Wood Powder Fuel for Lime Kilns – Replacing Fossil Fuels

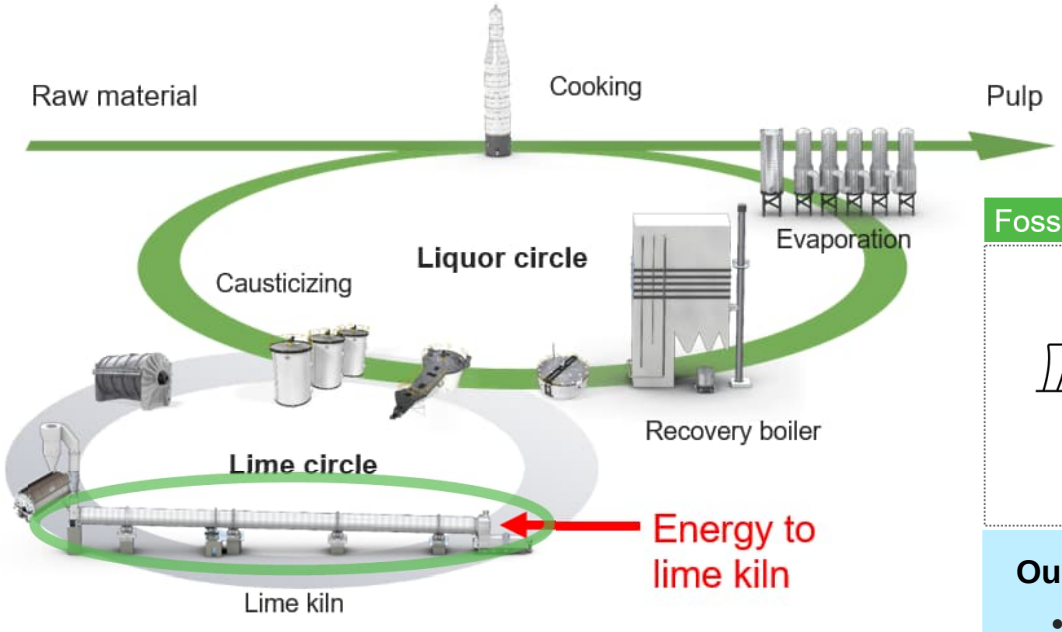
Carsten Jensen, Sales Manager

Copenhagen, Denmark

carsten.jensen@valmet.com

Decarbonization of Lime Kilns

Proven fossil-free fuel solutions for lime kilns



Fossil fuels	Fossil-free fuels
– Heavy fuel oil – Natural gas	– Gasified biomass – Saw dust, pellets, wood chips, stumps etc of clean wood – Tall oil pitch – Methanol, Turpentine, Hydrogen – Lignin – more to come…?

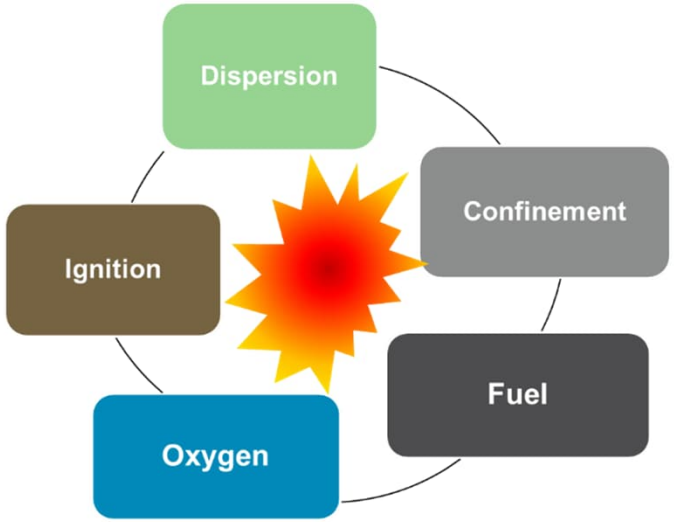
Our experience with wood powder and gasified biomass:

- 100% replacement of fossil fuels possible
- Very good business cases with surplus biomass available
- Biomass quality may have an impact on capacity
- Non-Process Element management is important
- Emissions depend on biomass quality

SAFETY FIRST

– in particular when substituting fossil fuels with biomass firing

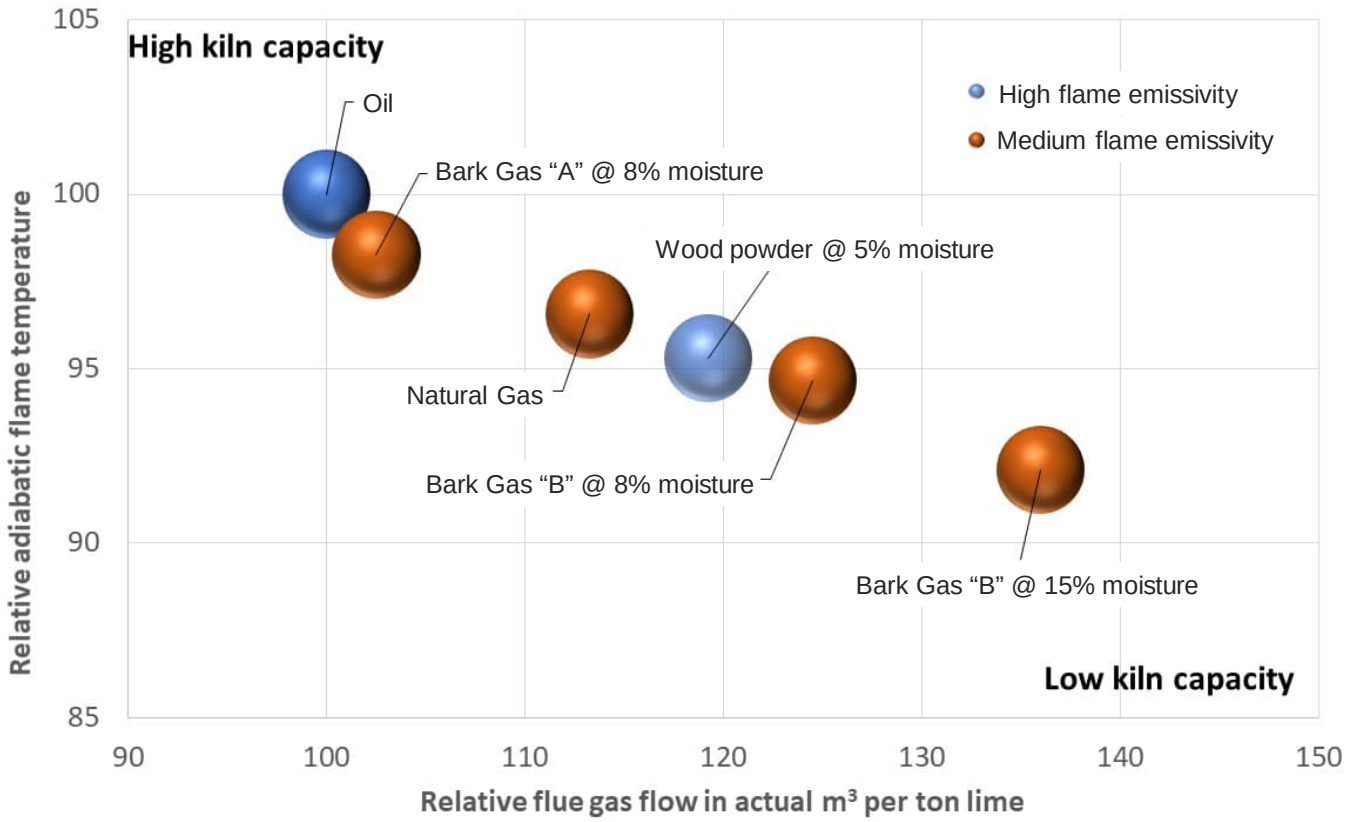
- Wood are combustible biomasses that dried can catch fire, self-ignite and possible explode as powder
- Parameters to characterize risks:
  - K_{st} (bar m/s) - maximum rate of explosion pressure rise
  - P_{max} (bar) - maximum explosion pressure
- Safety equipments
  - Explosion vents
  - Inertisation (N_2)
  - Spark Detection / water injection
  - Bicarbonate injection
- ***Keep it Simple = Keep it Safe***
- Minimize silo size, buffers, number of conveyors etc where possible



