Clean Energy from Renewables–Biomass & Waste -Valmet initiatives

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1. Abstract:

Today world is facing the challenge of reduction of fossil fuel foot print and associated emissions. There is an increasing demand for replacing primary fuels in energy intensive manufacturing industries and power plants for electricity generation with competitive and renewable alternatives. With urbanization on the upward trend, the generation of waste is increasing at a rapid pace. Many countries still landfill the majority of their municipal solid waste, causing significant damage to environment. The fact that waste is a source of valuable raw material and competitive alternative to fossil fuels cannot be just ignored.

It is mandatory that with challenges outlined above the one unique solution is necessary to effectively burn the waste with no side effects to environment. This would ensure the reduction of fossil fuel usage, preserving space and yet disposing all the wastes.

Valmet has a solution of advanced thermal conversions for the use of waste in the production of electricity and heat. The solution identified is the state of art fluidized bed combustion and gasification of waste derived fuels.

By adopting an integrated solution for waste management and energy production, a municipality can reduce the environmental impact of waste and increase their revenues from recycling and energy sales. This approach starts with efficient sorting of waste to separate recyclates and wet bio-waste. Residual waste is pretreated in a recycling facility to recover remaining recyclates and produce a refuse derived fuel (RDF). Energy intensive industries are looking at using RDF to replace fossil fuels.

Valmet has a vast experience (more than 4 decades) in supply of fluidized bed boilers and gasifiers for the thermal conversion of a wide range of solid fuels, including fossil fuels, biomass and waste derived fuels. Presently the best practices and lessons learnt from gasification technology installed in Europe is proposed to be commercialized and implemented in other regions.

This technical article provides an overview of Valmet’s sustainable solutions for efficient use of RDF as competitive fuel for a reliable power / CHP applications. The main benefit offered by Valmet’s combustion and gasification technologies is the combination of higher fuel flexibility, efficient power production and reduced emissions. These feature provides plant operators greater flexibility for fuel sourcing and maximize power production, both improving the bottom line.

Turning waste into clean gas also gives the option to replace fossil fuels with RDF in existing plants including coal fired boilers and cement and lime kilns. The concept of connecting a waste gasifier to an existing plant is discussed.

The well proven solution is now ready to be implemented in Energy from Waste (EfW) market for Asia pacific region in general and Thailand in particular.

2. Introduction

Since the late 1970s, Valmet has installed more than 260 fluidized bed boilers and gasifiers for the thermal conversion of a wide range of solid fuels, including fossil fuels, biomass and waste derived fuels.

CFB combustion is well established as reliable technology for RDF. The experiences with CFB combustion at Prosessivoima, E.ON Norrköping and Stora Enso Langerbrugge are discussed and the world's largest waste firing CFB plant at Mälarenergi is introduced.

To serve the increasing market for medium-scale energy-from-waste plants, Valmet has introduced their new modular RDF power plant concept "RecycPower" which is based on CFB combustion for high availability and efficiency.

Valmet's waste gasification concept turns RDF into clean gas for combustion and provides the highest power production efficiency for energy from waste. The latest experiences from the world's largest waste gasification power plant at Lahti Energy is briefly outlined.

3. Waste to RDF

Circulating fluidized bed (CFB) combustion and gasification enable a high-efficiency recovery process that fits well in the waste hierarchy. Pretreatment of waste to produce RDF is an important step in maximizing the recycling rate of valuable materials such as metals. To make waste suitable for fluidized bed processes it is typically sufficient to have a single shredding followed by removal of metals in magnet and eddy-current separators. In case the waste contains a high amount of glass and stones an air classifier may be recommendable. Pretreatment can be at the energy-from-waste plant or in dedicated mechanical recycling facilities (MRF). Properties of resulting refuse derived fuels (RDF) vary greatly, but heating values are typically in the range of 8 to 15 MJ/kg.

4. Reliable energy-from-waste with CFB combustion

This section briefly describes the features and characteristics of Valmet CFB technology.

Figure 1 CFB hot loop

4.1 CFB combustion technology

The key components of the CFB boiler are the furnace, cyclone and loop seal, together forming the "hot loop" shown in Fig. 1. The hot loop is water cooled as integral part of the boiler evaporator circuit. Bed material in the furnace is fluidized by primary combustion air blown in via nozzles in the furnace floor. Secondary combustion air and solid fuel are fed to the lower part of the furnace. Depending on its properties fuel is fed gravimetrically, pneumatically or mechanically.

Bed material consists of natural sand and fuel ash. Part of the bed material escapes the furnace with the flue gas to be collected by the cyclone and transported back to the furnace via the loop seal.

The turbulence in a CFB and circulation of bed material offer very good mixing of bed material, fuel and combustion air, long residence time for fuel and an even combustion temperature profile throughout the hot loop of 800 to 950 ˚C.

