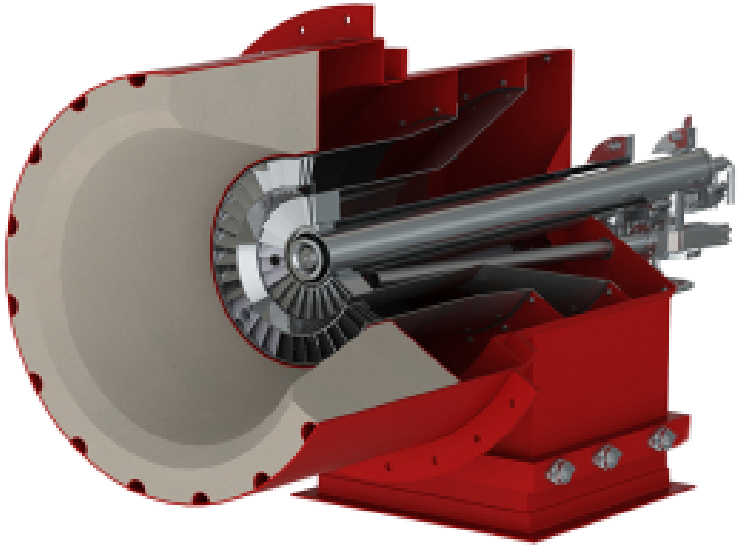
WTS AB
POWDER BURNERS



Björn Forsberg
Global Market Manager

www.wtsab.com

Who we are and what we do.

World Thermal Service AB is a Swedish burner manufacturing Company specialized in powder Combustion.

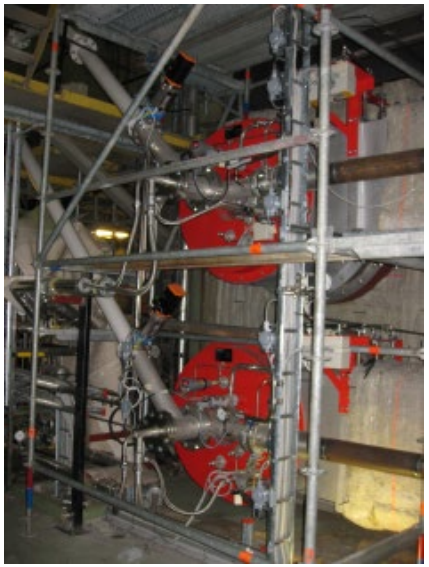
We are the leading experts in converting oil, gas and coal fired boilers into profitable, efficient and future safe biomass combustion.

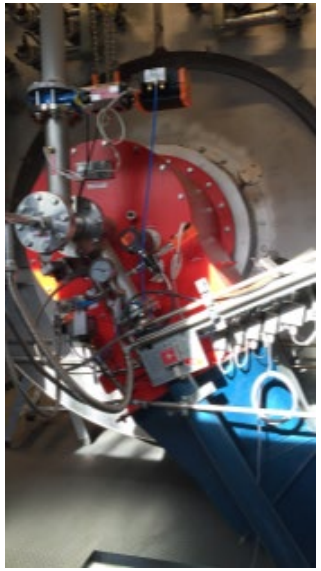
Both small and large scale plants.

WTS AB has worked World Wide with biomass powder combustion for more than 30 years.

Our core business is all about enabling our customers making the transition into renewable fuels and at the same time increase their profits.

- Powder burner: 2-50 MW
- Smallest supply: 100 kW
- Largest supply: 180 MW (4 x 50 MW)





