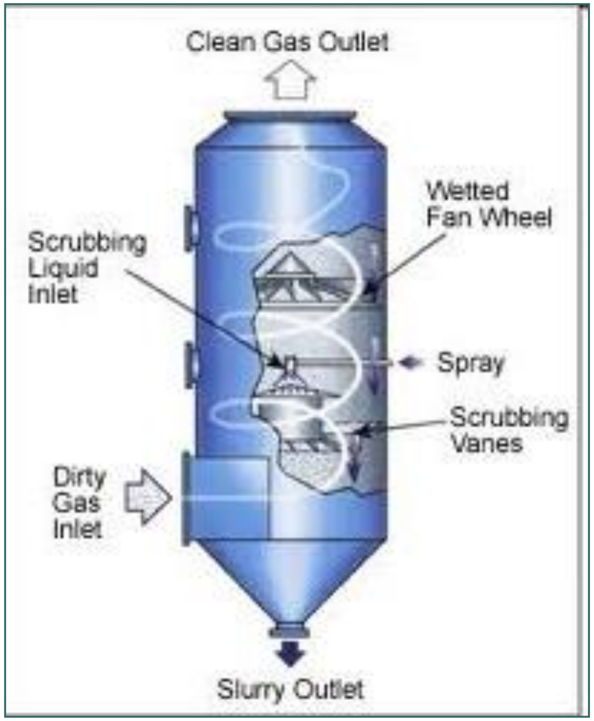


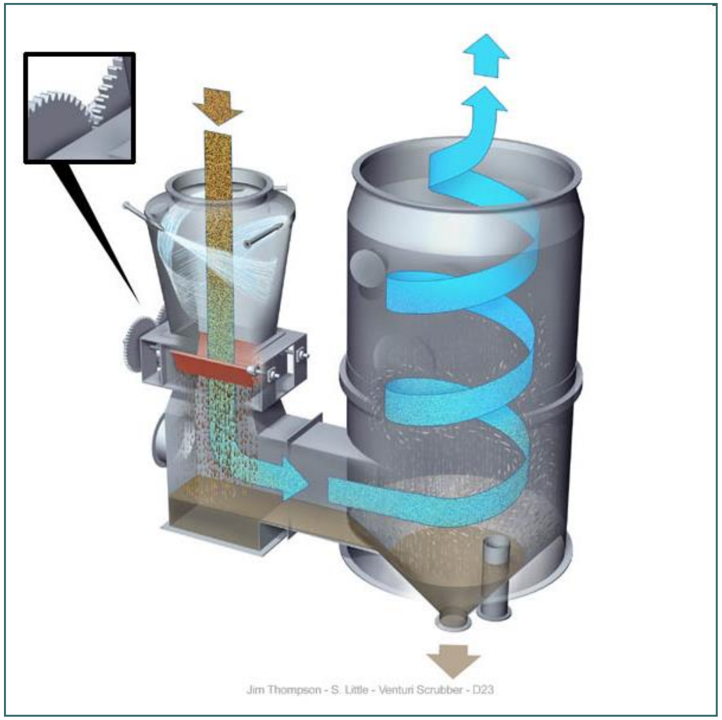
Sand bed filters also use mass forces for removal of particles.

When the particles are deflected during passage through the sand bed they stick on the surface and are collected. The particle cut diameter for a well designed sand bed filter is around one μm and it can then remove the main part of the coarse particles. By introducing electrostatic fields in the sand bed the removal of small harmful particles can be improved.
A sand bed filter is robust and can stand extreme conditions.

Wet scrubbers also rely on mass forces for the removal of particles.
The working principle is the same as for sand bed filters – instead of sand water droplets are used.
The particle cut diameter is very dependent on the velocity difference between droplets and particles. Higher velocity difference requires more power.