These optimum combustion conditions ensure high burnout of fuel, low primary emissions and low risk of fouling and slagging of heat transfer surfaces. After the cyclone flue gases pass through the boiler convective back-pass & flue gas cleaning system to leave via the stack.

Fine fuel ash (< 100 µm) passes through the cyclone and is collected in the flue gas treatment. Coarser ash is removed via bottom ash discharge openings in the furnace floor.

CFB combustion covers a wide size range with fuel inputs between 50 and 1000 MWth and is suitable for a wide range of solid fuels, including low and high grade coals, demanding biomass fuels and recovered fuels such as demolition wood and RDF. One of the main advantages of the CFB combustion technology is its wide firing range, providing great fuel flexibility as illustrated by Table 1.

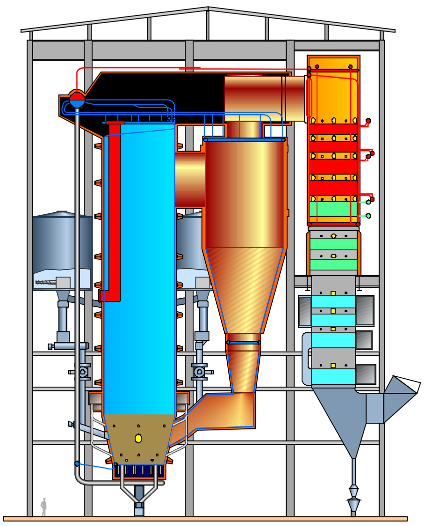

Figure 2 CFB boiler

Table 1 Range of fuel burned in Valmet CFBs

Heating value:	Biomass 6,5 MJ/kg to petcoke 32 MJ/kg
Moisture content:	Coal 7% to biomass 60%
Ash content:	Petcoke <1% to waste coal 65+%
Sulfur content:	Biomass 0% to petcoke 6%
Fuels:	Wide range of fuels including biomass, waste derived fuels, and fossil fuels, in one boiler if needed. The same boiler can be designed for 100% biomass and 100% coal and any combination in-between.
Arrangement	Refer Fig.2

4.2 Emission control in CFB combustion

In combustion of waste derived fuels the flue gas treatment typically consists of a bag house filter with upstream injection of sorbents for control of acid gases and heavy metals. For biomass a dry system is typically sufficient, but for RDF typically a semi-dry solution is necessary. Primary NOx from a CFB boiler is very low and can be further reduced by injecting ammonia into the cyclone inlet. For high sulphur fuels a CFB boiler provides the possibility of in-situ removal of sulphur by injection of limestone into the furnace. Expensive downstream deNOx and desulphurization are seldom required.

4.3 Tackling operational challenges with waste derived fuels

RDF is one of the most challenging fuels due to its high contents of chlorine, heavy metals and incombustible debris. It can cause significant fouling, corrosion and combined corrosion-erosion in the boiler if proper design measures are not taken.

Waste derived fuels generally contain large quantities of debris (metal, glass, stones). To effectively remove this from the furnace, Valmet has developed a dedicated furnace floor design for waste fired boilers and uses robust bottom ash equipment.

Fouling in a CFB is typically less of a concern than in other boiler types. The hot loop of the CFB is kept clean by circulating bed material and the low combustion temperature avoids ash melting, greatly reducing the fouling potential in the back-pass.

The high efficiency separation of ash in the cyclone makes convective heating surfaces in a CFB makes it inherently less prone to erosion compared to other boiler technologies.

Corrosion of boiler heat transfer surfaces is typically caused by condensation of alkali chlorides and/or lead chlorides. Alkali chlorides may cause corrosion at metal temperatures above 450˚C. For lead chlorides the critical temperature can be as low as 360 to 420˚C.

Measures to mitigate corrosion in a CFB boiler burning RDF or other challenging fuels include:

- Extended or complete coverage of the furnace with refractory lining to avoid direct exposure to corrosive flue gases.
- Empty, water-cooled back-pass to cool flue gases below 620˚C upstream the convective superheaters to solidify chloride compounds to less aggressive solid phase.
- Steam temperature limitation in convective superheaters to keep metal temperatures below the critical temperature for alkali chloride corrosion.
- Convective superheater arrangement to ensure that highest steam temperatures “see” lowest flue-gas temperatures to further minimize metal temperatures.
- Final superheater located in the loop-seal of the CFB hot loop where the environment is less corrosive.
- Easily exchangeable superheater construction to facilitate fast and economic exchange of corroded surfaces.

