ECNs moving bed torrefaction technology in light of desired product qualities

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ECN

Energy research Centre of the Netherlands

ECNs moving bed torrefaction technology in light of desired product qualities

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Presentation overview

- Introduction
- ECN's torrefaction development status
- Product characteristics
  - Exothermicity
  - Self heating
- SECTOR project
- Conclusions

Energy research Centre of the Netherlands

- Core activities
  - Sustainable energy technology development
  - R&D services to industry
  - Feasibility studies, system & technology assessments

- Largest Dutch energy R&D institute
- Independent
- 570 employees
- R&D units:
  - *Biomass*
  - *Solar energy*
  - *Wind energy*
  - *Energy Efficiency*
  - *Policy studies*





ECN and Torrefaction

- In 2002 ECN identified the potential of torrefaction for bio-energy applications

- Present status:
  - ECN's torrefaction technology is proven on pilot-scale
  - Demonstration and commercial market introduction together with industrial partners

ANDRITZ Pulp & Paper

VATTENFALL

Torrefaction

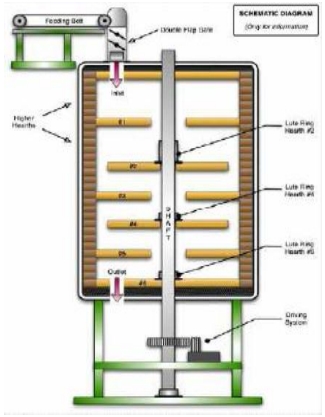
Pelletisation

Andritz/ECN Torrefaction Demo Plant Project

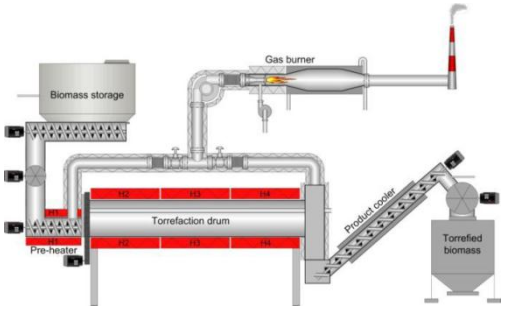
- 1 T/hr Torrefaction Demo Plant in Sdr. Stenderup, Denmark
- The plant incorporates:
  - Biomass (Wood Chip) Receiving
  - Biomass Drying
  - Torrefaction
  - Pelletizing
- Commissioning and initial testing phase scheduled for mid 2012

Pictures: March 2012

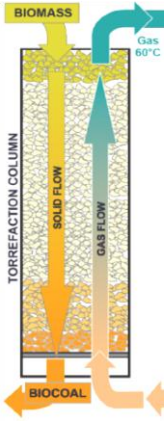
Torrefaction technology – reactor concepts