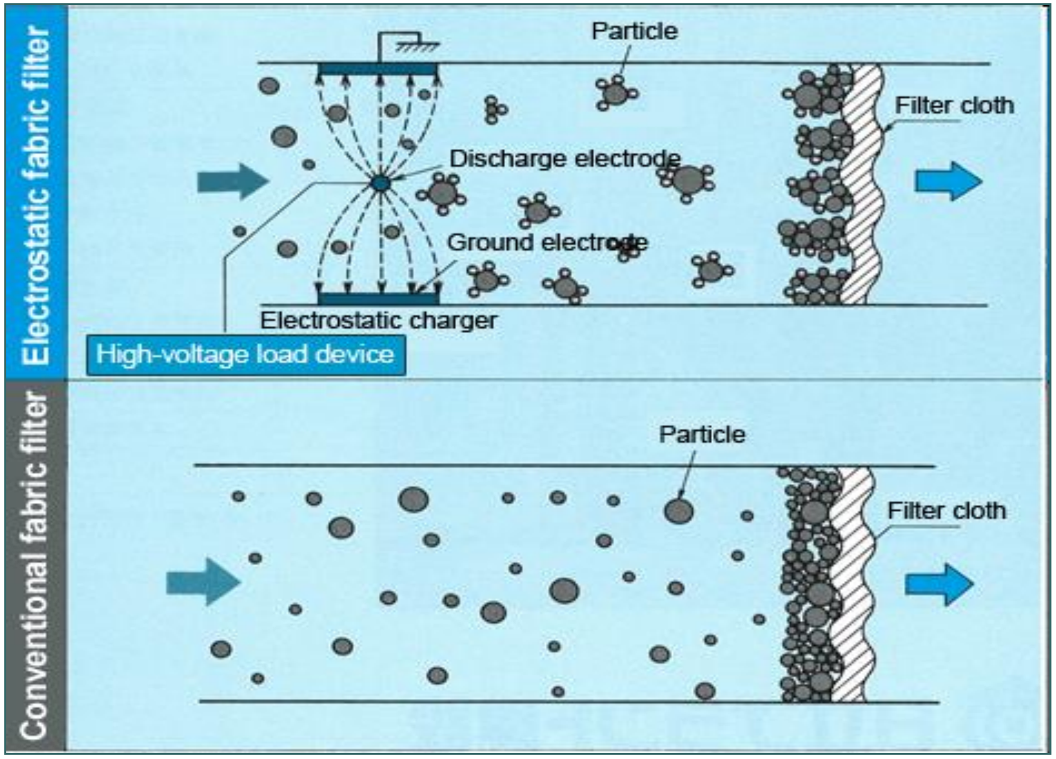
The removal of small particles can also be done using electrical forces, normally by charging particles and droplets with opposite charge.





Adhesion separators

Fabric Filter (FF) (Bag (house) filter, Fibrous filter, Textile filter)
- The most common adhesion separator.
- has a large area of woven or needled fabric which the flue gas has to flow through.

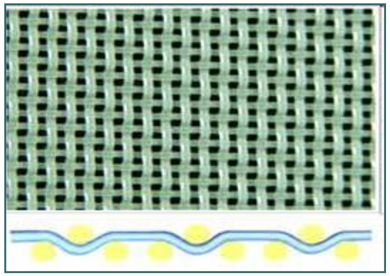


During passage, the particles are removed by deflection (mass forces), interception, diffusion (adhesion forces) and electrical forces.

Fabric filters can operate up to 200 - 250 °C with common fabrics, higher temperatures require special material.

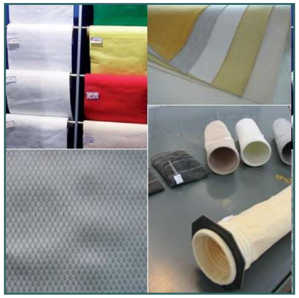
The dust cake which is formed on the fabric is regularly removed by shaking, pulsing, gas reversing, etc.