Valmet

Biomass quality impacts the lime kiln operation

Lime kiln capacity of typical fossil-free fuels using oil as reference



Inspired by presentation made by Patrik Löwnertz in AFRY Forum webinar June 04th 2020 "Biobränsle för mesaugnar – alterniv och deras egenskaber"

Biomass used is important

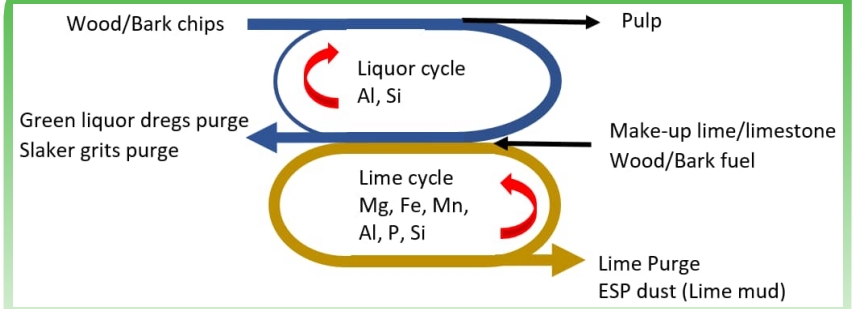
- Biomass quality is the key!
- Moisture cools the flame!
- Peak kiln capacity may be reduced using biomass firing
- Nitrogen in biomass is partly converted to fuel-NOx emission

Valmet

Non-Process Elements in White Liquor plants

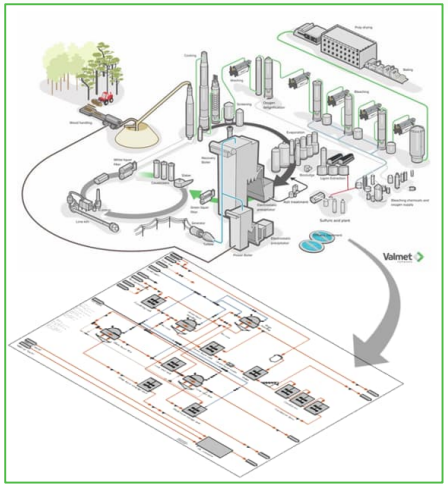
Addressing the NPE challenges in your sustainable pulp mill

- Some of the critical NPEs are
  - Mg: Reduces filter capacity and lime mud quality
  - P : Increases deadload in the lime cycle and consumes lime
  - Si : Reduces filter capacity and lime mud quality. Consumes lime



Modified after Ulmberg, P. (1997). "Non Process elements in bleached pulp mill with a high degree of system closure - state of the art." Nordic Pulp and Paper Reasearch Journal 1(12), 32-41.

- Need a good lime manegement strategy – evaluated by NPE model for the pulp mill
  - Evaluate possible purge sources of NPE.
    - ESP dust purge is a common purge point
    - Phospor is enriched in ESP dust
  - Use good quality makeup limestone or lime
  - Use limestone as gasifier bed material and not dolomite (contains Mg)



Lime kilns fired with wood powder

What you need from dryer to wood powder burner

Wood powder burner

Biomass dryer

Grinding unit

Gravity feeder & pneumatic dosing

Valmet

Fossil free pulp mills – Commercially proven solutions

to decarbonize Lime Kilns

Biomass drying and gasification

- Biomass used: bark, forest residues, pins & fines
- Suitable for medium to large sized kilns (>30MW)
- Attention on Non-Process Elements in bark
- Very good business case with surplus of bark

Wood powder firing

- Biomass used: saw dust, pellets & wood chips
- Suitable for all kiln sizes
- Very good business case with surplus of clean wood

Valmet

Wood Powder Design Considerations

- Based on Valmet experience the following design parameters have an impact on wood powder and kiln system performance
  - Type of wood used as fuel
  - Lower Heating Value of wood
  - Moisture content in wood after drying
  - Particle size distribution
  - Burner design

Valmet

Type of Wood

- The following wood material can be used
  - Wood Chips
  - Saw Dust
  - Pellets
  - Bark (depending on bark type and NPE content). Limited substitution
- Wood chips
  - Moisture content can vary, e.g. seasonally
- Saw dust
  - Moisture content can vary
  - Off-spec dimensions
- Pellets
  - Change of supplier can result in changes in grinded particle size

Particle Size Distribution

Wood Powder Dust:

- Rule of thumb is that 1-2wt.% of particles above 1mm is acceptable for high intense flame formation and complete burn-out.
- If material is dry the material can be larger and it will still be possible to achieve burn-out.