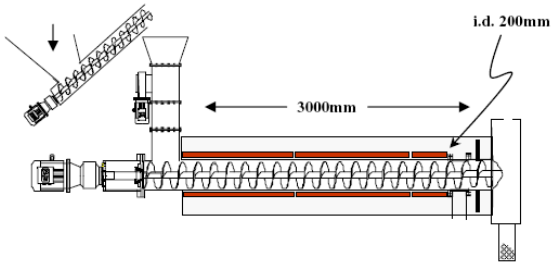
Multiple hearth furnace



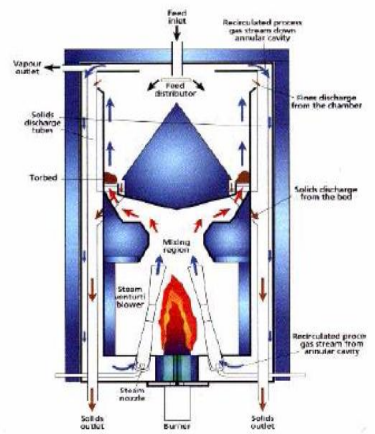
Rotary drum reactor



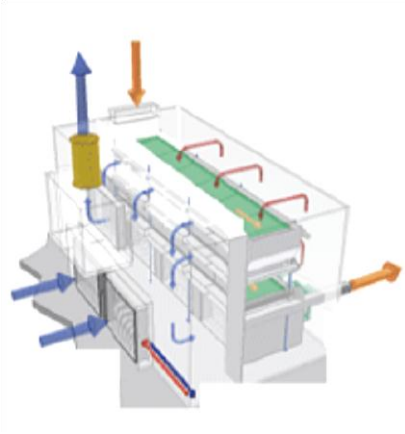
Moving bed reactor



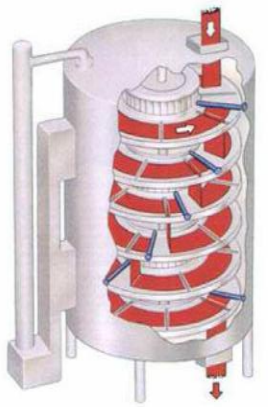
Screw conveyor reactor



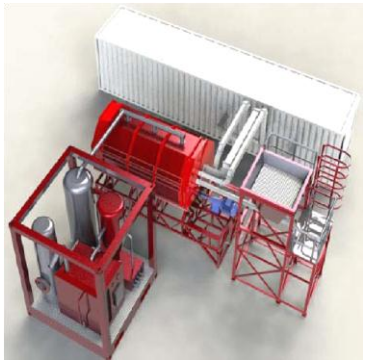
Torbed reactor



Oscillating belt reactor



TurboDryer



Microwave reactor

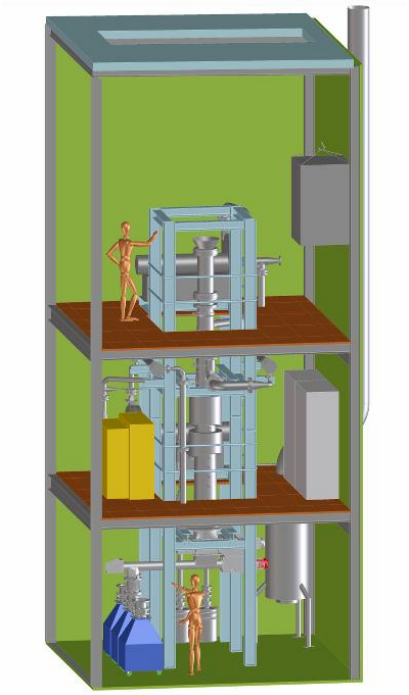
Bench-scale testing

20 l batch reactor

5 kg/h Auger reactor
(screw reactor)