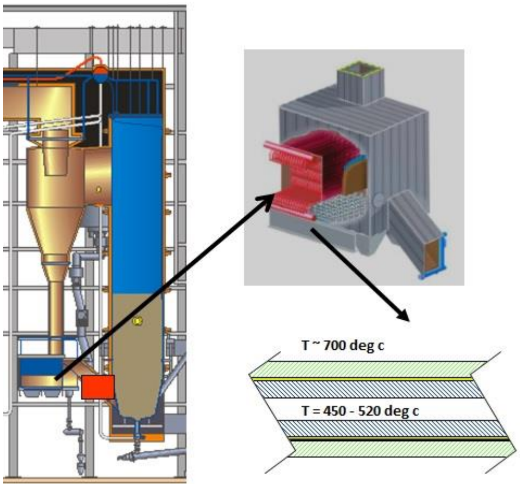

Figure 3 Loop-seal Super Heater

One of the advantages of a CFB boiler compared to other boiler types is the possibility to locate the final superheater in the loop seal, which is an air-fluidized, bubbling bed. It has high temperature and efficient heat transfer but a much less corrosive environment. In boilers burning a very high portion RDF the loop-seal superheater is designed with multilayer tubes consisting of pressure tubes with a ceramic outer layer. This construction avoids direct exposure to the environment and increases tube surface temperatures above the condensation point of corrosive compounds (~ 700 ˚C). Refer Fig 3 which depicts the points discussed above.

The loopseal superheater enables a high steam temperature for 100% RDF firing up to 520 ˚C, whilst minimizing corrosion risk and ensuring acceptable superheater lifetime. For biomass fuels this can be 565˚C or higher. Together with the relatively high steam pressure this gives a high power production efficiency for recovered fuel fired power plants, as high as 37%.

4.4 Valmet Bio/Multi-fuel CFB boiler design

Compared with traditional fossil fuel combustion, the main challenges of burning a mixture of biomass, coal and RDF (multi-fuel) are increased risks of fouling and high temperature corrosion. To meet these fuel related challenges special design features are included in the Valmet Bio/Multi-fuel CFB boiler design, as shown in Figure 4:

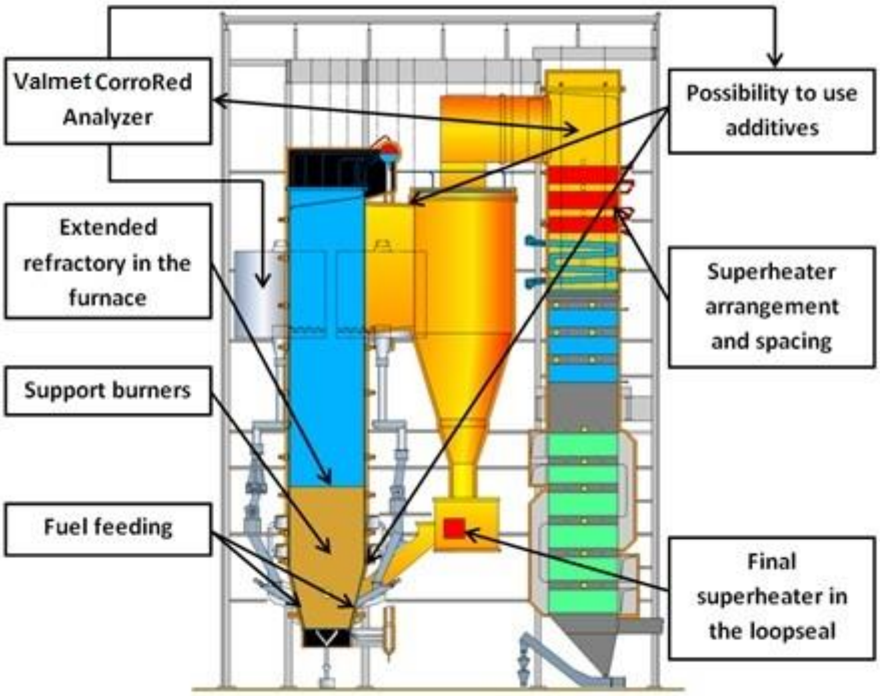

Figure 4 Bio/multi-fuel CFB design for limited RDF co-firing

- Biomass is a low density, heterogeneous fuel typically containing high amounts of non-fluidizable debris such as stones. The boiler is therefore equipped with robust fuel feeding and ash removal equipment and two fuel feeding lines for redundancy.
- When co-firing RDF the plant falls under the waste Incineration directive (WID). The lower furnace is therefore covered with extended refractory to ensure 850 ºC / 2 s over a wide load range. Support burners ensure compliance also during disturbances or burning very wet fuel.
- The boiler is equipped with several features to mitigate corrosion risk, including locating the final superheater in the less corrosive environment of the loop-seal, convective superheater arrangement to optimize flue gas and steam temperature profiles and thereby minimize metal temperatures, use of stainless steel material in part of the convective superheaters and possible feeding of sulfur based additives to reduce flue-gas corrosivity.
- Fouling in the convective pass is mitigated by selecting moderate flue gas velocities and wide tube pitches and optimized on-line cleaning with soot blowing.

Thanks to these measures the Valmet Bio/Multi-fuel CFB boiler design is suitable for demanding biomass mixtures and co-firing up to 20% RDF.