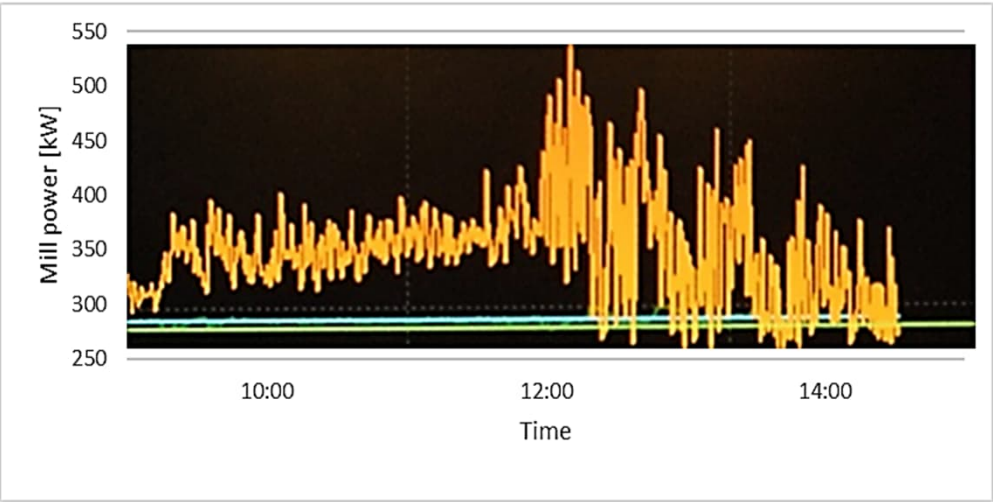
Before Hammer Mill

After Hammer Mill

Moisture Content

- To minimize impact on kiln operation when operating on 100% wood the moisture should be less than 8%
- Excess moisture may cause issues with stability of the flame and flame monitoring
  - Similar to burning of methanol with high moisture content
- The lower the moisture - the less impact on fuel consumption and kiln peak capacity
- 4-5% moisture in dried wood is ideal

Hammer Mill Screen Pluggage – High Wood Moisture



Wood Drying with Low Temperature Belt Dryer

Valmet Biomass Dryer main parts

2-layer recirculation dryer design to safely reach lowest moisture

HEAT SOURCES FOR AIR HEATING

Glycol used in freezing condions

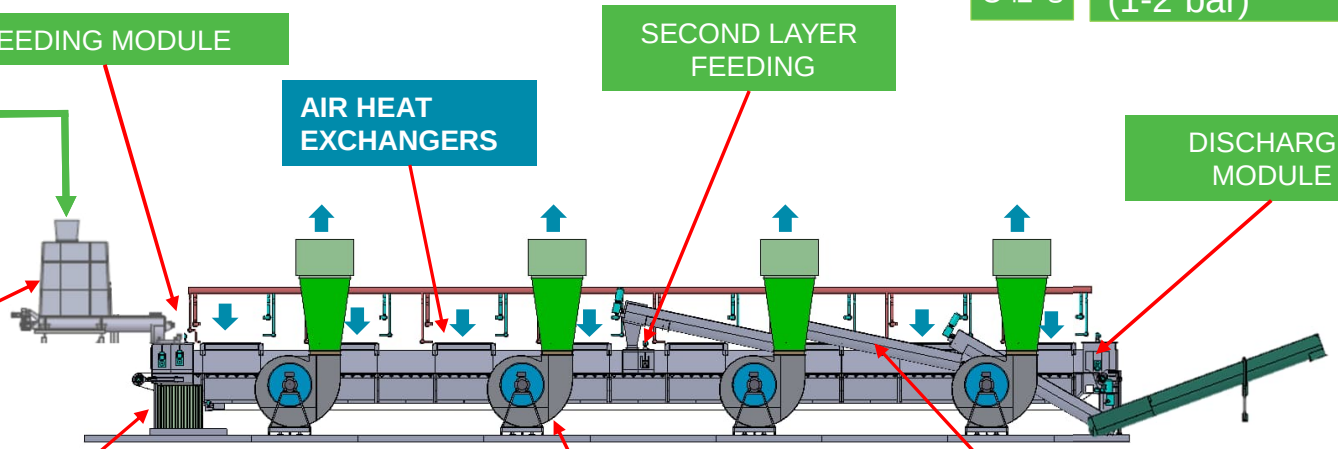
Hot water (50..120°C)

Steam (1-2 bar)

