Gasification of sewage sludge in the Freiberg COORVED lab scale unit for in-situ recovery of Phosphorus

Tobias Ginsberg¹, Jens Hannes¹, Jörg Kleeberg², Thorsten Liese¹, Juliane Schaefer², Christian Wolfersdorf¹,
¹RWE Power AG, Essen, Germany,
²IEC (Virtuhcon), TU Bergakademie Freiberg, Germany
CtP @ RWE – New options from alternative feed streams

RWE develops innovative Coal-to-Products process chains (CtP)\(^1\)

- **Drying**
- **Gasification**
- **Gas treatment**
- **Synthesis**

Alternative routes:
- Synthesis gas
- Synthetic Natural Gas
- Chemicals
- Fuels
- Waxes

> Recent focus: Recovery of P from sewage sludge by gasification
Phosphorus from Sewage Sludge – Circular Economy going live

> Sewage sludge production and treatment in Germany\textsuperscript{[2]}

- Production (2016): 1.8 Mt (wf) $\Rightarrow$ ~130 kt P\textsubscript{2}O\textsubscript{5}
  (Germany: ~288 kt P\textsubscript{2}O\textsubscript{5} applied as fertiliser 2015/16)\textsuperscript{[3]}
- Agricultural use decreasing due to heavy metals and drug residues contained (2016: 35%)
- Combustion steadily increasing (2016: 64%)

> New German Sewage Sludge Ordinance (AbfKlärV, 2017)

- Phosphorus to be recovered from sewage sludge from 2029 and 2032 on, respectively (depending on sewage plant capacity)
Phosphorus production, the thermal way – The Wöhler process\[5\]

> P is released from mineral Phosphates at high temperature and strongly reducing conditions
⇒ Transfer to gasifier possible?
The idea – Gasification with in-situ recovery of Phosphorus

- Thermal treatment of sewage sludge, recovery of Phosphorus and utilisation of carbon in form of synthesis gas in one process step
- Phosphorus obtained in high quality form (yellow P or H₃PO₄)
- Blends of ash from sewage sludge combustion and coal are suitable inputs as well
Sample selection for laboratory investigations and lab scale trials

- Results from extensive analysis campaign (240 sewage sludge samples)
- Samples processed through pre-gasification laboratory tests (Oxide analysis, mineral phases, ash melting behaviour …)
- Samples used for COORVED gasification trials (7 one-day trials with different mixtures of sewage sludge, dry lignite and sewage sludge co-combustion ash)
The COORVED internal circulation (INCI) lab scale gasifier (60 kW_{th})[4]
Gasification of pure sewage sludge – Overall balances (wf)

- Sewage sludge: 87.9 kg
- Coke: 8.1 kg
- Ash: 41.6 kg
- Ca: 6.5 kg
- P: 4.8 kg

Bottom ash:
- Ca: 2.1 kg
- P: 1.7 kg

Filter ash:
- Ca: 4.5 kg
- P: 2.0 kg

Mass balances:
- Ash: 1.1 kg Loss (2.6%)
- Ca: 0.1 kg Gain (1.5%)
- P: 1.1 kg Loss (22.9%)

> Significant release of Phosphorus achieved
Gasification of pure sewage sludge – P-Release

Re-condensation of P-compounds

Raw gas to combustion chamber (
~ 130 - 170°C)

Fraction entrained to primary gasification zone:
Coke: 100 %
Sewage Sludge: 65 %

No P-release due to low temperature

> P-loss of 36% achieved from sewage sludge entrained to primary gasification zone
> Very high P-Loss probably during startup operation with coke

Hot dust (sampled ca. 1 h during steady operation with sewage sludge)
P (ash, wf): 9.98 wt.-%
Sewage sludge:
P (ash, wf): 11.68 wt.-% (14.6% loss)
⇒ Not sufficient to explain overall P-loss

⇒ P-loss of 36% achieved from sewage sludge entrained to primary gasification zone
⇒ Very high P-Loss probably during startup operation with coke
Sewage sludge gasification with P-recovery – An attractive CtP-approach

- Large scale implementation of Phosphorus recovery from sewage sludge is required by German legislation

- Sewage sludge gasification offers potential to
  - carry out thermal treatment, recovery of Phosphorus and recovery of Carbon in one process step
  - obtain Phosphorus in high quality form
  - treat mixtures of coal and sewage sludge combustion ash

- Extensive laboratory tests and 7 one-day gasification trials carried out
  - Promising P-release rates achieved temporarily
  - Further optimisation required to operate gasifier in P-recovery-mode
Thank you for your attention!
References


https://www.destatis.de/DE/ZahlenFakten/GesamtwirtschaftUmwelt/Umwelt/UmweltstatistischeErhebungen/Wasserwirtschaft/Tabellen/TabellenKlaerschlammverwertungsart.html, as of 27.5.2018