4.5 Valmet RDF CFB boiler design

Waste derived fuels are the most challenging fuels, containing high amounts of chlorine, heavy metals and incombustible debris. These fuels may cause significant fouling and corrosion and in many cases combined corrosion-erosion. To be able to burn up to 100% of fluffy and corrosive RDF, Valmet has included several special design features in the RDF CFB boiler design, as shown in Figure 5:

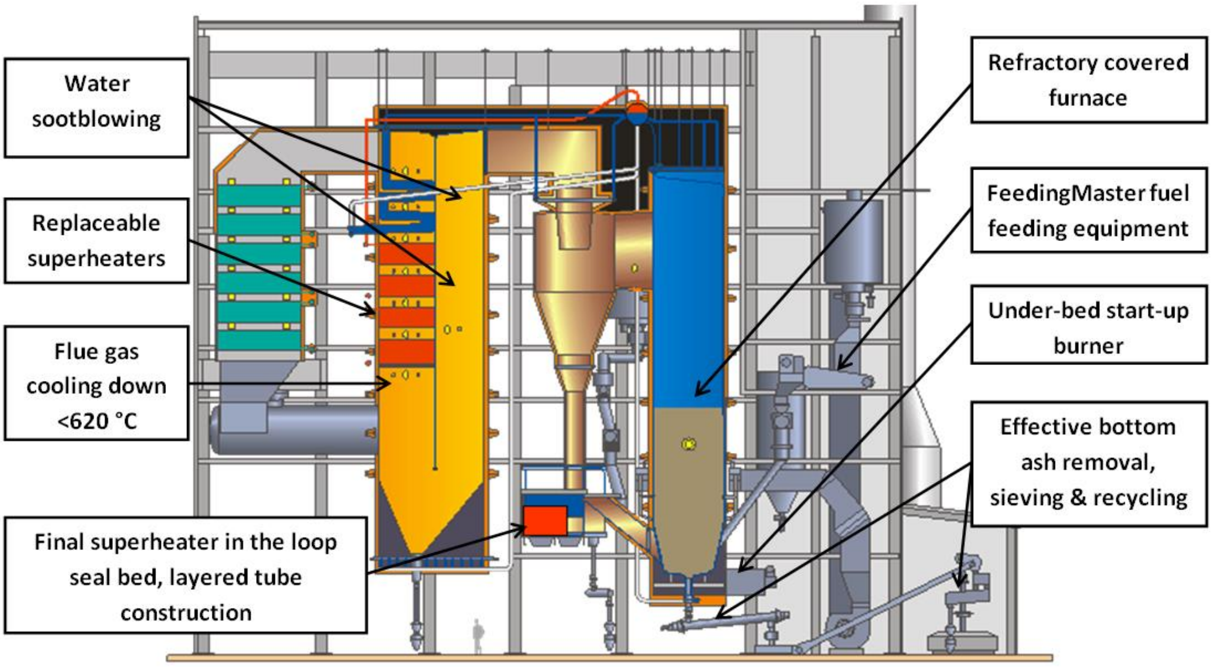

Figure 5 RDF CFB design for 100% RDF firing

- Even and controlled feeding of fluffy RDF is ensured by a specially designed apron-type dosing feeder (Feeding Master). Incombustible debris is effectively removed via large bottom ash openings in the inclined furnace floor, which is also equipped with directional fluidizing air nozzles. Robust design and redundancy in the fuel feeding and ash removal equipment ensure high availability. Bottom ash is sieved and fine material is recycled back to the furnace to reduce the amount of make-up sand. Heat from cooling of ash conveyers is recovered by preheating combustion air, increasing boiler efficiency.
- The furnace is completely covered with a thin refractory lining to protect against corrosion and ensure compliance with 850 °C / 2 s over a wide load range of typically 60 to 100 %. Support burners are installed in the upper furnace to ensure compliance during disturbances.
- To cope with chlorine and heavy metal corrosion, the boiler is equipped with a water-cooled empty pass cooling flue gases below 620 °C before entering the convective superheaters. Metal coating is applied to the upper part of the empty pass. Superheater corrosion is minimized by using a loop-seal heat exchanger with multilayer tubes for the final superheater and limiting the steam temperature in convective superheaters below 400˚C. All superheaters are easily replaceable.
- Fouling and erosion of heating surfaces are mitigated with low flue gas temperature and velocity. Soot blowing includes water blowers in the empty pass and steam blowers at convective superheaters and economizers.

Valmet has delivered several RDF CFB boilers, the most recent references summarized below:

EON Norrköping, Sweden	Stora Enso Langerbrugge, Belgium	SAICA El Burgo de Ebro, Spain	Mälarenergi Västerås, Sweden
75 MW_{th}, 65 bar, 470 °C	125 MW_{th} 60 bar, 475 °C	140 MW_{th} 75 bar, 520 °C	155 MW_{th} 75 bar, 470 °C
MSW, industrial waste, recycled wood, sewage sludge	RDF, untreated and treated wood, coal, gas	Paper processing rejects (plastics), mill sludges	MSW, industrial waste, recycled wood, wood, peat, sewage sludge
Start-up 2002	Start-up 2010	Start-up 2011	Start-up 2014

Table 2 Most recent Valmet CFB boiler references for RDF

4.6 Overview of Valmet References for CFB technology.

This section outlines the typical references of Valmet. For the sake of clarity one example is presented for each of various fuels in CFB described in the previous section.