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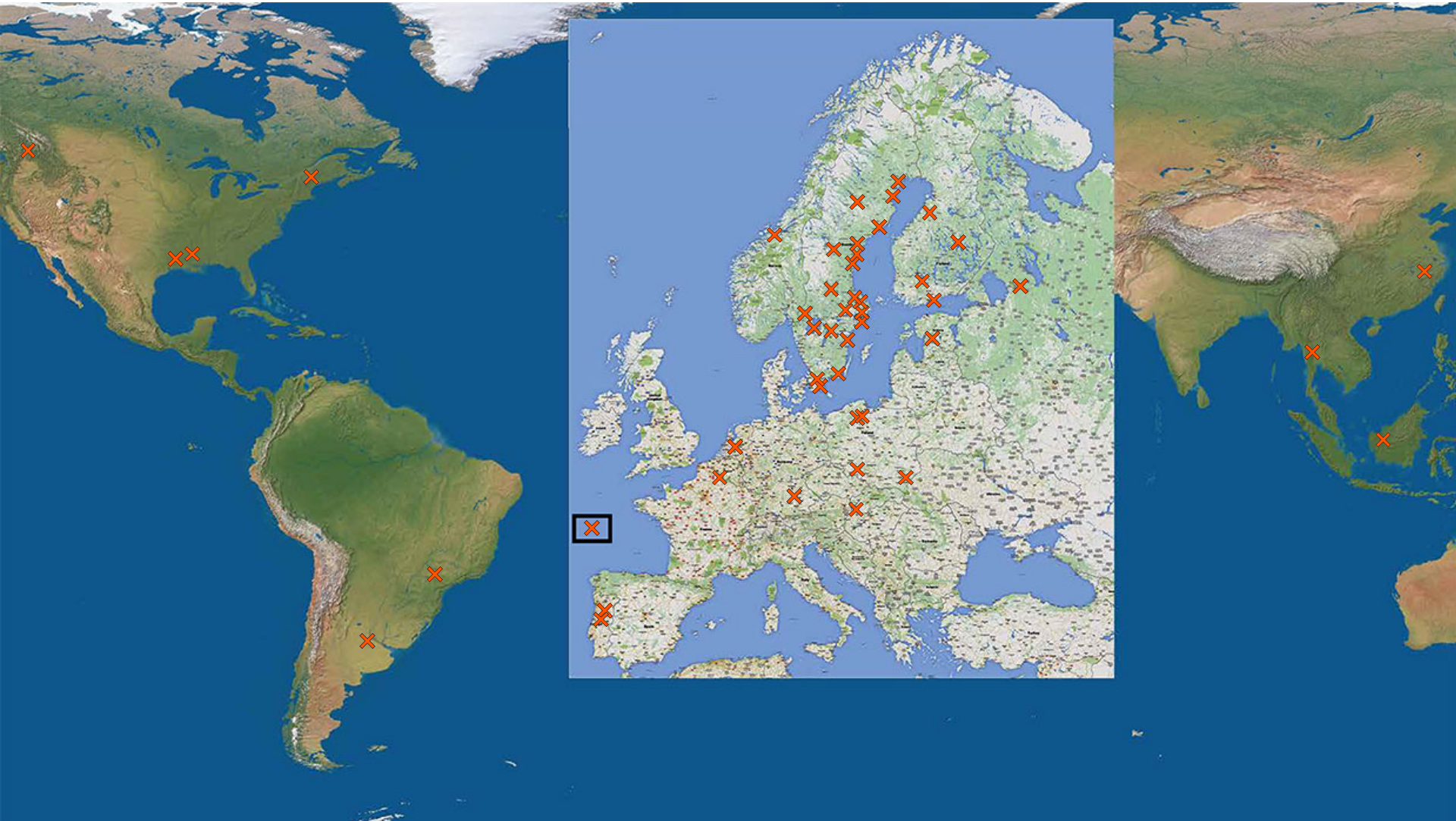
For more than 30 years WTS has been involved in supplying powder burner systems worldwide.



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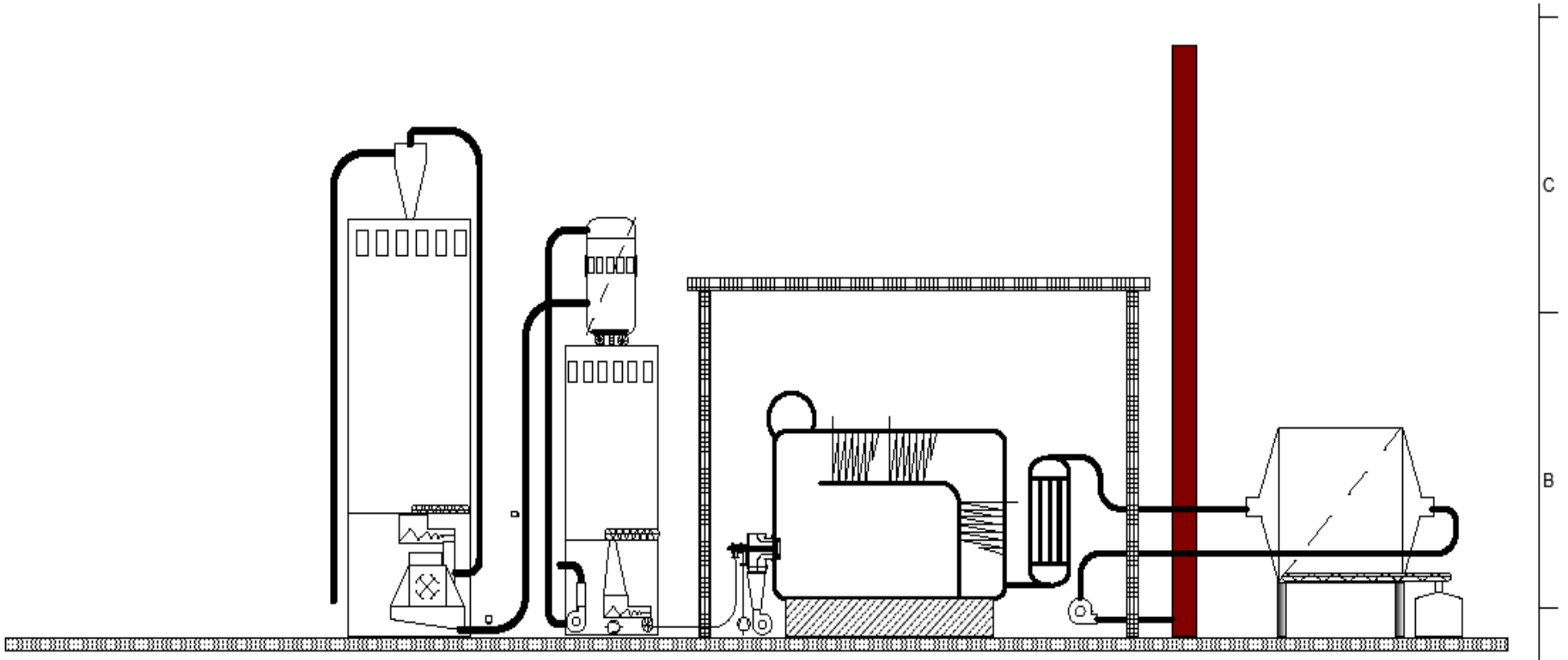
Principle of a small industrial boiler converted from fossil fuel to wood powder combustion