Pre-drying

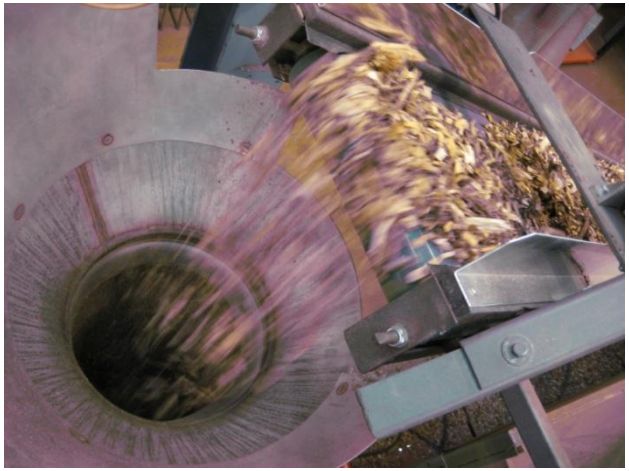
Feeding



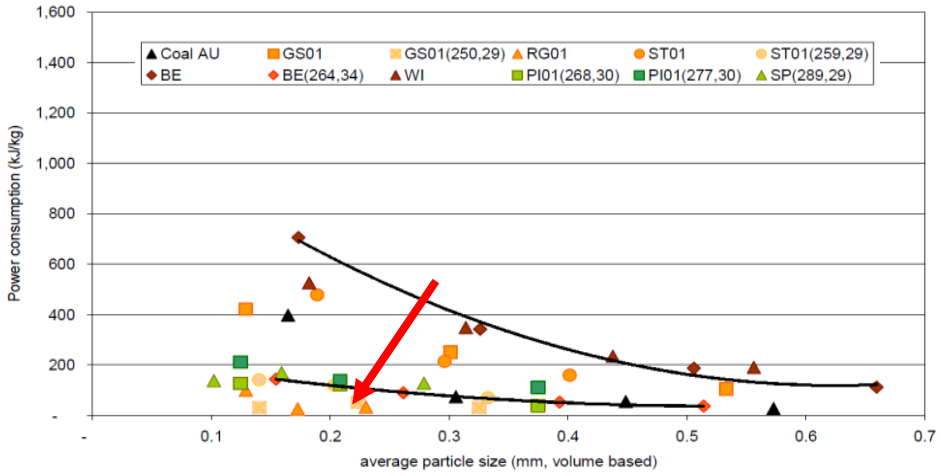
Pilot-scale test facility PATRIG

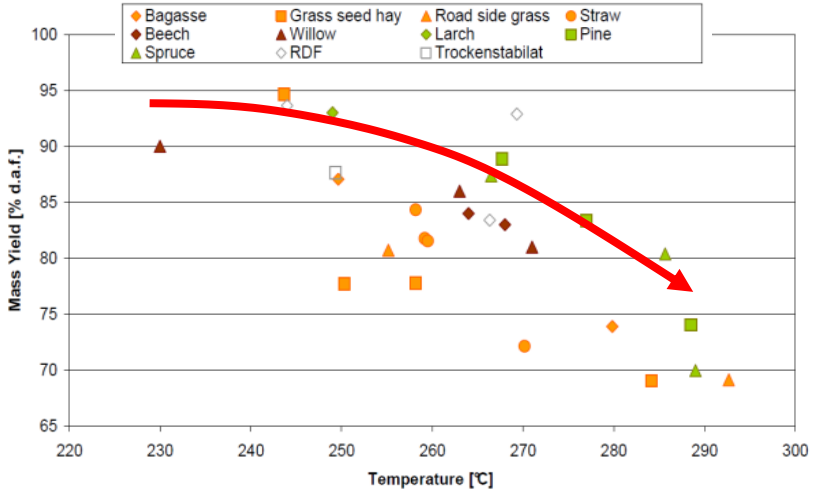
Pilot-scale testing

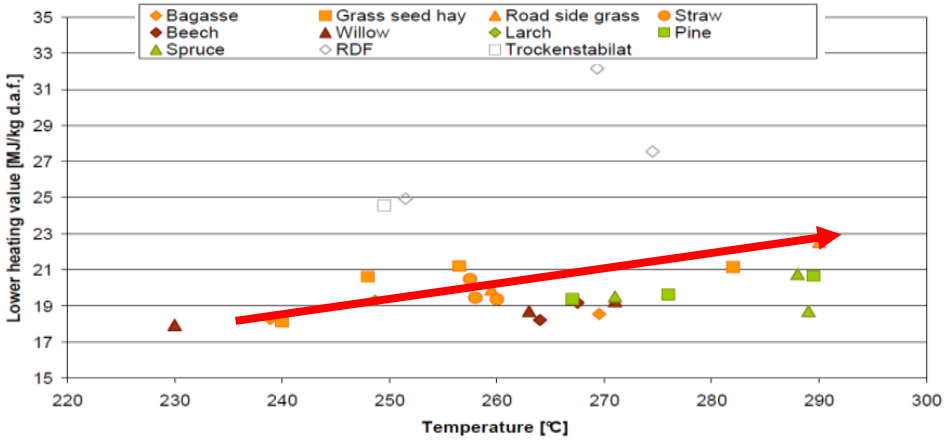
- Testing history:
  - Start-up 2008
  - Over 1400 hours of operation (50-100 hour runs); >40 tonnes of torrefied material produced
  - Biomass feedstock: a.o. poplar, pine, wood mixtures, forestry residues, agricultural residues (POR)
  - Conditions: 220-280 °C torgas inlet temp., throughput approx. 60 kg/h (input basis)