4.6.1 Co-firing waste in industrial and municipal energy production at Pori

A good example of the capability of a CFB (fig: 6) to burn multi-fuels is the boiler plant delivered by Valmet to Porin Prosessivoima at Pori, Finland. Since its start-up in 2008 this boiler plant has reliably provided the Sachtleben Pigments factory with electricity and process steam and the city of Pori with heat using a competitive mixture of biomass, peat, waste derived fuel and coal. The boiler produces 67 kg/s of steam at 84 bar(g) and 522 °C using 195 MWth of fuel.

Figure 6 Pori CFB Boiler Plant

The fuel mixture consists on average of 45% indigenous peat, 45% forest residues, 10% RDF and 3% coal. Chlorine content in the fuel mixture varies between 0,1 and 0,2 % (w-DS). The boiler is designed for a very wide heating value range of 8 to 30 MJ/kg, as shown in Figure 7. A look at availability of this boiler for last few years indicate an average figure of 95% with a reliability close to 100%. The plant has one planned maintenance stop of two to three weeks each year.

Maintenance mainly includes overhaul of material handling equipment. Superheater corrosion has not been an issue with no sign of corrosion in the loopseal superheater. Only some starting material loss detected in a limited area in the convective pass.

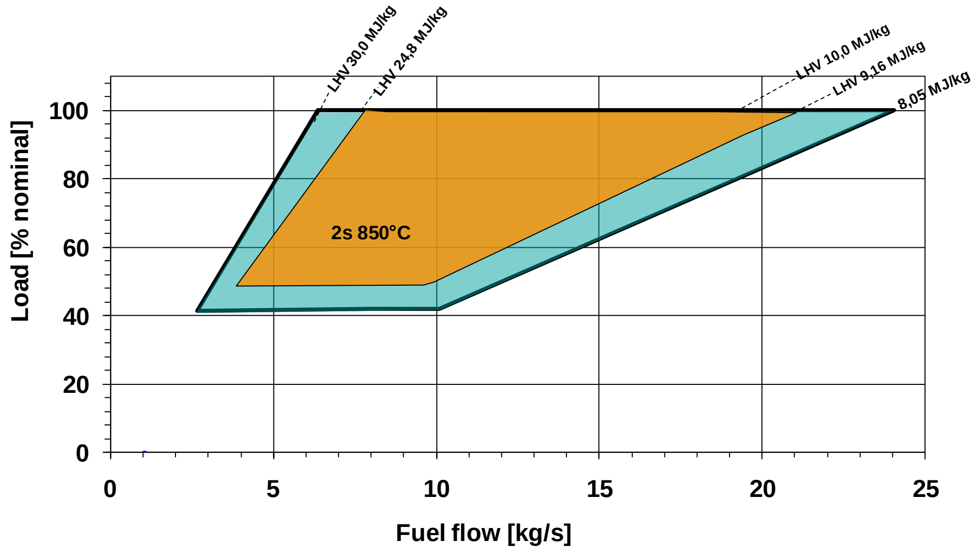

Figure 7 Boiler firing diagarm (850 °C / 2s)

4.6.2 Waste as competitive fuel for district heating supply to city of Norrköping

A good example of the reliable and efficient combustion of 100% RDF in a CFB is the P14 boiler plant delivered by Valmet in 2002 to the E.ON Händelöverket plant in Norrköping, Sweden. The boiler plant produces electricity, process steam and hot water for district heating using 200 ktpa of a mixture of household and industrial waste streams. The boiler produces 27 kg/s of steam at 65 bar (g) and 470°C from 83 MW of fuel.

As one of the first CFB boiler plants for waste several undesired challenges were experienced during the first operating years. The biggest challenge was strong deposit formation and rapid corrosion of the loopseal superheater limiting its lifetime to six to twelve months. Fast corrosion caused frequent tube leakages leading to unplanned plant shutdowns. After extensive investigations a novel type of loopseal superheater was developed by Valmet with a multi layered tube construction. Since its installation in November 2005 the lifetime of the final superheater has significantly increased to about three years and tube leakages have been fully avoided.

4.6.3 Recovered fuels for competitive energy supply to Langerbrugge paper mill

A more recent example of the RDF concept is the CFB boiler (Fig 8) installed by Valmet at the Stora Enso Langerbrugge paper mill in Gent, Belgium. This boiler plant was taken into commercial operation in 2010 to provide the mill with process steam, heat and electricity using a flexible and competitive mixture of recovered fuels. The boiler also ensures full backup capability with coal in case of unavailability of recovered fuels.