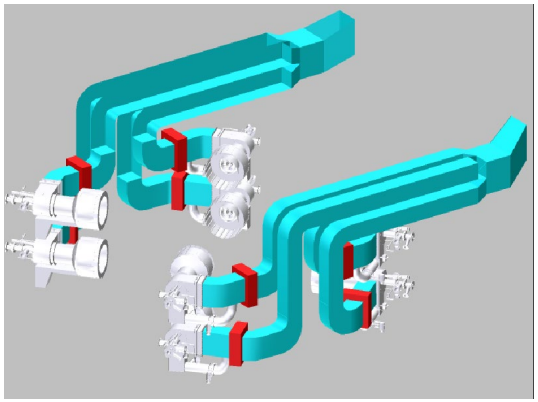
World Thermal Service AB Box 557 611 10 NYKÖPING SWEDEN	Princip schema för pulver eldning. WTS AB POWDER BURNERS

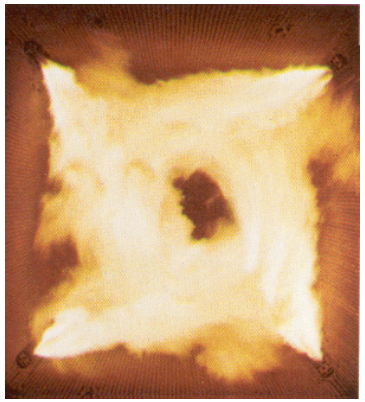
Burners location on boilers

Water tube boiler, top fired

Horizontal furnace, fire-tube boilers

Water tube boiler CHP, tangential fired





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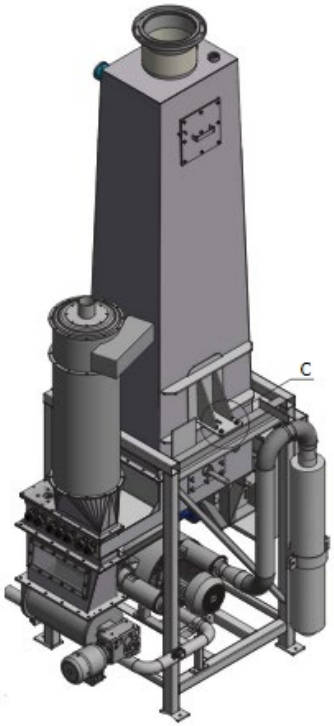
Powder dosing units



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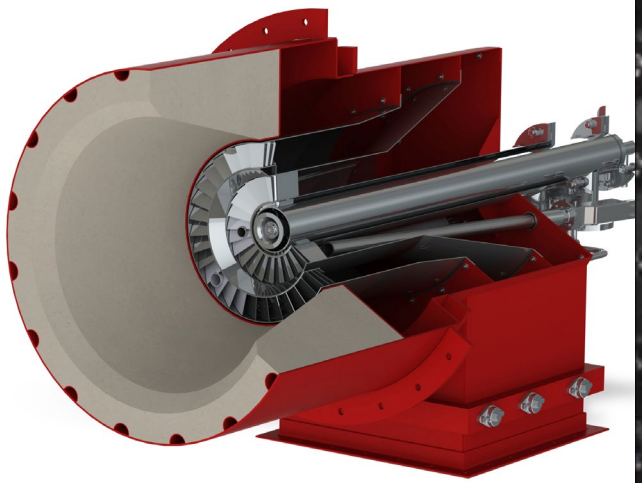
WTS Multi fuel burners for powder & oil & gas