WET BIOMASS IN

Wood chips

Saw dust



Valmet

Wood Powder Milling - Firing

MILLING

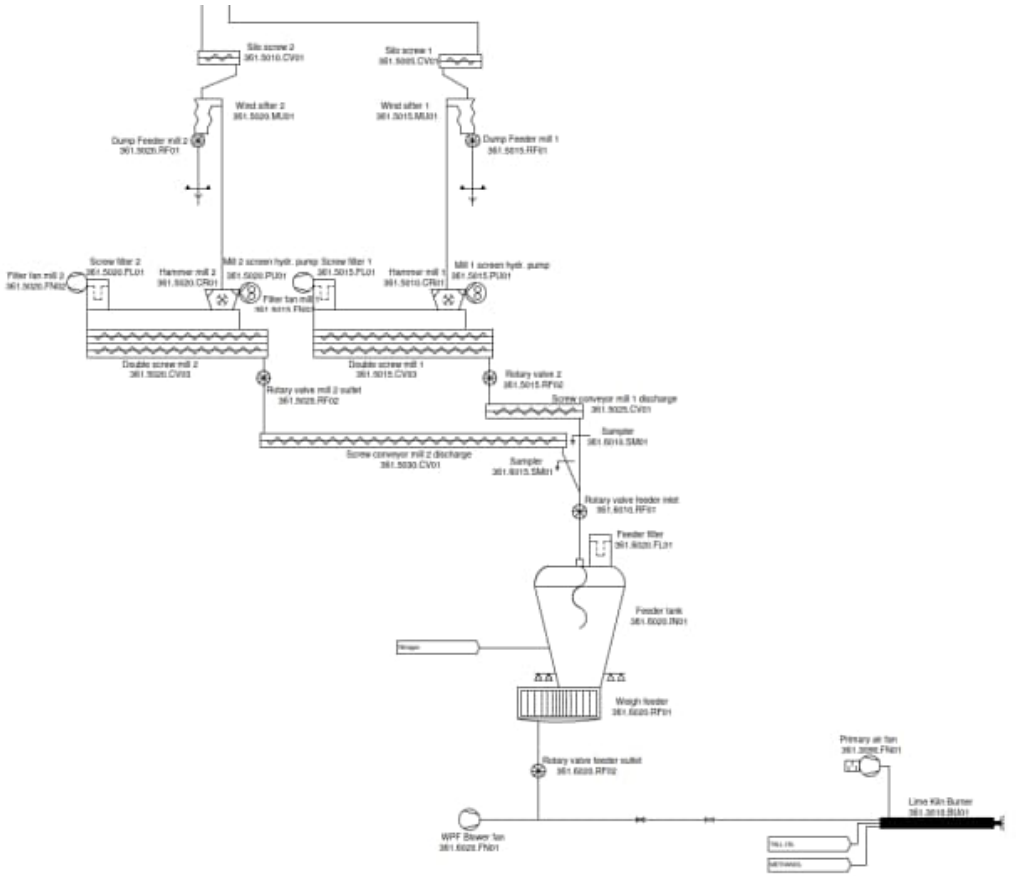
FEEDING

BURNING

OBJECTIVE

To achieve wood particle size that will allow using it in the kiln.

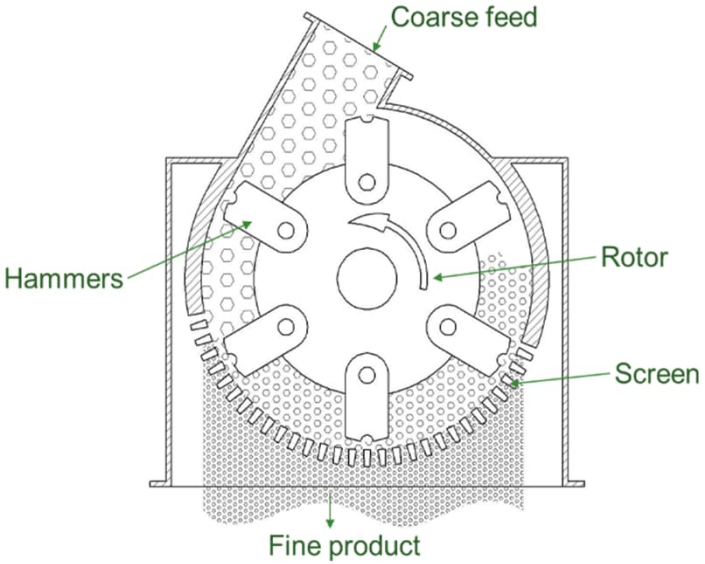
Wood powder firing – with 2 grinding units
Grinding, dosing and burner



Hammer Mill

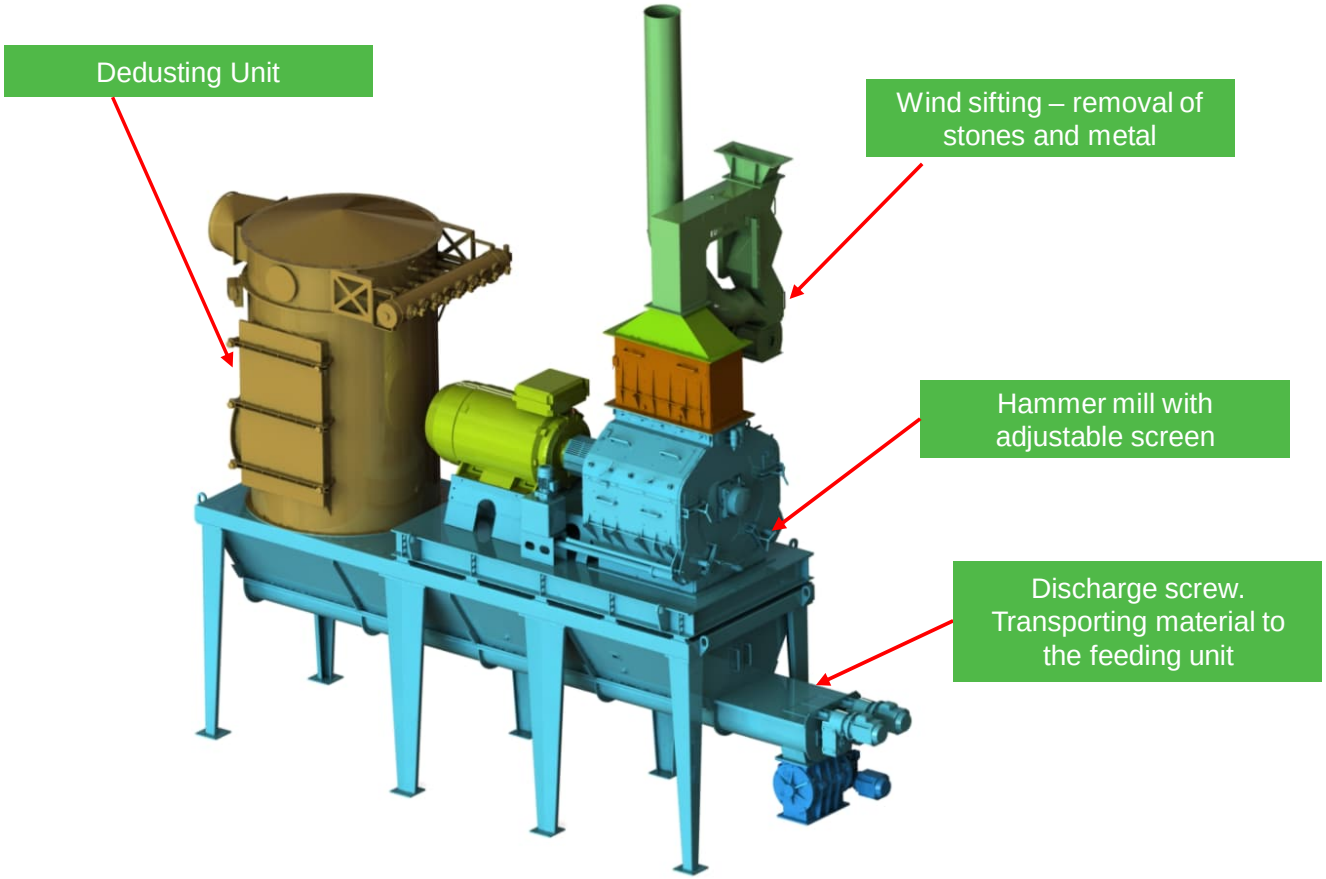
Hammer Mill Design:

- The hammer will ensure that the wood powder to the kiln has uniform size - 99% less than 1 mm
- The mill consists of a mill grinding chamber wherein a shaft with mounted hammers rotates. The wood particles entering the mill will be subjected to impacts both from the hammers and on the walls of the grinding chamber.
- Hammer mills typically have a screen in the outlet, which together with the speed of the rotor gives control of the product particle size.