Figure 8 Langerbrugge CFB boiler plant

The boiler produces 45 kg/s of steam at 60 bar(g) and 475 °C and is designed to burn a mixture of RDF, recycled wood and coal with a heating value (LHV) range of 10 to 26 MJ/kg. All of these fuels can be burned 100% individually or as a mixture in any combination. The daily fuel mixture is typically near 50%/50% RDF/recycled wood with chlorine contents ranging between 0,5 and 1,0 w%-DS.

The reliability of this unit has been over 99% and availability on average 95% since its start-up late 2010.

During the shorter stop the furnace grid is cleaned and some minor maintenance is done. The longer stop is for a full overhaul of all the auxiliary equipment, including fuel feeding and ash handling equipment.

Refractory lining has generally been in good condition with only local wear observed at the fuel feeding and cyclone inlet areas. Corrosion has not been an issue. The finishing superheater in the loopseal has not suffered from any significant material loss or deposit formation. After about three years of operation there has not been any repair or replacement of boiler pressure parts due to corrosion. The main repairs have been in the fuel feeding and ash handling conveyors and fluidizing air nozzles in the furnace floor.

4.6.4 World's largest waste firing CFB boiler by Valmet for MälarEnergi

Valmet's waste fired CFB boiler at Mälarenergi at Västerås, Sweden (Fig 9) is successfully in commercial operation from the year 2014, burning 480,000 MT /year of RDF generating 50 MWe of power and additionally 130 MWth of district heat. This is considered to be the largest waste fired boiler in the world.

The main reason for Mälarenergi to select a CFB boiler was the combination of proven high reliability of this technology for demanding fuels and the great fuel flexibility it offers for the future. The Mälarenergi boiler is designed to burn a mixture of household and industrial waste streams, as well as recycled wood (70%), peat (30%) and biomass (70%). It can even burn sewage sludge up to about 4%.

Despite the higher chlorine content in the fuel mixture (1,6 w%-DS), sufficient care has been taken to deliver higher steam parameters (73 bar(g), 470 °C) giving a high power production efficiency.

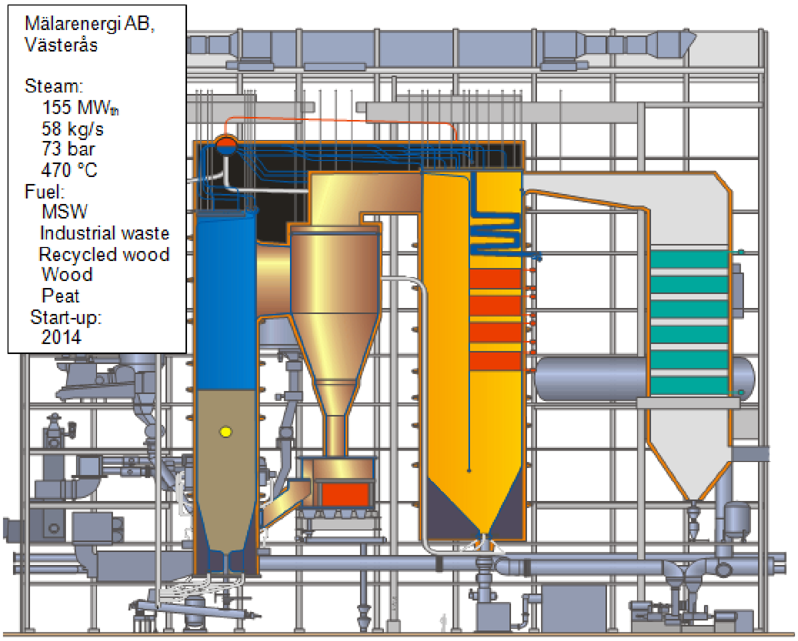

Figure 9 Mälarenergi CFB boiler plant

4.7 Recyc Power: community size energy-from-waste plants from Valmet

There is an increasing demand for medium size energy-from-waste plants as part of local waste management schemes of municipalities and recycling centers. The aim is to treat waste locally and maximize the recovery of valuable materials and energy. An optimized waste management concept starts with sorting of waste to separate recyclates and wet biowaste. Residual waste is treated to extract remaining recyclates and produce a refuse derived fuel (RDF) for efficient energy recovery.

For this demand, Valmet has developed a community size RDF power plant concept based on the turnkey delivery of a standardized and modularized plant using CFB technology for high availability and high efficiency. In line with the proven BioPower concept of Valmet (modular power plants for wood based fuels) the "RecycPower" plant is based on delivery to site of shop-assembled modules for the main plant systems.

RecycPower is designed to handle a fuel input of 40 MWth corresponding to approximately 100,000 tpa of RDF. The electric power output in condensing mode is 10 MWe (net). Heat supply is in accordance with the turbine design and can be steam or hot water. Flue gas emissions are in accordance with the European limits of the WID. The plant has a high level of automation to minimize the number of operators. The power plant building is compact with a footprint of 33m x 33m x 33m.