fabric filter



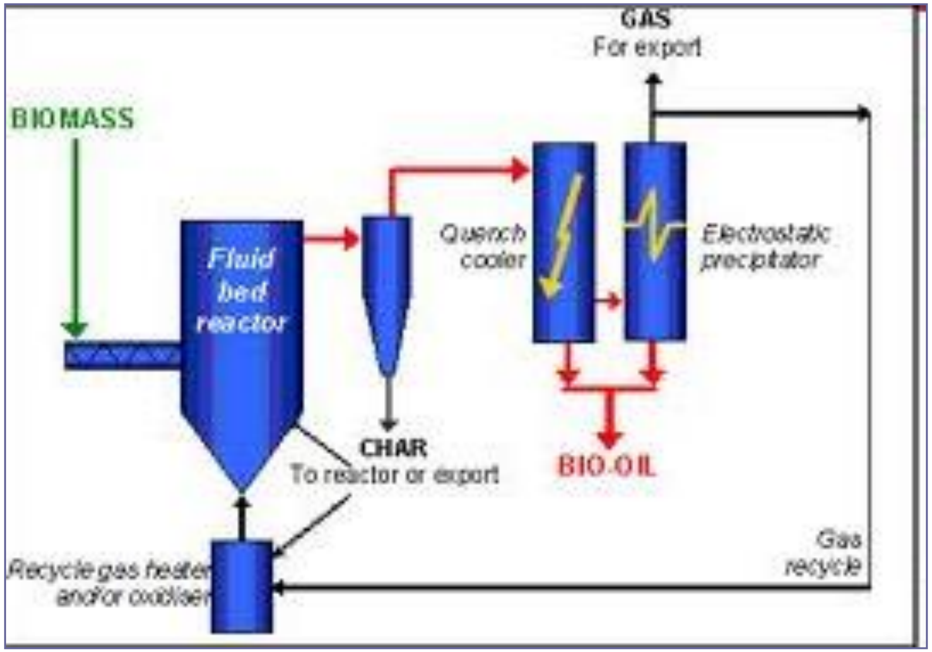
*Polyester **filter fabric***

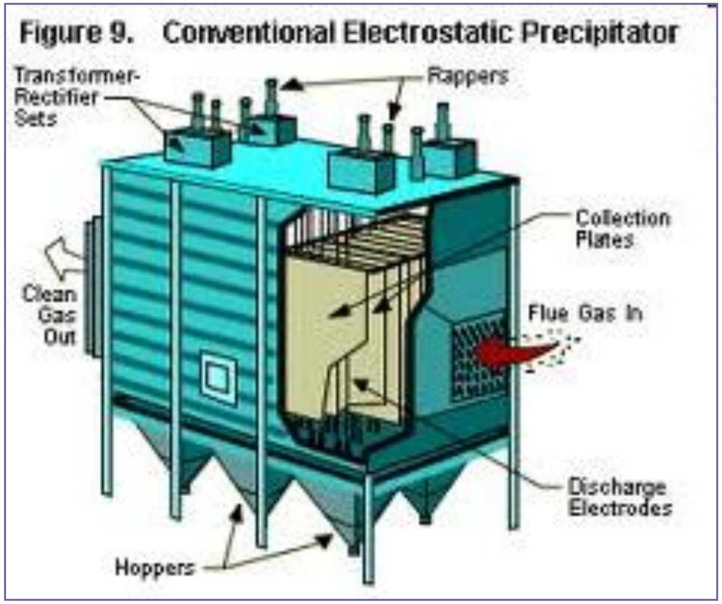
Non Woven needle punched felt fabric for dust collection



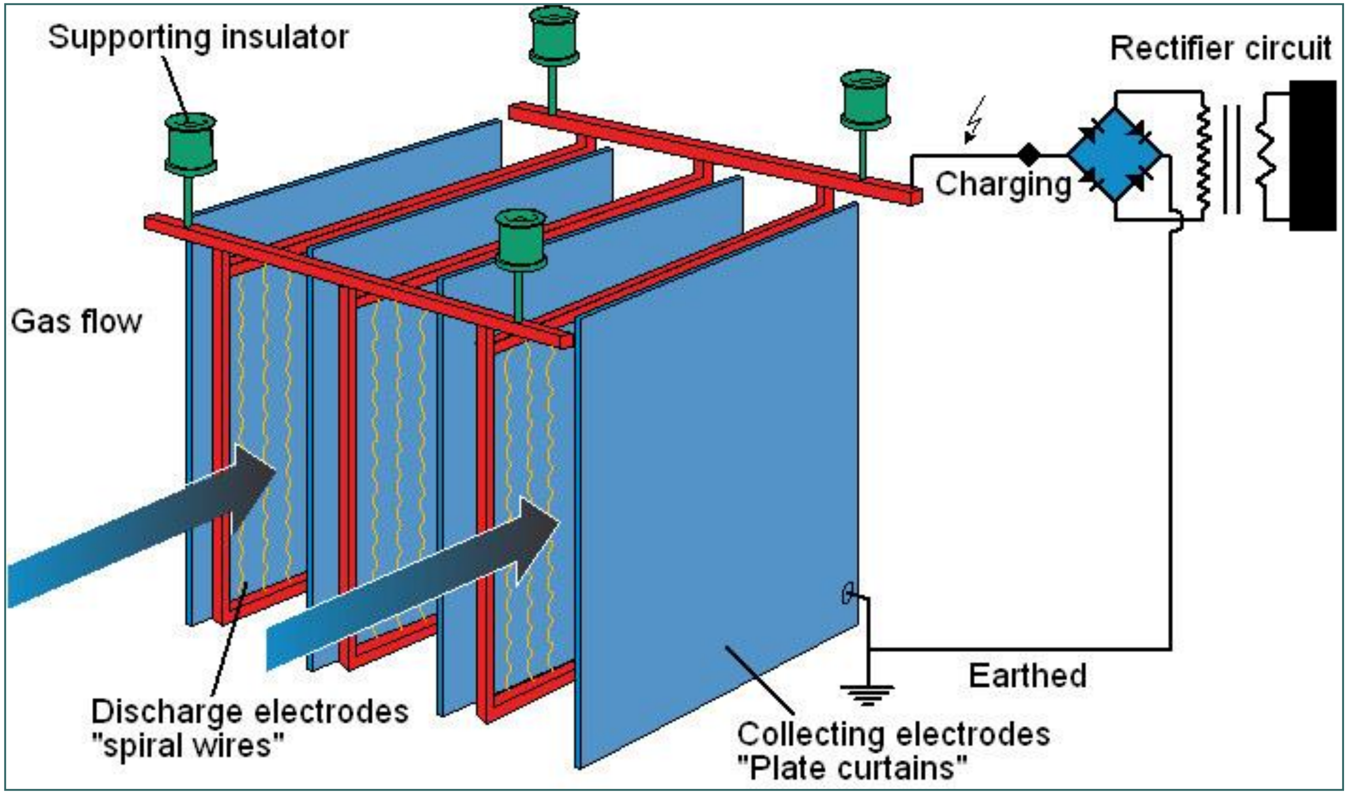
Electrostatic precipitator (ESP)