Compact hammer mill solution for wood powder grinding

With integrated dedusting and stone trap



Rotary Weight Feeder

OBJECTIVE

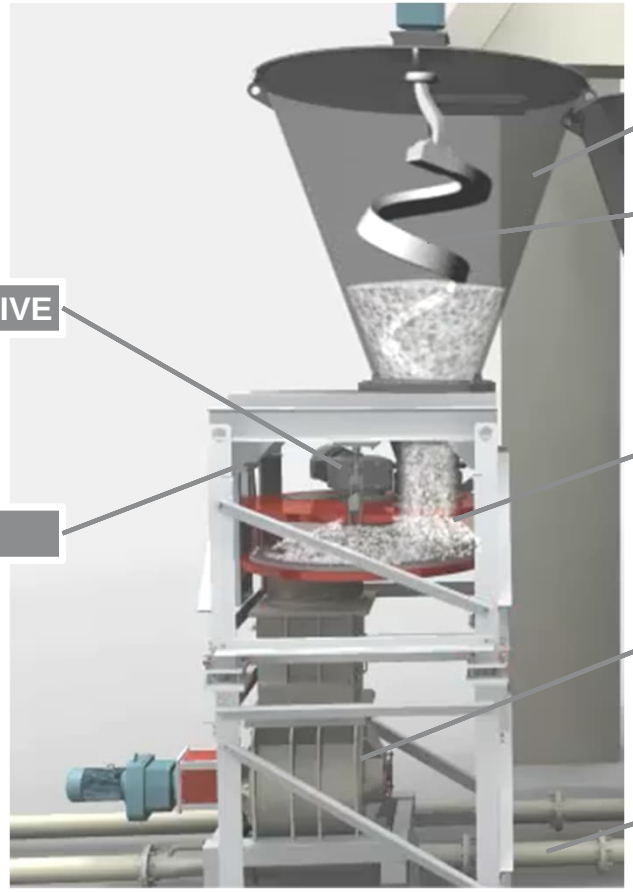
To measure mass flow rate and control the wood powder feed to the burner.

ADVANTAGES

- High fuel accuracy feeding control for safe and low fuel consumption
- Can withstand pressure excursion

