Innovative hydrothermal carbonization (HTC) process for a Nordic pulp and paper mill

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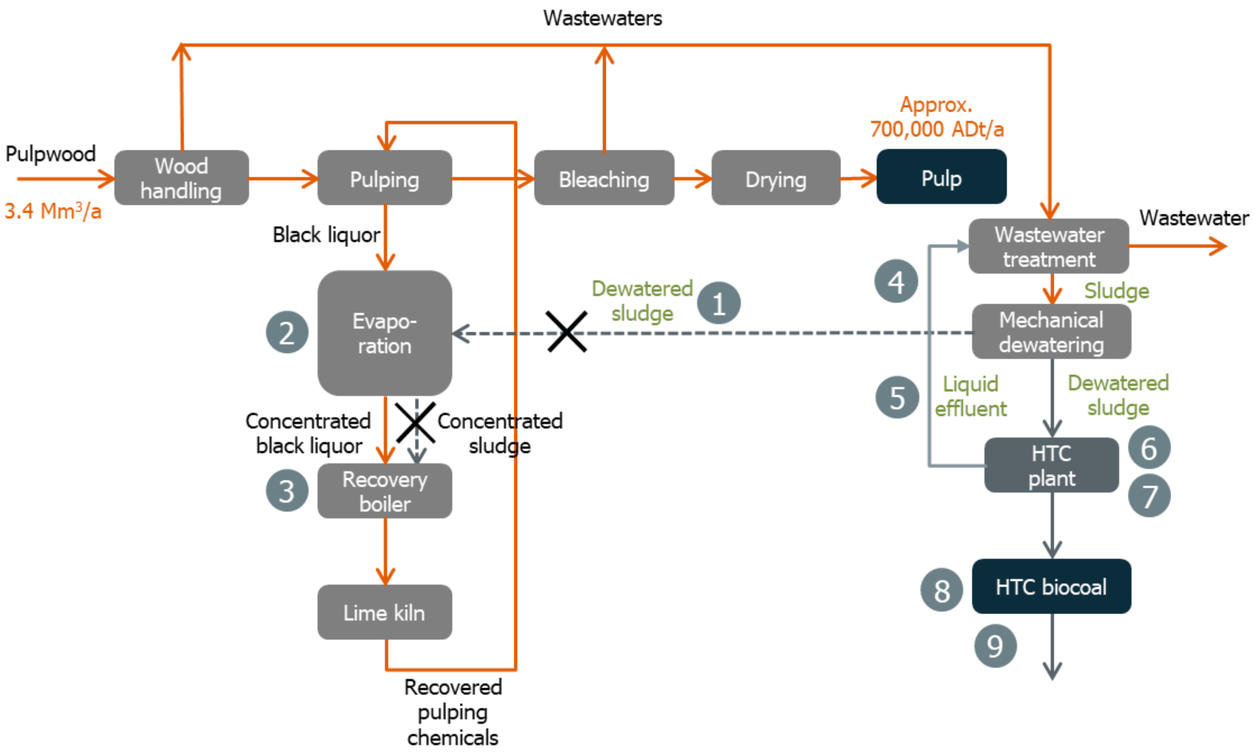
1 Introduction and methodology

- The common way of handling sludge from pulp and paper (P&P) mill's wastewater treatment plant (WWTP) is combusting it in the recovery boiler at the site.
- Sludge is considered as a biogenic product of low quality due to its high water content.
- BIOFIT Case Study assesses valorisation of this waste stream to contribute P&P sector's need to broaden their product base.
- In this study, C-Green's OxyPower HTC technology is integrated to a Nordic sulphate pulp mill to convert the sludge to a more valuable bioenergy product called HTC biocoal.
- The approach contains assessment of effects of integration to pulp mill's mass and energy balance, and market, economic and sustainability assessments.
- Laboratory tests were performed for the secondary sludge sample from a Nordic Kraft pulp mill to determine the HTC biocoal yield and energy content.

2 Concept and approach



Key effects on the pulp mill's mass and energy balance	
1	4,725 t/a dry matter sludge (10.4 wt-% dry solids content) is removed from evaporation and recovery boiler and led to HTC plant.
2	Energy demand for evaporation decreases 4,390 MWh/a.
3	Heat output from the recovery boiler is reduced by 20,212.5 MWh/a, which leads to lost power production of 4,800 MWh/a (i.e. feedstock cost for the HTC plant).
4	Biogas could be produced from the liquid HTC effluent.
5	HTC effluent replaces the urea needed in the pulp mill's WWTP, since the effluent contains nitrogen in the form of ammonia (1.6 g/l NH3-N). 60 t/a of nitrogen is replaced. This is a cost saving for the mill.
6	HTC plant consumes 1,260 MWh/a power, e.g. for oxygen production.
7	Cooling water flow (110 kWh/t of dry sludge) at 50-60 °C from the HTC process could be exploited.
8	HTC biocoal absorbs sulphur and potassium, which reduces make-up NaOH consumption in the recovery cycle. Also metals are absorbed in the HTC biocoal.
9	5,610 t/a HTC biocoal is produced (48 wt-% moisture content, 7 GJ/t wet bases LHV).

3 Results

Economic results

- Internal rate of return (IRR) of 4% with payback time of 14 years, when a 30% Energy Aid is received and HTC biocoal market price of 40 €/MWh is assumed.
- The current way of dewatering the sludge by mechanical dewatering and black liquor evaporator is so efficient that it is challenging to obtain economic feasibility.
- The economic feasibility would improve if
  - there was no way to treat the sludge in the current situation,
  - the scale of the HTC plant was increased,
  - sludge had to be transported from the site (transport cost and gate fee) before the HTC plant integration,
  - benefits from the increased pulp production capacity was accounted,
  - or HTC biocoal market price increased to 58 €/MWh or more.

Environmental results

- 77% reduction in GHG emissions compared to base case.
- Significant GHG emissions savings from the combustion of biogenic fuel as a substitute of fossil fuel; 87% in case of the biosludge and 98% in case of the biocoal compared to RED II.
- Over 50% of the nitrogen in the sludge ends up as ammonium ions in the separated water, which lowers the need for fossil based N-nutrient.

4 Conclusions

- Waste Framework Directive creates a challenge for the use of HTC biocoal, since biosludge and HTC biocoal are currently declared as waste.
- End-of-waste (EoW) status is needed to create higher value and a market for the product.
- Use as soil amendment or local energy use are foreseen as most promising applications.
- It is challenging to find an economic case in P&P industry, as sludge can already be disposed in the recovery boiler without any gate fees.
- Biosludge treatment into HTC biocoal, instead of burning it in a recovery boiler, presents a sustainable retrofit option that minimises the environmental impact.

Cases for improved feasibility

- Case in which HTC plant integration would avoid transportation of sludge.
- Demand for renewable low-carbon fuel to replace fossil fuels increases, e.g. in semi-mechanical pulping mills.
- Evaporator or recovery boiler is a limiting factor for pulp production capacity, which can be increased by removing sludge flow to the boiler.
- Wet oxidation process for other hard-to-process streams is an interesting opportunity, especially in mechanical pulping.

Concentrated sludge, photo: VTT Ltd

HTC-process

Biocoal pellets, photo: C-Green Technology AB

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