The principle of an electrostatic precipitator is very simple: charge the particles, separate them from the gas in an electrostatic field to a collector and remove the dust layer by *dry* or *wet* methods.





In principle, an ESP can be designed for very high removal efficiency for all particle sizes, simply by increasing the size.
Construction material is mild steel and therefore DESP's can operate up to about 350 °C.



Dust separation at biomass combustion plants

Diominik Steiner from the company "Scheuch“ presented about innovative technologies and processes for clean air in the company.

The company have developed own product line-up, which includes:

centrifugal separators,

fabric filters,

wet and dry electrostatic precipitators,

biological exhaust gas scrubbers,

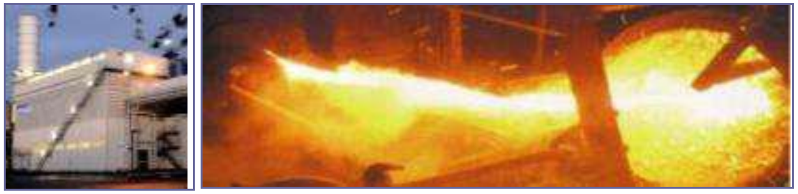
a variety of cooling and heat extraction systems, as well as fans, rotary valves, discharge devices, valves and control systems or control devices.

All components were completely compatible with each other and were optimized for the respective application.

The company "Scheuch" have five main business segments:

Wood processing industry

Wood based panel industry



Metals industry

Industrial minerals

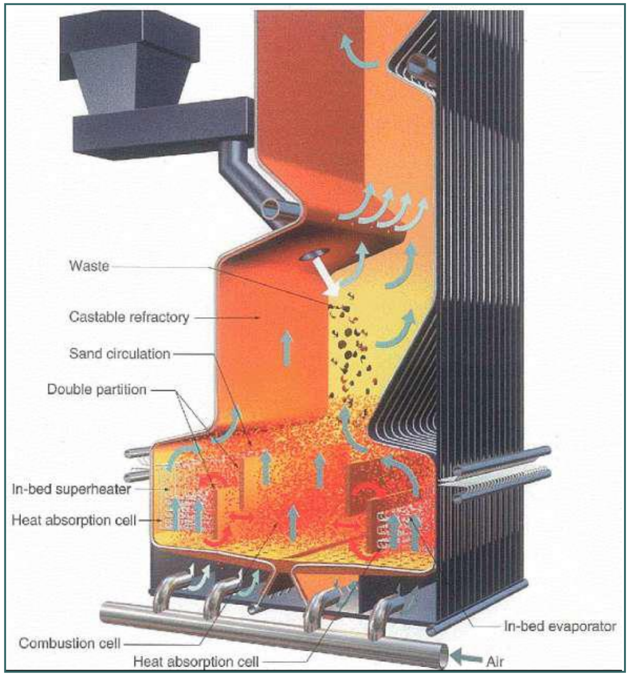
Energy industry

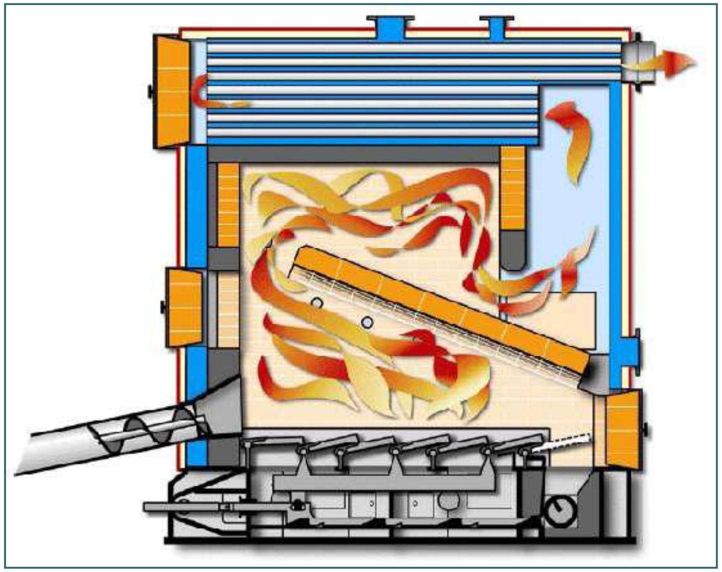
Energy Industry - which included a range of innovative

Systems to dedust, reduce pollutants and recover heat from bio-mass fired heating plants and combined heating and power (CHP) plants for the energetic utilization of fossil fuels, scrap wood, residual materials and waste materials.