Valmet

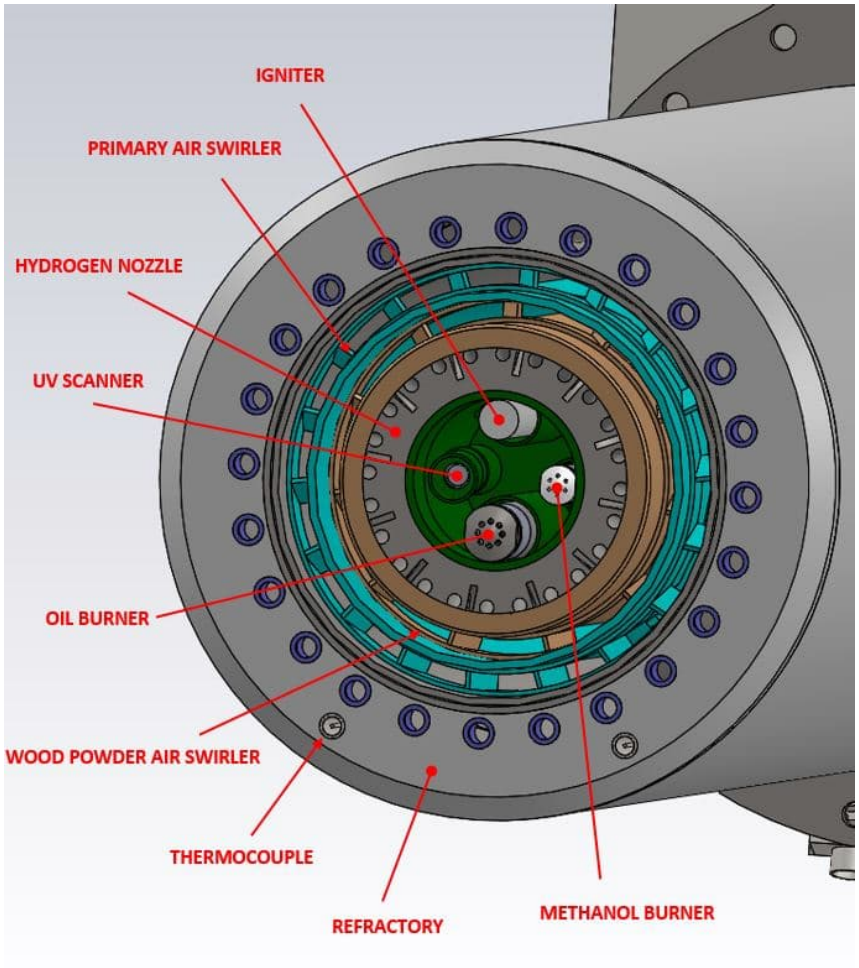
Rotary Weight Feeder

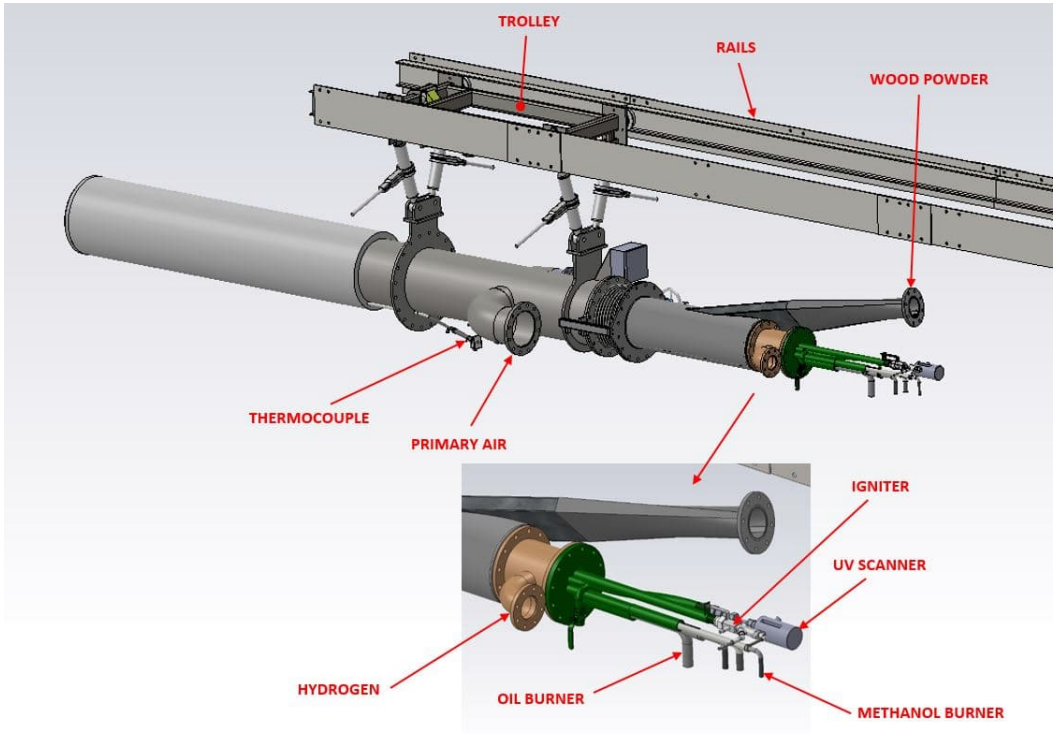


Burner Design

- Continued development of burner design for rotary kilns with increased alternative fuel substitution
  - Stable flame
  - High flame momentum for efficient flame radiation
  - Fuel flow stability with a good mix of fuel(s) and combustion air
  - Minimize NOx formation
- Solution: Wood powder swirl and primary air jet nozzles