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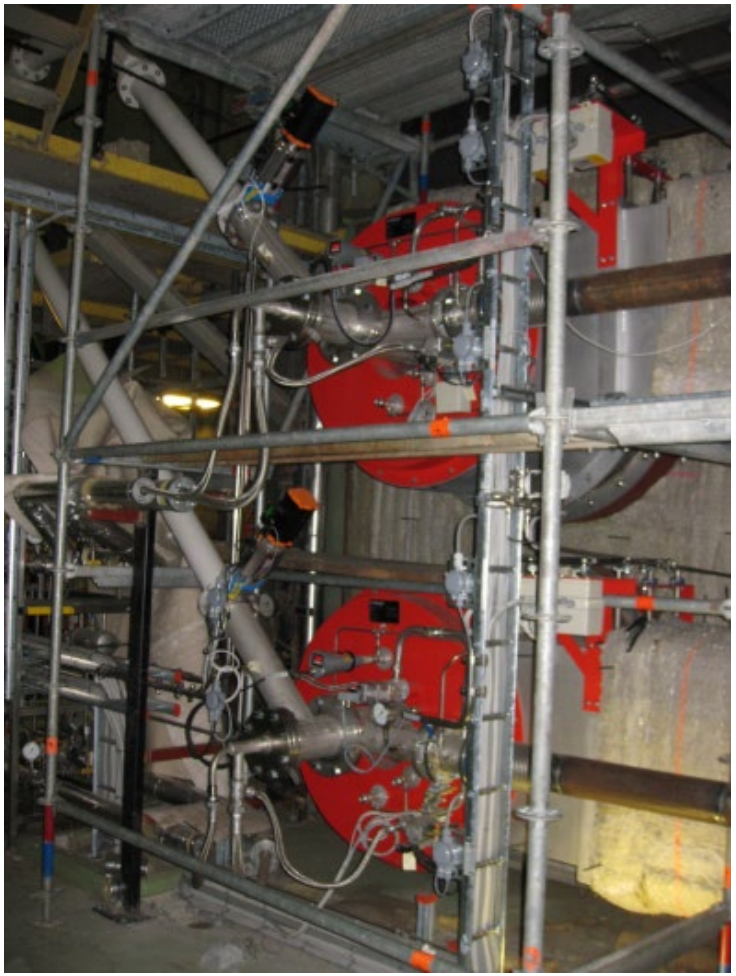
Burners installed in 90 t/h steam boiler in a Swedish paper mill



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POWDER BURNERS

Conversion of fossil fired steam or hot water boilers things to consider.

This presentation will focus on conversion from oil, gas and coal.

Coal boilers are generally very well suited for conversion to dry biomass powder
Oil and gas boiler has some more things to look out for.

When a conversion will be done, things to consider are listed below:

- Fuel
- Boiler
- Furnace
- Convection pass
- Flue gas cleaning
- Emission controls

The Fuel

Type of fuels to to be used in a conversion are:

Wood

- The primary source to be used, would be wood pellets since this is available almost everywhere. The pellets is milled to a fine powder.
  The origin has a large impact on the properties of the wood pellets.
  Pellets are easy to store and handle since it behaves more like grain.

- Briquettes is another source of wood to be used but it requires a bit more complicated storage and handling as well as higher milling power since it is coarser wood particles are used to make briquettes.

- Dry wood chips, dry sawdust and grinding dust from wood industry is also one of the larger sources to be used but then the risk of contamination has increased.

Agro residues

- A very large source of biomass that are not utilized as much as it should are agriculture residues.

- The main reason is that when used as fuel, agro residues create a number of problems inside the boilers: ash is melting to slag, ash deposits build up on SH tubes and convection tubes, chlorine content creating corrosion, nitrogen content is higher and therefore NOx will increase significant and the higher ash content must be considered more carefully.

- However, the large volumes of agriculture residues make these fuels interesting in the future, but they require to be processed and treated to become interesting in large scale. The processing required is primary to remove unwanted components before they reach the boilers.

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Conversion of fossil fired steam or hot water boilers things to consider.

Residues from production

- Many companies have residues from their own production that could be used direct as they are. Or they need to be processed more, to be dried, cleaned etc.

- There is a larger risk that these products are contaminated with plastic or metal that require different handling and they may fall under the waste directive and that will require a different type of boiler than those that could be converted relatively easy.

Other fuels that would be considered easier

- Biooils is a large family of different qualities and but in general considered easier to deal with so I will not focus on these.

- Biogas both conventional biogas but also syngas could be considered to be used but I will not consider focus on these due to the same reason as biooil, relatively easy to use when making conversions.

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Conversion of fossil fired steam or hot water boilers things to consider.

Fuel properties

- When using powder in a burner it is important that powder is dry and milled to correct particle distribution.
- WTS has the following general criteria for the fuels to be used:

  Moisture = < 10%

  Particle distribution: 100% < 1mm & 70% < 0,5mm
- If the fuel contains contamination such as sand, erosive ash or other materials it is important to consider the internal wear of the powder handling, in the powder transport and inside the burner.
- The amount of ash is not really a big problem for the combustion but the ash that do not follow with the flue gases remain inside the boiler as bottom ash, and must be removed, in one or another way.
- The amount of fuel N is important since this has a strong impact on the NOx emissions.
- Chlorine will create corrosion in the back end of the boiler if the flue gas temperature is allowed to drop too low.
- Sulphur is not a main problem for the combustion since it participates in the combustion process in a positive way and can quite easy be removed by limestone injection into the flue gases.

Conversion of fossil fired steam or hot water boilers things to consider.