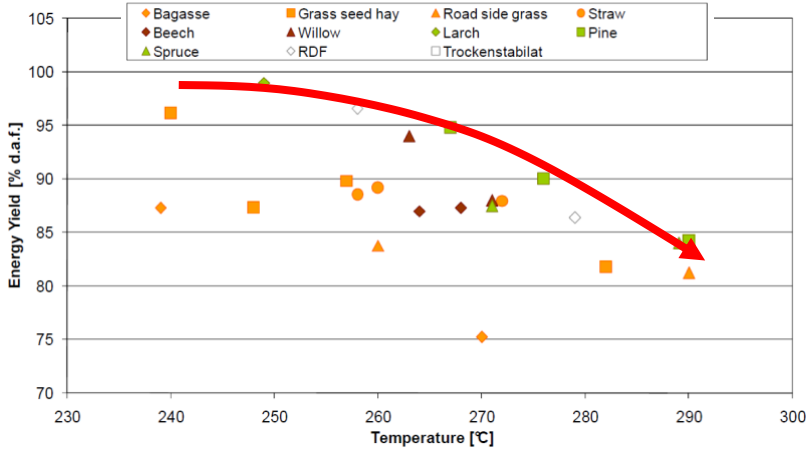


Characterisation of Torrefied biomass





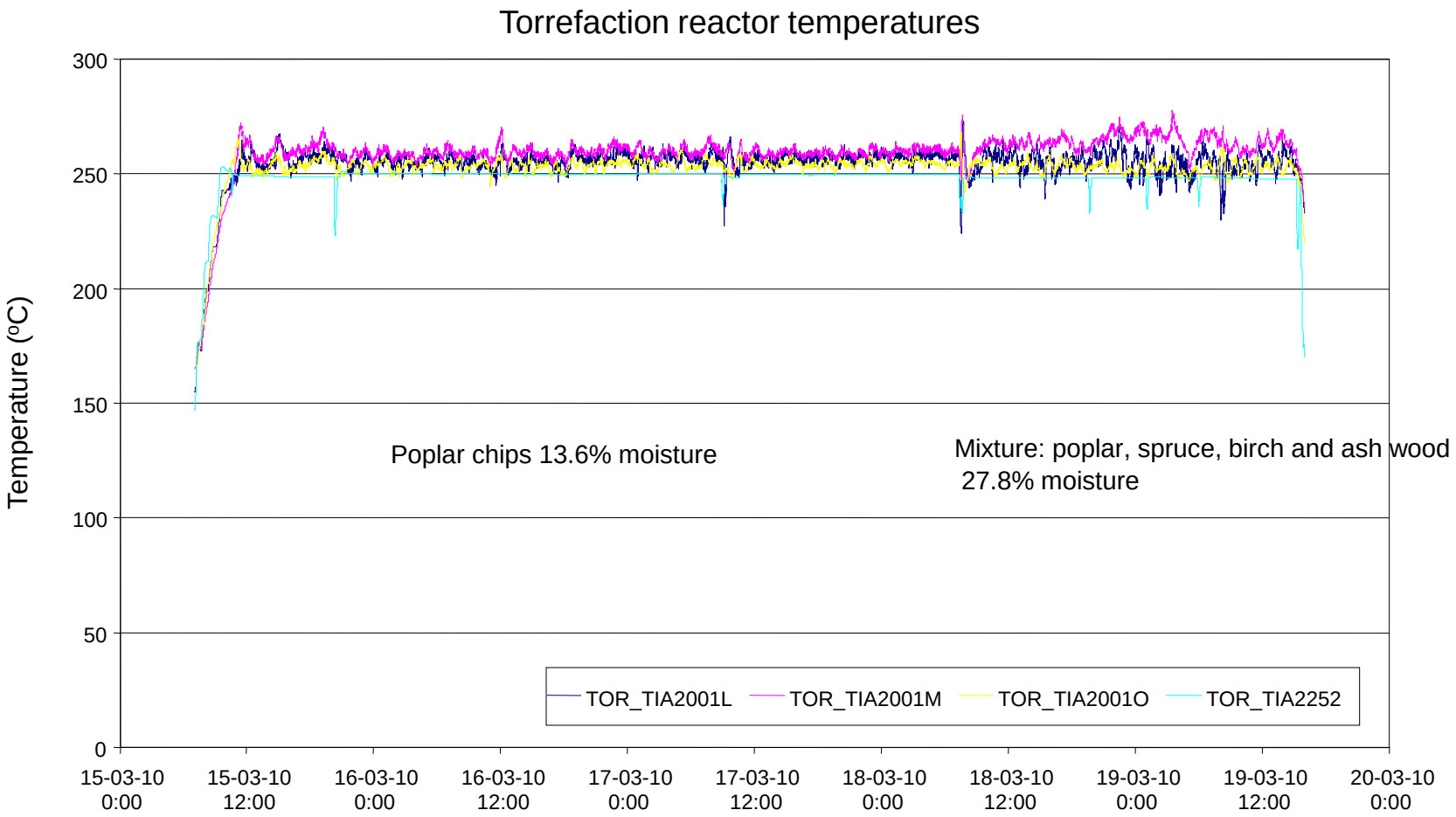




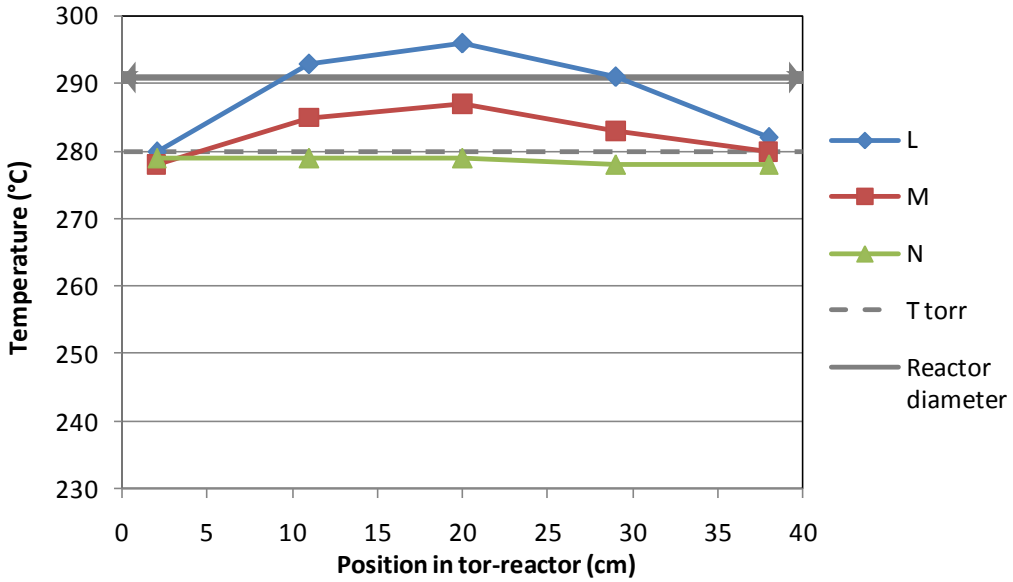