Burner Design

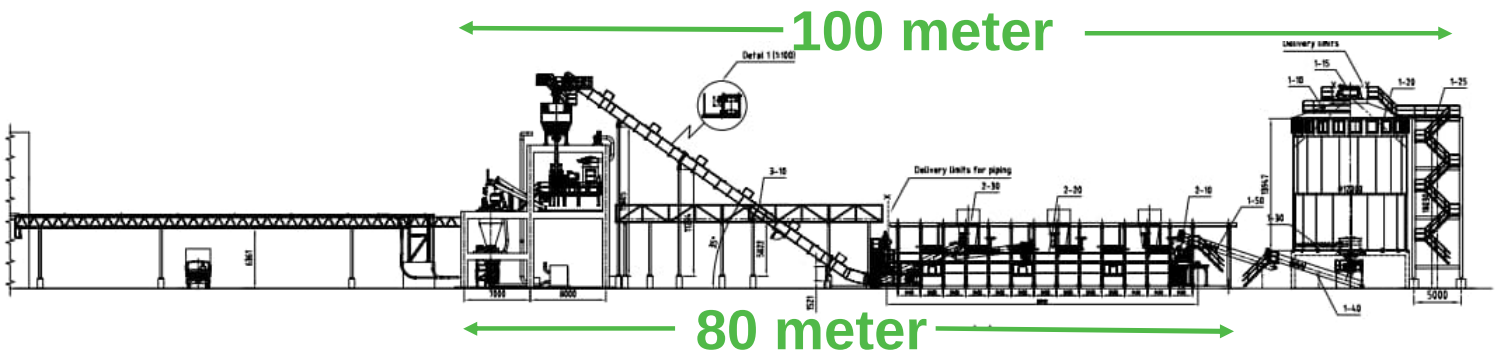


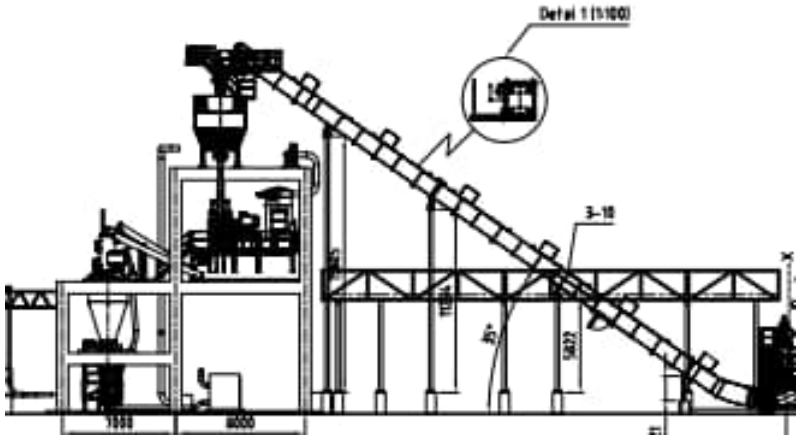


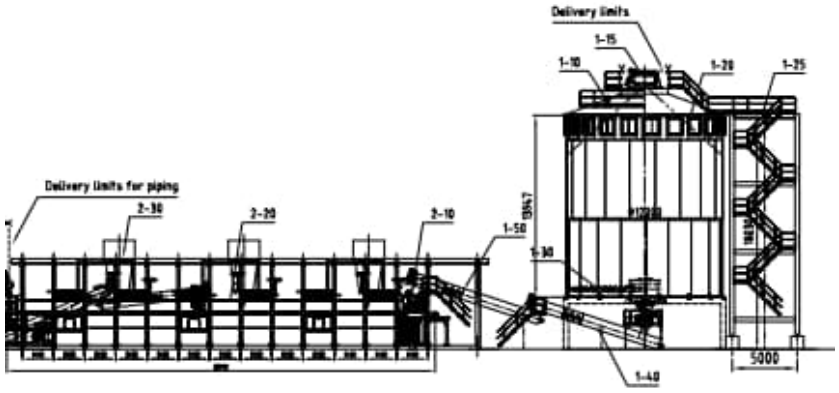
Wood Powder Layout

Valmet

Wood Powder Layout Example







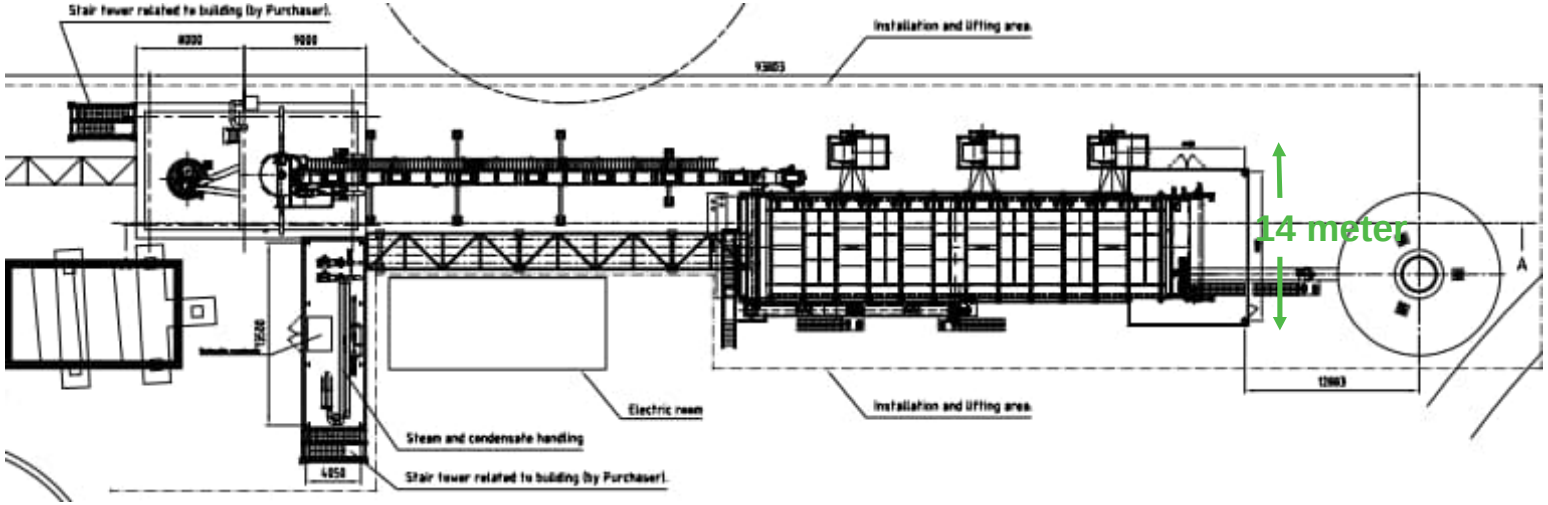
Milling and Transportation

Dryer

Silo

Valmet

Wood Powder Layout Example



Fossil free lime kiln – wood powder firing

Case: SCA Obbola mill (Sweden), 220 tpd lime with 18 MW wood powder system

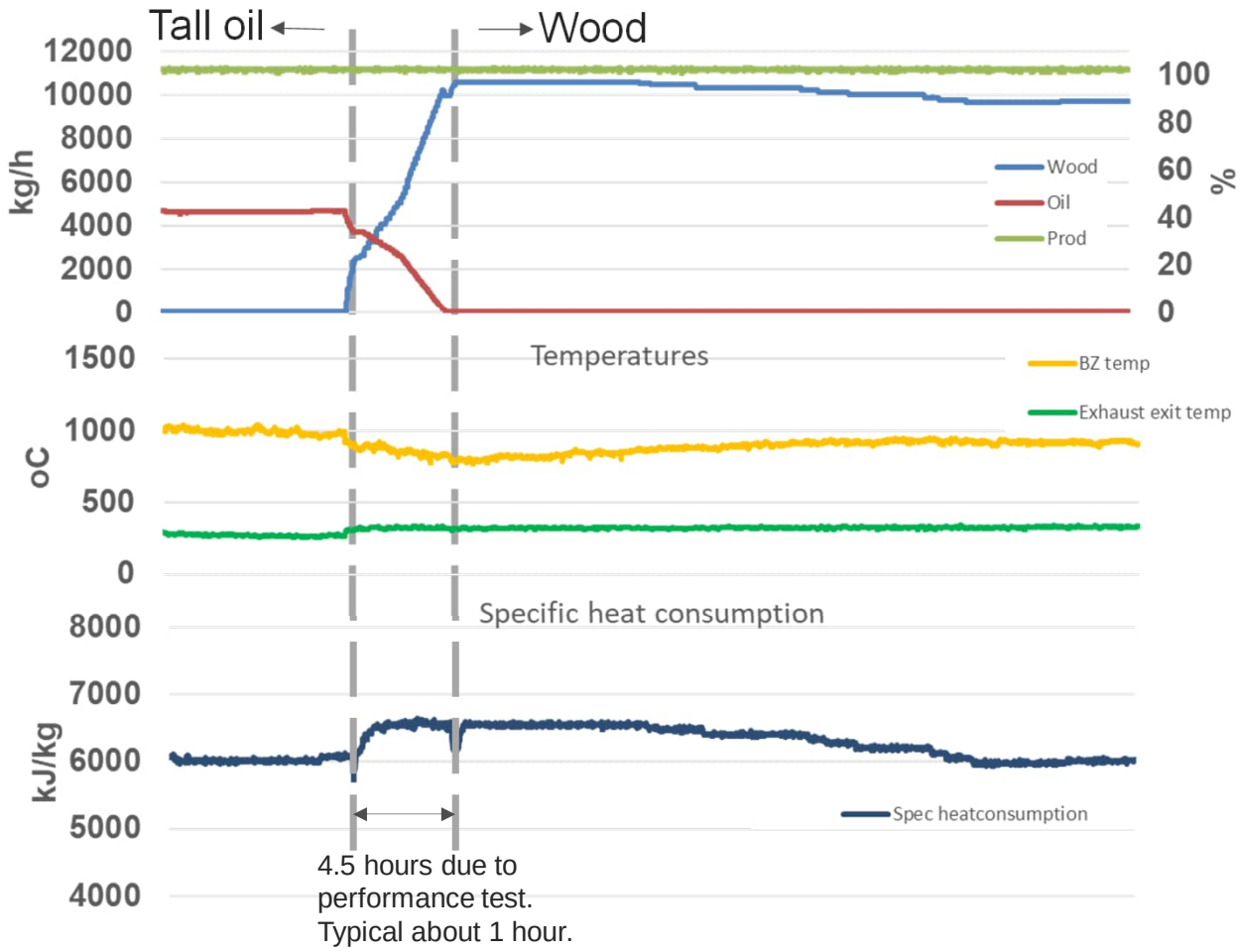
Proven technology with significant benefits