Biomass combustion technologies

Fluidized bed combustion





Grate combustion

Challenges for gas cleaning systems dependent on combustion system

1. Native wood and wood pellets
 - Wood chips
 - Sawdust
 - Pellets

2. Biomass with higher ash content
- Bark
- Straw
- Grass and hulls

3. Waste wood
 - Categorie A1-A4

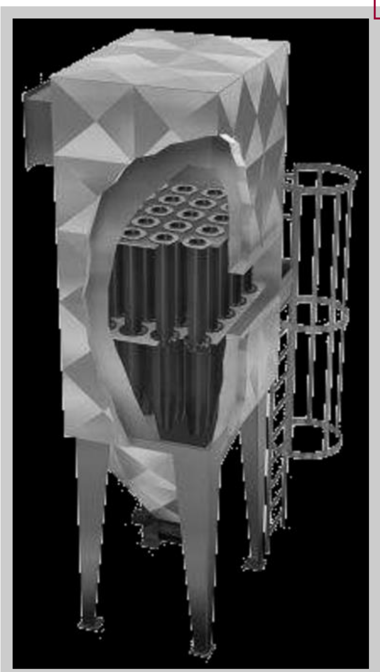
Challenges for gas cleaning systems dependent on combustion system

	Fluidized bed combustion	**Grate combustion**
Dust load	high	moderate
Gas properties	stable	changing
Dust properties	homegenous	varying
Combustion size	>30 MW	<50 MW

Legal requirements and biomass dedusting technologies

Biomass dedusting technologies

Centrifugal separators (Cyclones and Multicyclones as pre-separator)



Electrostatic Precipitators ESPs

Fabric Filters

Biomass dedusting technologies

Three main technologies:

1. **Effective dust separation** - for the separation of particles and centrifugal separators for pre-separation and dry electrostatic precipitators for final cleaning.

2. **The ERCS processes** (Energy-Recovery & Cleaning-System) which were developed and patented by "Scheuch" and offers dust and particle separation and highly efficient heat recovery and energy-optimized plume removal.

3. **Efficient removal of pollutants** - the bag filters. The fabric filter plants are extremely well suited for filtering fine dust and for use in combination with sorption processes to reduce pollutants.

Centrifugal Separators - Multicyclones

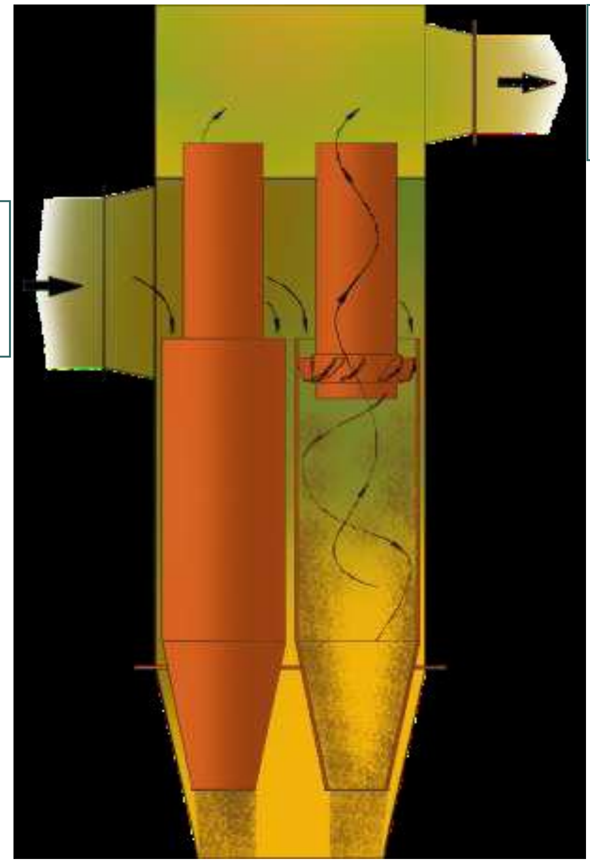
- Used as pre-separator
Clean Gas Dust Content
≤ 150 mg/Nm³dry

- Incinerator Heat Power
from 0,2 to 100 MW

- Gas Temperatures:
• < 300 °C (Standard)
• > 300 °C (Optional)