Exothermicity

Self heating

Pilot-scale torrefaction – results of typical run

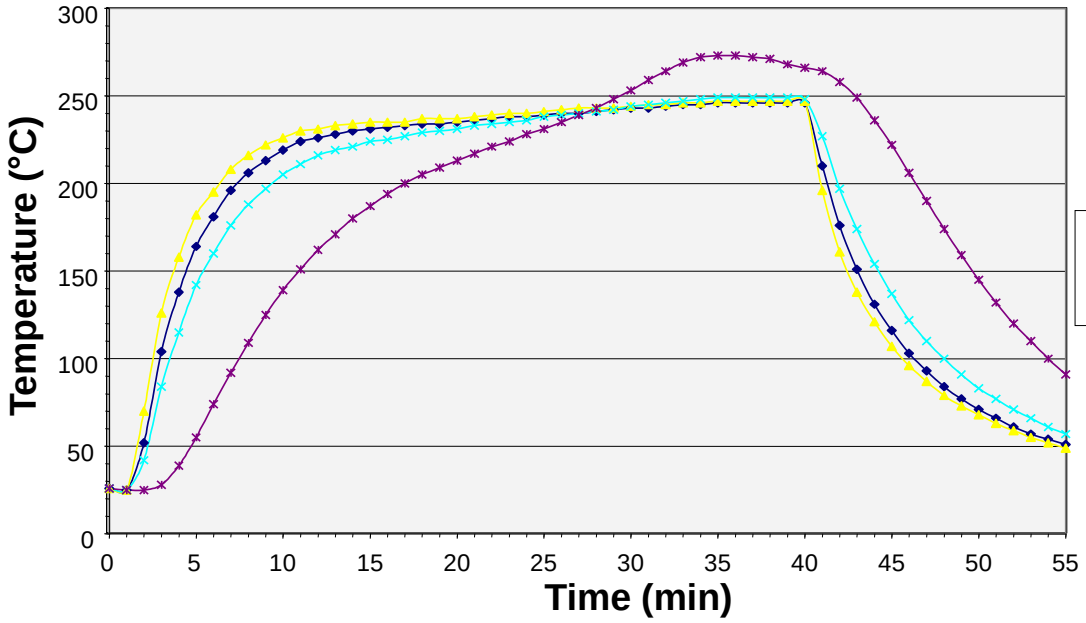


Exothermicity – pilot scale