- Wood pellets produced from own pellet plant
  - A residual by-product of forestry and industrial operations
  - No special NPE management due to low ash content
- No biomass dryer required using pellets
- Lime kiln wood powder burner for 220 tpd lime
  - Multifuel burner with primary air jet nozzles
- Tall oil pitch as back-up fuel
- Saving 10,000 m^3 of oil/year
- CO_2 neutral solution. Reduces CO_2 emission by 20,000 tons/year CO_2

Valmet

Operating Experience

From 100% tall oil to 100% WPF



Valmet Lime Kiln Wood Powder experience

SCA Obbola, Sweden, 2021
In Operation
Pellet based WPF system - 18MW (220 tpd lime)

Sun Paper Laos, Laos, 2018
In operation
Wood chip based WPF - 33 MW (400 tpd lime)
Dryer evaporation - 7.6 ton/h water

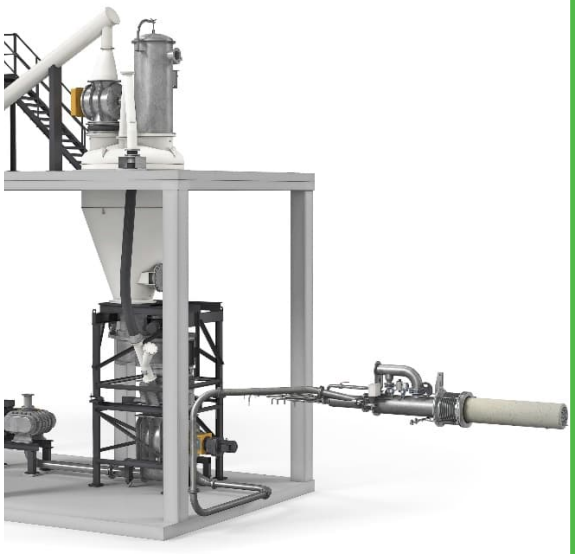
SE Enocell, Finland Laos, 2015
In operation
Saw dust based WPF 50 MW (600 tpd lime)
Dryer evaporation - 14 ton/h water

SCA Munksund, Sweden, 2013
In operation
Pellet based WPF - 25 MW (300 tpd lime)

Södra Cell Värö, Sweden, 2012
In operation
Pellet based WPF - 50 MW (680 tpd lime)

Smurffit Kappa Piteå, Sweden, 2006
In operation
Wood powder burner - 16 MW (200 tpd lime)

Smurffit Kappa Piteå, Sweden, 2000
In operation
Wood powder burner - 12 MW (150 tpd lime)



Lessons learned

- Biomass free from metal, stones etc!
- Low moisture content in powder important for good kiln operation. Target 3-5% moisture.
- Powder size < 1-2 mm for efficient burn-out
  - Some % of +2mm particles are ok
  - Pellet strength varies between suppliers
- Reach high turn-down ratio of ~7-100%
- High accuracy weight gravity feeder provides accurate and reliable regulation. Target ± 1wt%
- Pneumatic transport of powder
  - Flexible and can be over long distance
  - Consider pipe design to avoid surges
- Primary air jet nozzles provides a good flame and low NOx emission

Lime kilns fired with gasified biomass

What you need from dryer to kiln gasifier burner using a Circulating Fluid Bed gasifier

Valmet Lime Kiln CFB Gasifier experience

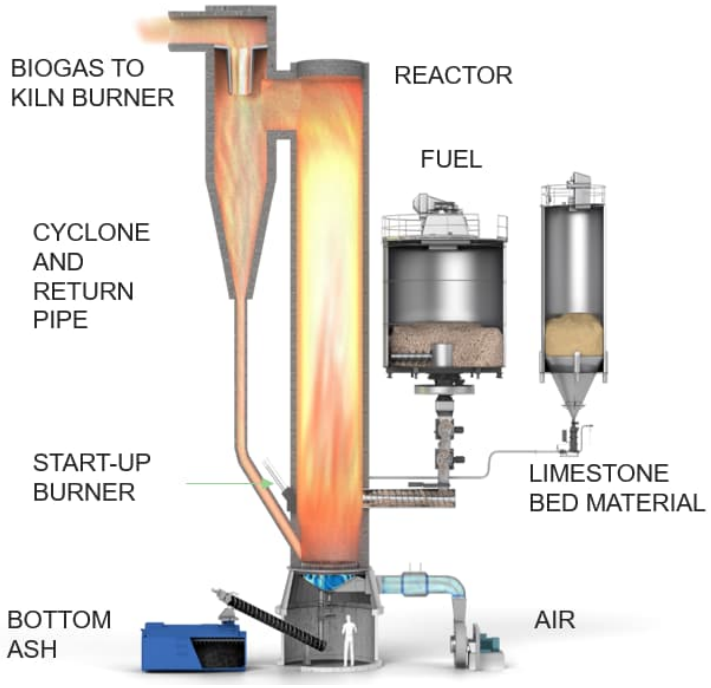
Metsä Fibre Kemi, Finland, 2023
Under construction
Gasifier 100 MW (1400 tpd lime)
Dryer evaporation 32 ton/h water

Bracell STAR, Brasil, 2021
In operation
Gasifier 2 x 87 MW (2 x 1200 tpd lime)
Dryer evaporation 2 x 12 ton/h water

Chenming Huanggang, China, 2018
In operation
Gasifier 50 MW (900 tpd lime)
Dryer evaporation 12 ton/h water

Metsä Fibre Äänekoski, Finland, 2017
In operation
Gasifier 87 MW (1200 tpd lime)
Dryer evaporation 24 ton/h water

APP OKI, Indonesia, 2017
In operation
Gasifier 2 x 110 MW (2 x 1250 tpd lime)
Dryer evaporation 2 x 19 ton/h water



Lessons learned

- Biomass free from metal, stones etc!
- Need homogeneous mix of biomass feed with acceptable ash content
- Low moisture content is critical for good operation (< 8% moisture). Target 5%.
- CFB operation around 750-800 °C
- Can reach turn-down ratio down to ~40-100%
- Minimum gasifier size ~30 MW
- Primary air jet nozzles in kiln burner provides a good flame and low NOx emission
- Use limestone as gasifier bed material. Not dolomite (contains Mg)
- NPE can be managed by ESP dust bleed


Valmet
FORWARD