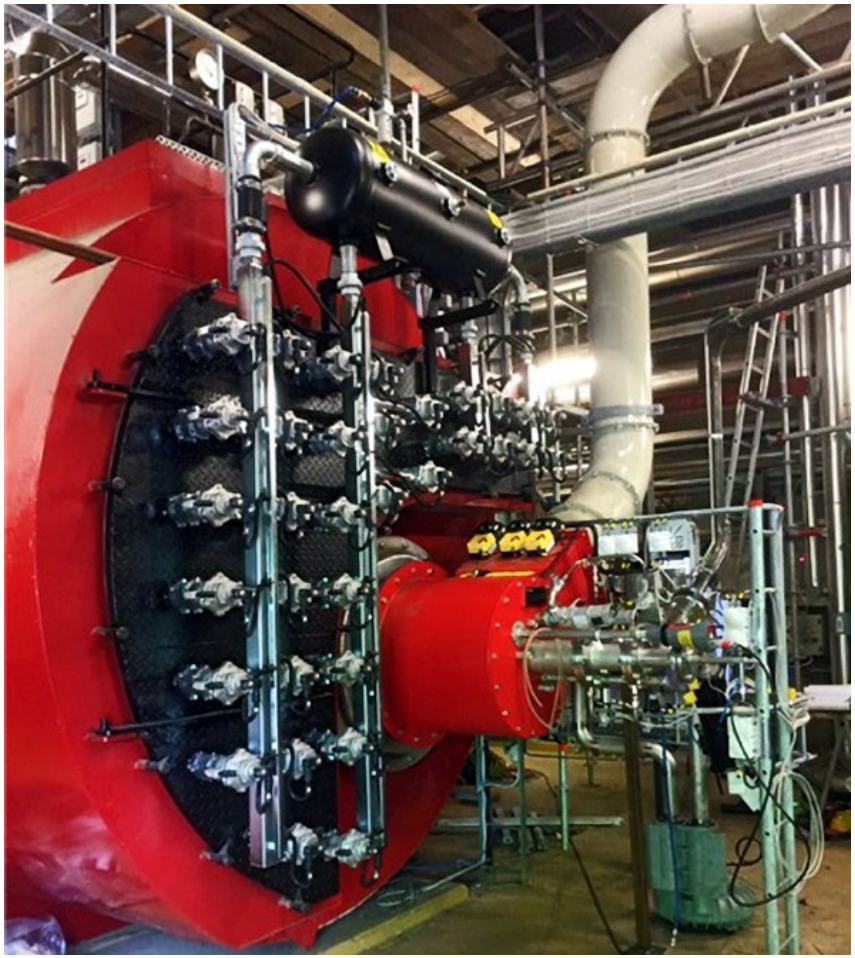
Boiler types:

- Smoke tube boilers are possible to convert but the restricted flame tube diameter and volume makes them limited for conversion to powder and usually requires significant de-rating of the capacity.

  The reason for this is that the powder flame is larger than an oil or gas flame and it requires a longer residence time to be completely combusted.

  A small flame tube diameter also creates a cooling surface that cools the flame, and this will create CO of not handled correct during a conversion.

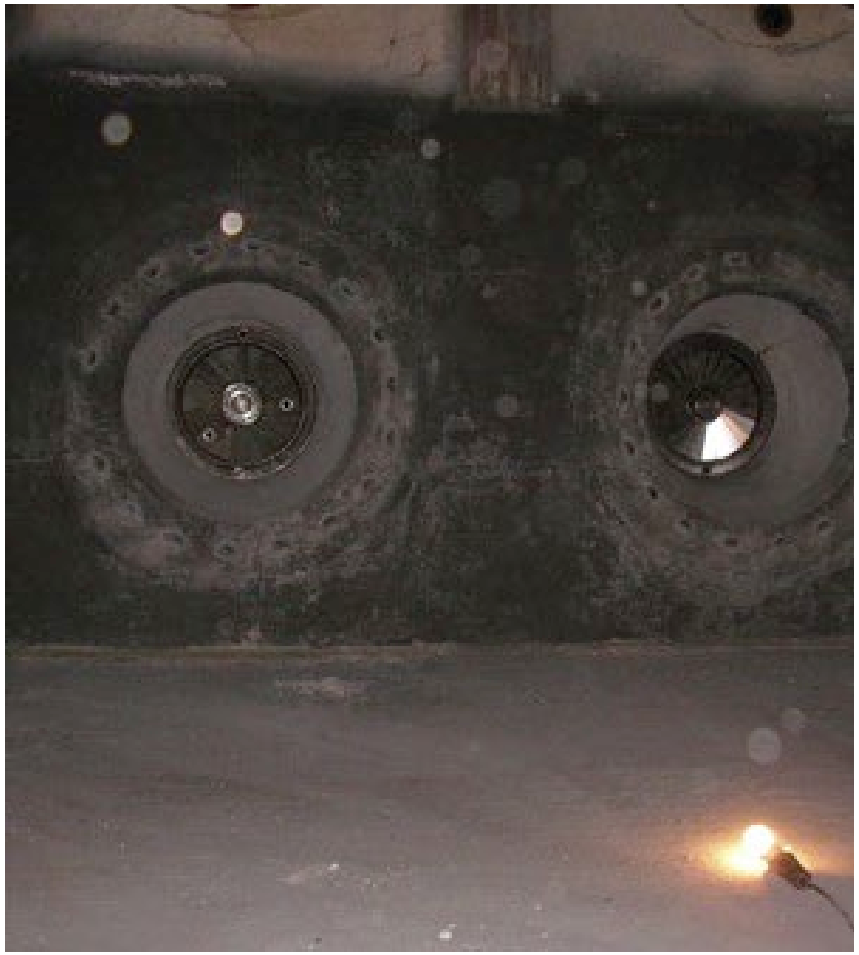
  To limit this problem the flame tube should be partly covered with refractory to maintain temperature and create radiation towards the flame and allow complete combustion.