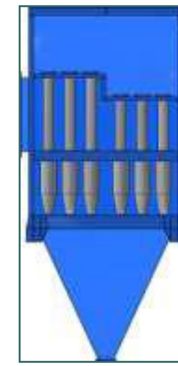
Functional principle

Crude gas from combustion

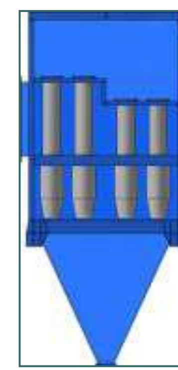


Clean gas after multicyclone

Fly ash



mk 230 n



mk 360 n

Multicyclone in operation
Type mk 360n and mk 230n

Electrostatic Precipitators – ESPs

-For Dedusting of Flue Gas
Clean Gas Dust Content ≤ 10 mg/Nm^3dry

- Incinerator Heat Power
from 0,5 to 100 MW

- Gas Temperatures:
• < 300 °C (Standard)
• < 420 °C (Optional)

Dry ESP on Biomass Incinerators

1- Field

2- Field

1- Field with Multicyclone

3- Field

2- Field with Multicyclone

Single Compartment Filters

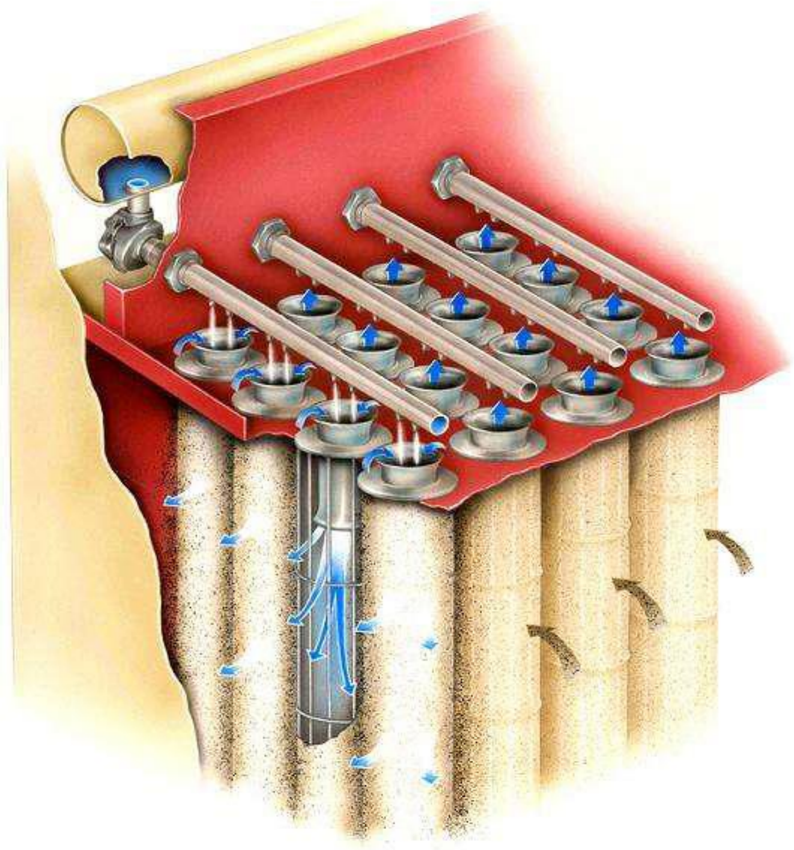
Plants < 10 MW / Single Compartment Filter

- Clean Gas Dust Content ≤ 5 mg/Nm^3dry

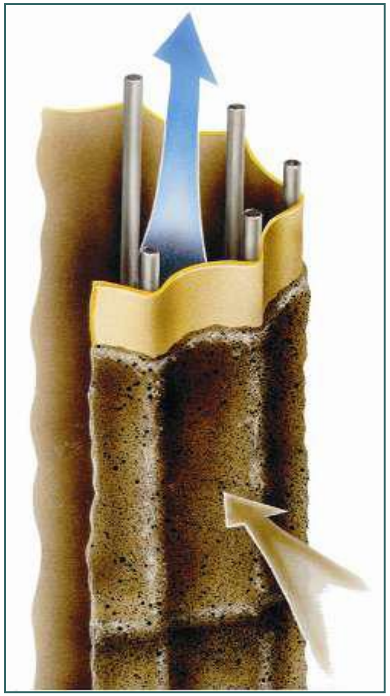
- Incinerator Heat Power >0,2 (suggested >5 MW)

- Gas Temperatures:
• < 250 °C (dependent on fabric media)