The standardized and modularized concept provides customers with the benefit of fast project development and implementation thanks to shorter pre-engineering, planning, permitting and building times. The CFB technology provides the benefit of high power production efficiency and multi fuel capability with a very broad fuel spectrum including biomass, RDF, coal and even wet sludges. The turnkey delivery provides the project with increased bankability.

4.8 Benefits of CFB combustion

The circulating fluidized bed combustion (CFB) technology provides many benefits for energy-from-waste applications, both municipal and industrial:

- High power production efficiency,
- High proven availability and reliability,
- Capability to co-fire a wide range of different fuels,
- Excellent environmental performance with low flue-gas emissions
- Low maintenance cost.
- Strong track record (CFB in general and experience of Valmet in particular)

Valmet has installed up to date seven CFB boilers dedicated to burning 100% RDF and in many of our more than 260 fluidized bed boilers waste is co-fired with other demanding fuels.

CFB combustion provides the highest combustion efficiency and allows high steam parameters for waste fuels with low corrosion risk, which combined gives high power production efficiency maximizing revenues from electricity sales.

The availability history of the presented CFB boilers burning waste shows reliability is typically higher than 97% and in some references as high as 99.9%.

CFB combustion has a wide firing diagram and enables co-firing of multiple fuels. Selecting a modern CFB boiler avoids locking into one type of waste fuel for the lifetime of the plant and enables optimization of the fuel basket based on fuel pricing and availability.

CFB combustion also provides excellent environmental performance. The relatively low combustion temperature combined with excellent mixing of bed material, fuel and combustion air creates optimum combustion conditions. This leads to very low NOx and almost zero unburned carbon in bottom and fly ash streams.

A further advantage of the CFB technology is that there are no moving parts in the furnace leading to relatively low maintenance cost.

In summary, CFB combustion maximizes recovery of valuable materials and energy from waste. Selecting a modern, efficient and environmentally friendly technology may also increase public acceptance and smoothen permitting for energy-from-waste plants.

5. EfW by gasification – A look at Valmet’s Technology

This section outlines the features of state of art Valmet Gasification technology. Gasification has been a key product in Valmet portfolio. It has a long tradition originating from the late 1980’s when Valmet delivered the first CFB gasifier to replace oil as primary fuel in lime kiln application at pulp mill. Valmet also carried out extensive research on pressurized fluidized bed gasification and hot gas cleanup in the early 1990’s using a 15 MWth gasifier test facility.

The main benefit of waste gasification compared to other waste-to-energy technologies is the higher net power production efficiency, which can be well above 31%. In Valmet’s waste gasifier, waste-derived fuels are converted into combustible and clean gas, which can be combusted in a high pressure steam boiler without corrosion risk. With the best practices available from European plants, Valmet intends to commercialize this technology to Asia Pacific region in the near future.

5.1 Circulating fluidized bed (CFB) gasification

In gasification solid fuel is converted into combustible product gas. Fuels suitable for gasification are woody biomass, bark, peat, waste-derived-fuels and agro fuels. The gasification reactions require heat, which is produced by combusting a small part of the fuel. The remaining fuel is converted into product gas under sub-stoichiometric conditions.

The required temperature in a CFB gasifier is in the range of 750 to 900 °C with an air coefficient between 0.2 and 0.4. The hot gas efficiency in CFB gasification is approximately 96 to 98 %. The product gas consists of combustible CO, H_2, CH_4 and hydrocarbons. The gas also contains higher hydrocarbons or “tars”, which are high in heating value but may condense on surfaces and cause fouling when the gas is cooled.

The heating value of the product gas is typically between 3 and 7 MJ/kg (LHV) depending mainly on fuel moisture content. In order to generate a product gas with sufficiently high heating value to support self-sustainable combustion the moisture content of the solid fuel mixture should be below approximately 40 w-%.

Valmet’s CFB gasifier is suitable for a wide range of biomass and waste-derived fuels. The gasifier is of simple construction with a refractory lined, un-cooled CFB reactor with self-supporting structure, shown in Figure 10. It’s simple and robust structure ensure good maintainability and high operational reliability.

The key data of Valmet's CFB gasifier include:

Capacity	20 – 150 MW_{th}
Fuel	Biomass, waste-derived fuels
Moisture content	< ~40 w-%
Gasification media	Air
Bed material	Sand and limestone
Operating temperature	750 – 900 ^oC
Operating pressure	Atmospheric (5 – 30 kPag)
Product gas	3 – 7 MJ/kg (LHV)

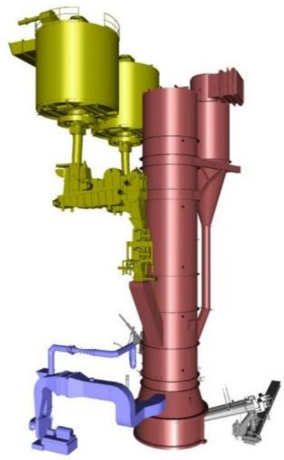

Figure 10 CFB gasifier

Figure 11 shows a conceptual diagram of the Valmet waste gasification power plant concept: waste-derived fuels are gasified in the CFB gasifier into combustible product gas, which is cooled and filtered to produce a clean gas for combustion in a conventional gas fired boiler to generate high pressure steam. The steam is led to a steam turbine for power and heat production.