Conversion of fossil fired steam or hot water boilers things to consider.

Boiler types:

- Water tube boilers are generally more suitable to convert to powder because the furnace geometry is better, and the furnace volumes are larger.
- When front wall fired, the distance from front to back wall could be a limiting factor.
- The residence time before the entrance of the convection is also one thing that could be a problem if it is too short.
- In water tube boilers we also add refractory to deal with CO during lower loads.
- Normally we can maintain same nominal load on a water tube boiler after a conversion.



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Conversion of fossil fired steam or hot water boilers things to consider.

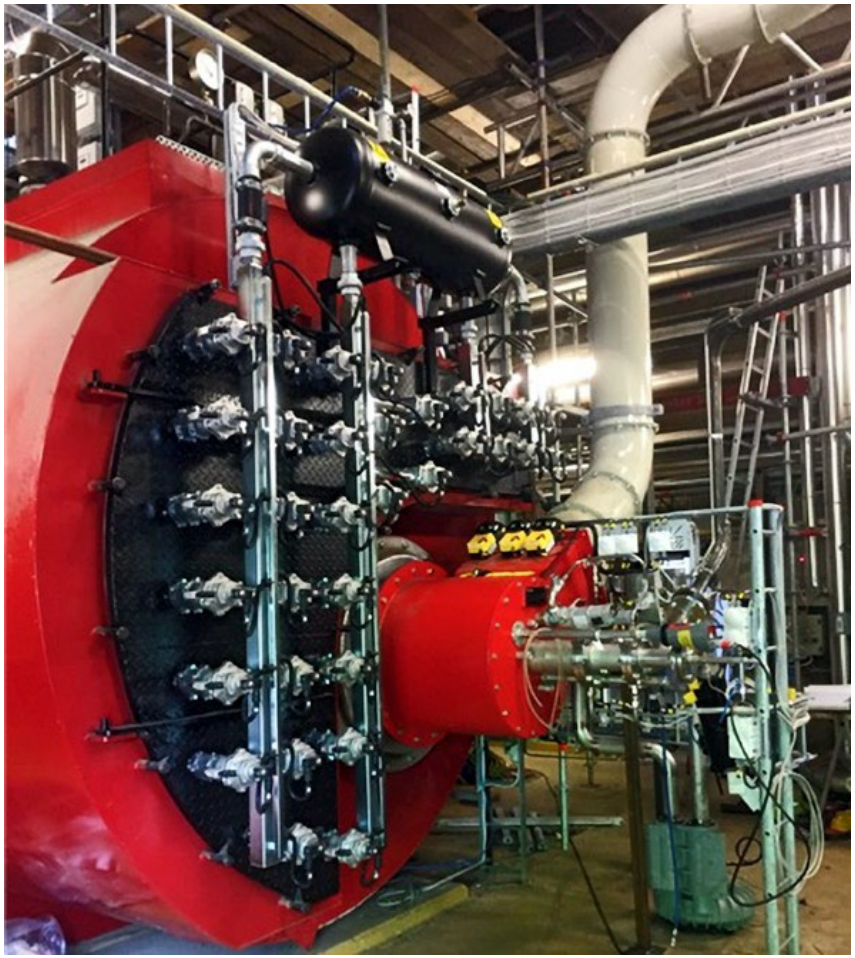
Ash

- Generally, oil or gas fired boiler are not equipped with any ash removal from the furnace, this is something that should have an impact on the fuel to be used.
- Class 1 pellets have limited ash content and > 99% follows with the flue gases out of the boiler as fly ash.
- Industrial pellets have a higher ash content, and the higher ash is normally contamination like sand or other inert material, and these will have problem to leave the furnace with the flue gases.
- When using Class 1 pellets the need to stop the boiler to remove ash from the furnace is limited and could be done once or twice per year.
- With industrial pellets it must be expected that this will be much more often and that should be considered when selecting the fuel source.

Conversion of fossil fired steam or hot water boilers things to consider.

Convection pass

- Since powder contains ash and this will follow the flue gases through the boiler there will be deposits on or in the convection tubes. Therefore, soot removal is required, and the easiest solution is to use compressed air operated soot shoots that create an impulse into the convection and then remove the deposits located on or in the tubes. Infrasound or typhon type of soot blowing could be used.
- It should be expected that manual cleaning of deposits once per year could be necessary.
- The flue gas temperature when no de-rating is needed should be expected to be higher than operating with oil or gas but due to the low dew point just below 70 deg C of dry powder an economizer could be installed after the boiler and improve the efficiency due to allow a lower flue gas temperature to the stack.



Conversion of fossil fired steam or hot water boilers things to consider.

Flue gas cleaning

Due to the ash in the flue gases, these must be cleaned before the stack to meet the requirements of particle emissions from the authorities.