Operating and cleaning principle



Filtration



Cleaning

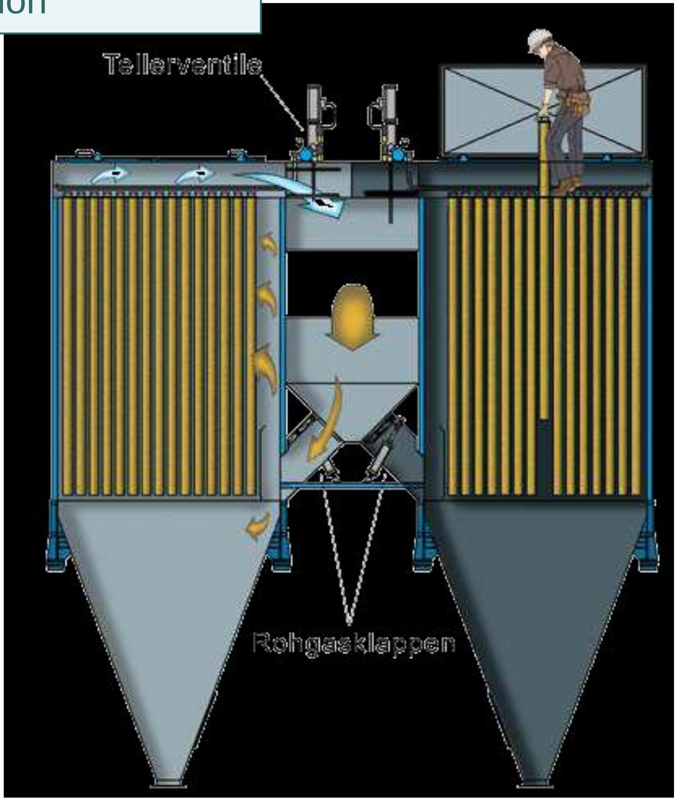
Multi-Compartment Filters

Plants > 10 MW / Multi-Compartment Filter

Multi-Compartment Filters

Plants > 10 MW / 1 Compartment in Maintenance

Remaining Compt.s in Filtration



Compt. In Maintenance

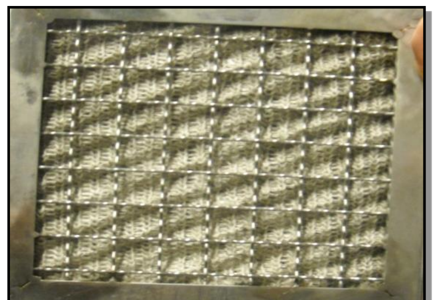
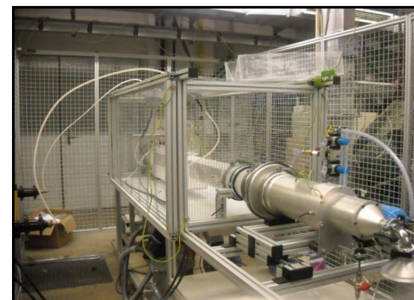
Filter Bag Change during Operation (Availability)
N2-Flushing of Compartments for Fire Prevention

Dust filter test equipment, laboratory at the Institute of Chemical Engineering

Lab-tour at the Institute of technology.

- Particle size measurement techniques and dust filter test equipment.

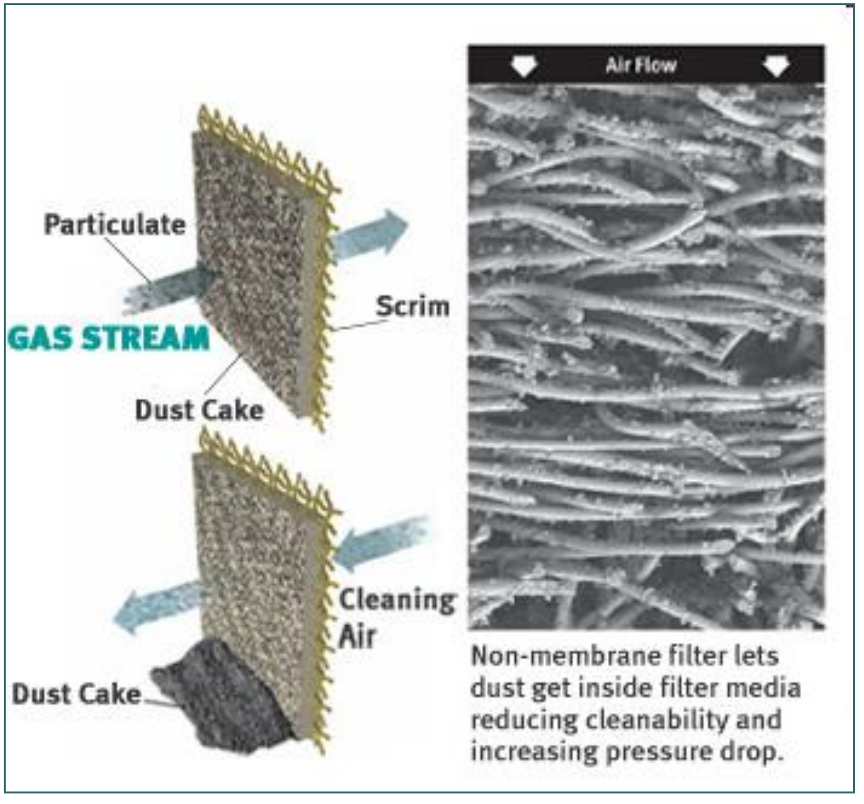
They have showed us the test equipment for measurement of clean gas concentration which consist two filters: **<u>membrane</u>** and **<u>polyamide</u>** filter.