The dirty product gas leaves the gasifier at about 850 to 900 °C after which it is cooled in the gas cooler to about 400 °C using boiler feed water. When the gas cools the corrosive alkali chlorides in the gas condense on to the flyash particles, which are subsequently filtered out in the hot gas clean-up consisting of rigid ceramic candle filters. The filtration temperature window is carefully selected to ensure condensation of corrosive compounds but avoid condensation of tars. After extensive test campaigns in a slip stream of an existing gasifier and comprehensive theoretical modelling the temperature was set at approximately 400 °C.

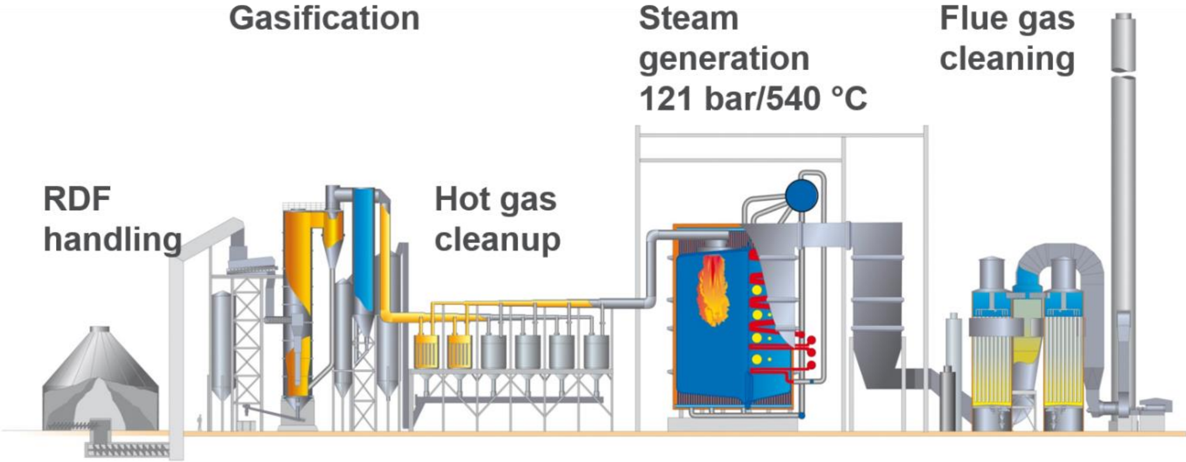

Figure 11 Conceptual diagram of a waste gasification power plant

Solid waste is not directly burned, but turned into a clean gas prior to combustion. This enables high steam parameters in the boiler without corrosion risk and gives a high overall power production efficiency. In traditional incineration steam parameters are limited to 400 °C @ 40 bar due to corrosion, whilst in waste gasification these are 540 °C @ 120 bar and can be even higher. This gives a much higher net power production efficiency of well above 31% compared to an average below 20% for traditional incineration.

RDF based Valmet's gasifier with a capacity to process 250,000 tpa has been operational from last 3 years at Lahti, Finland. It produces 50 MW of electricity and 90 MW of district heat from 160 MWth of solid waste.

Customer will have an option of co-firing of gases produced from Valmet gasifiers in the existing solid fuel fired boilers or cement kilns or lime kilns or other applications. There is a distinct advantage of substantial reduction of primary fuels in such cases. Valmet has several references of co-firing application with hot gas clean-up which is retrofitted to an existing boiler or kiln.

6. Conclusions

It is very clear that the world is heading towards biggest challenge of reduced fossil fuel foot print and emissions. On the other hand with urbanization on the upward trend increased production of municipality wastes need to be safely disposed. CFB solution offer a good bet for meeting all the challenges.

Valmet's fluidized bed combustion has demonstrated in different applications and provide many benefits for our customers using waste for energy production, which are summarized below:

- Increased revenue from energy business (electricity and heat sales) by providing higher power production efficiency than traditional incineration,
- Increased recycling of valuable materials by separation of metals and other materials before combustion or gasification,
- Low environmental impact and simple downstream flue-gas treatment, with emissions and ash quality in compliance with the most stringent European environmental legislation. This may also increase public acceptance and facilitate permitting. Operators are also able to adapt to future more stringent emission requirements.
- High fuel flexibility for a wide range of fuel properties and the possibility to co-fire multiple fuels, including biomass, waste and fossil fuels. Operators are also able to adapt to future changes in RDF quality due to increased sorting and recycling.
- The design practices adopted have resulted in higher levels of reliability and availability.

The proven solution is now readily available for the WfE markets generally Asia pacific region and Thailand in particular.

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