Some different solution that could be used are:

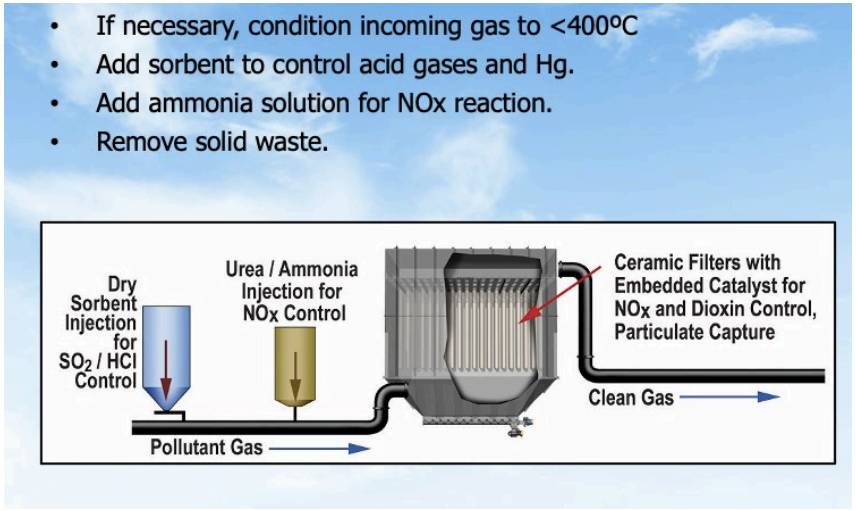
Bag house, simple but temperature sensitive and if glowing particles follow with the flue gases these can burn hole in the bags. To prevent this from happen a cyclone could be installed before the bag house to act as a spark catcher.
Emission levels below 30 mg/Nm3 are no problems.

Electric Precipitator are less sensitive to temperature and glow, but more sensitive to amount of particle concentration and velocity through the filter chambers as well as flow pattern.
Sometimes 30 mg/Nm3 could be an issue to maintain.

Conversion of fossil fired steam or hot water boilers things to consider.

Ceramic filters are not sensitive to the temperature or flow patterns.

Ceramic filters could be best described as a bag house with hard bags. Such devices are then called candles and has a ceramic wall that the flue gases can pass through, and the particles stay on the outside of the candles. When a layer is created on the surface of the candle the removal of the deposits is done by compressed air shoots into the clean side of the candle. The deposits then drop into the bottom and removed. Emissions from ceramic filters are extremely low and has no problem to meet levels < 10mg/Nm3.



ID fan and stack

- Normally, oil and gas fired boilers do not operate with ID fan. Instead, natural draught is created by the stack.

  But due to the ash in the powder as well as flue gas cleaning it is important to operate with a balanced draught pressure to achieve a slightly negative pressure in the furnace.

  This will make sure that fine ash particles from the combustion do not enter into the boiler room since it will be dusty as well as CO could be present in the boiler room.

- The balanced draught is created by the ID fan and to have a constant furnace draught pressure it should be VFD operated, and the pressure should be measured in the furnace.

- The flue gas volume from dry powder is very similar to oil and therefore very seldom the stack has to be modified.

Emission control

- Expect the O2 level to be slightly higher than when operating on oil or gas.
- Expect that CO levels to be slightly higher than with oil and gas but it is a function of several things, temperature in the furnace, the de-rating, fuel preparation and residence time before the convection but also the mixing in the combustion process.
- SO2 is nothing related to the combustion since Sulphur comes with the fuel.
  SO2 can be removed by lime injection into the flue gases.

Emission control

- NOx is a more serious thing and very often this has not been a requirement in the boilers when operated on oil or gas.
  But when a fuel change takes is done this always becomes a requirement.

- There are several factor that has impact on NOx: fuel N, burner design, stage combustion, residence time and it also reacts opposite to CO, i.e high CO → reduces NOx and low CO →increases NOx.

- To meet NOx levels of 150 mg/Nm3 @ 6%O2 in converted boilers it must be expected that stage combustion with SNCR based on NH3 or Urea injection must be used. This can be difficult in some boilers since the injection has to be done in the correct temperature window as well as residence time and that may not be possible to get access to in some boilers.

Emission control

- One solution is to use a SCR where the NOx is reduced by a catalyzer and then very low NOx emissions can be achieved.

- The temperature to get the correct reduction of NOx is important but will take place below 400 deg C. Then the flue gases are not cleaned so particles can then contaminate the catalyzer and it loses its efficiency over time. Such solution requires maintenance as well as replacement or regeneration of the catalyzer elements.

- It is also possible to combine a ceramic filter with a catalyzer after the cleaning since the ceramic filter is not sensitive to the temperature.

- Another solution is where the catalyzer is embedded inside the ceramic candles and then the function becomes double of the flue gas cleaning, since the particles are removed and the NOx is reduced in the same equipment.

- One other good thing with that is that the economizer downstream gets completely clean flue gases and can be very efficient.

WTS AB
POWDER BURNERS

Project CHP Stalowa Wola, Poland.
100% conversion from coal to bio-powder

- Project in numbers:
- 8 WTS burners fuel: natural gas / biomass powder, maximum capacity 16,5 MW per burner. Total thermal load 100 MW with 6 burners in operation,
- Raw biomass silo, 5 hammer mills, powder silo, transport line from milling house to boiler house, dosing systems to burner, natural gas installation,
- Steam production for turbine: 120t/h with temperature 500^{o} C at pressure 7,5 MPa.
- Flue gas emission: NO_x and CO below contract limits.
- Biomass fuel: a wide range of biomass, wood pellets, dry micro chips and mixture of woody biomass with agro biomass.
- System is design for pellets and micro chips biomass with wide range of density,
- Total weight of delivered machinery: 240 ton
- Main contractor was RAFAKO.