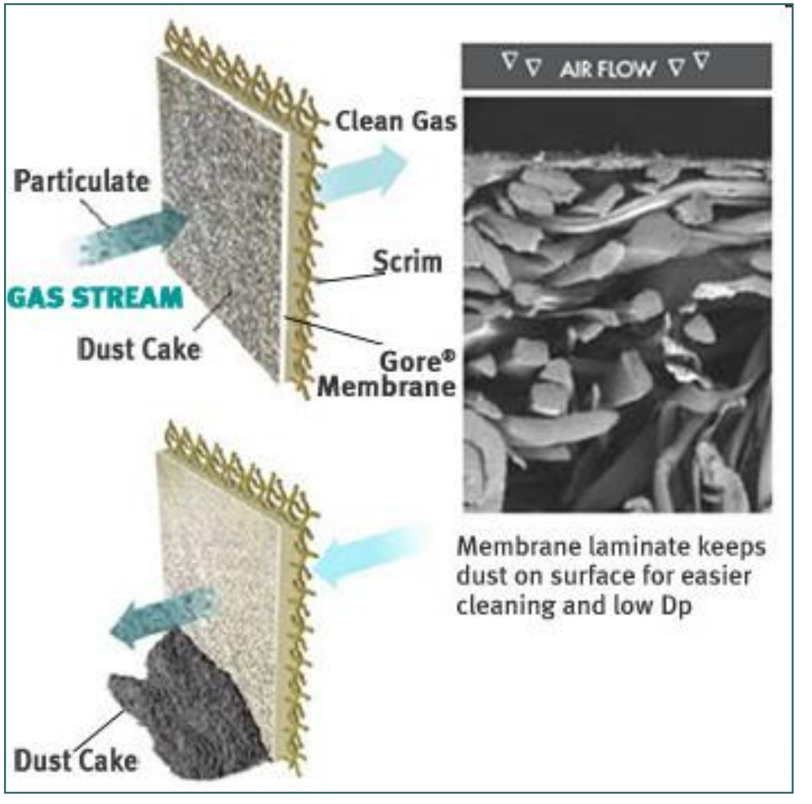





Vienna University of Technology laboratory at the Institute of Chemical Engineering

In the laboratory of the institute they work *according to standards*.
By using white xenon they could note the particles size and count the number of particles which cross trough the xenon light and they could make a short flash. The good filter should be cleaned after 20 minutes of work. The membrane filter was very thin and the clean gas concentration was about 0.5 mg on cubic meter. Because this filter was very thin the problem could be occur if there is a mechanical damage, so all the particles in that case would be walk trough the filter.

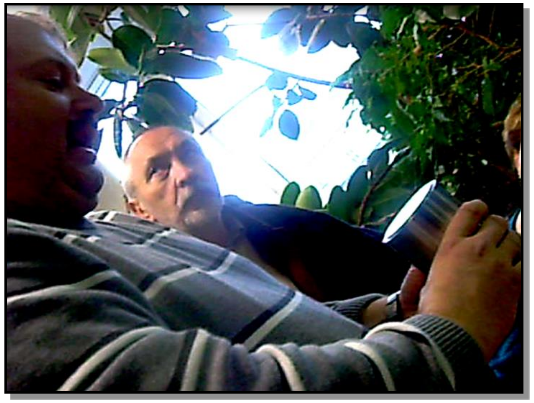
Non – membrane vs. Membrane filter





Vienna University of Technology, laboratory equipment

By using the contemporary laboratory equipment they could classify the load of particles with using electrostatic field. They have produced special voltage of the electrostatic field so called mono dispersion which means that all the particles will have the same particle size. With this method they have got information about the particle size and their number concentration, so they could be calculate the particle size distribution. Particle size distribution has been very low starting with 4 or 5 nm up to 1000 nm. They could get the information in the time of 2 – 3 minutes. The scanning process was very quick.



Thank you for your attention !