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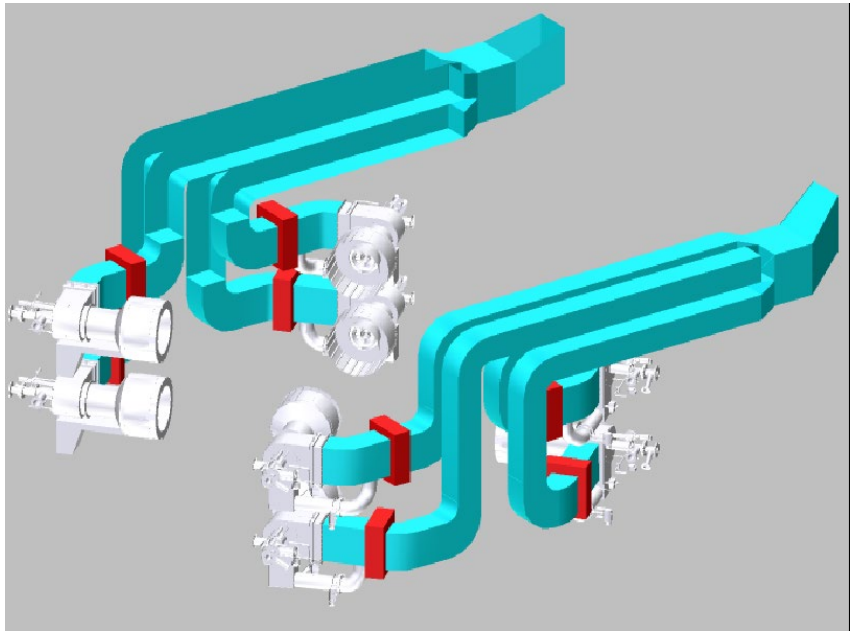
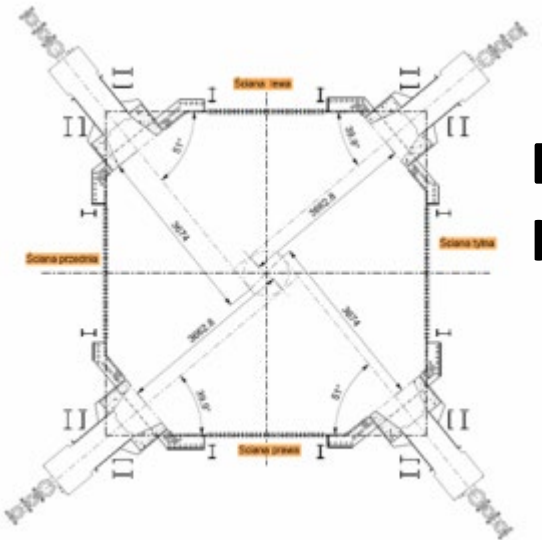




Burner configuration
In the corners

Project CHP Stalowa Wola, Poland.
100% conversion from coal to bio-powder

Milling house

Burner installation:

Biomass powder feeding system

Pneumatic transport

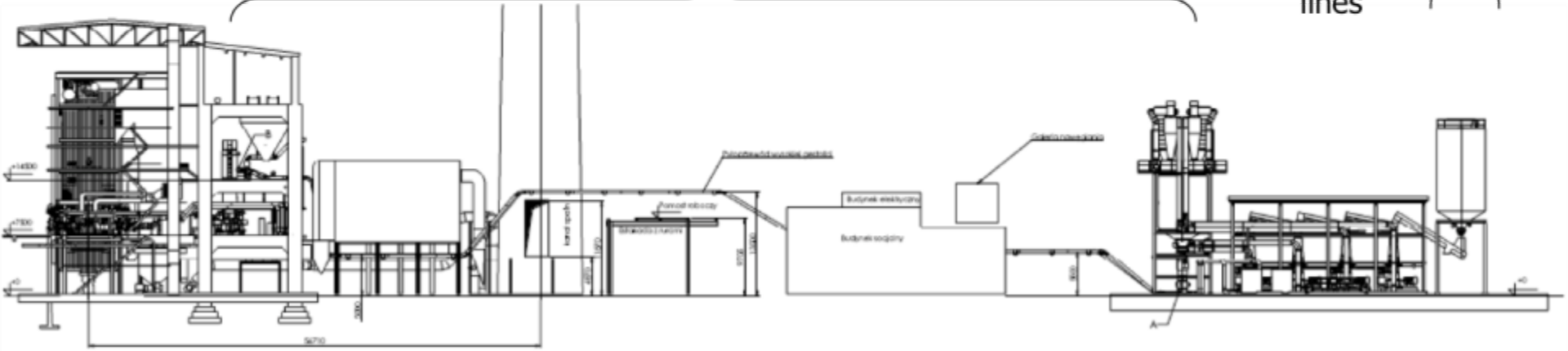
Milling house→ Boiler house

ZB4 silo V=200 m^3

Milling house building

4 milling lines

ZB3 silo V=300 m^3



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