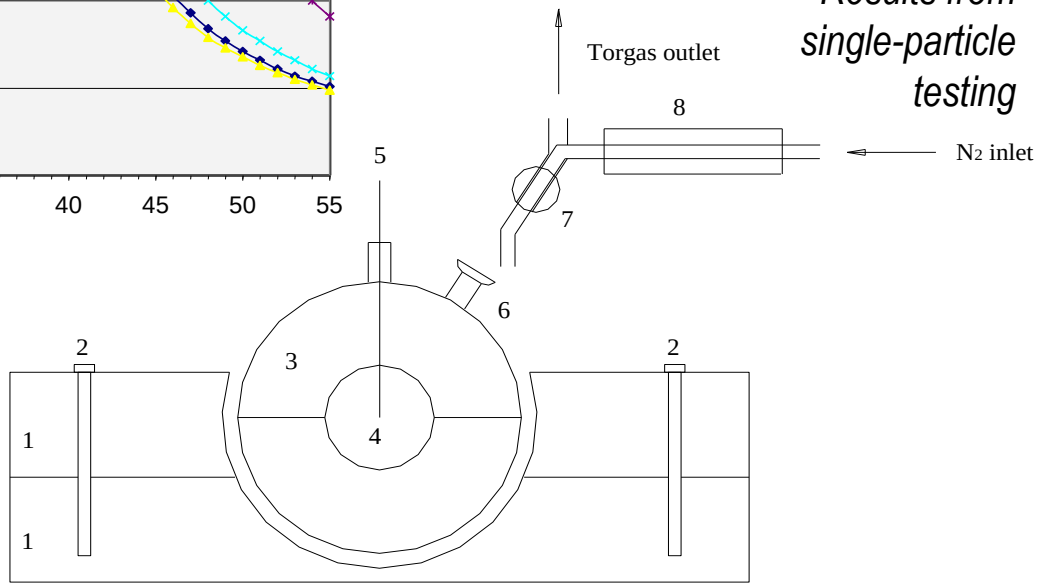


Example of temperature profile over the reactor diameter (biomass = softwood)

Exothermicity – single particle

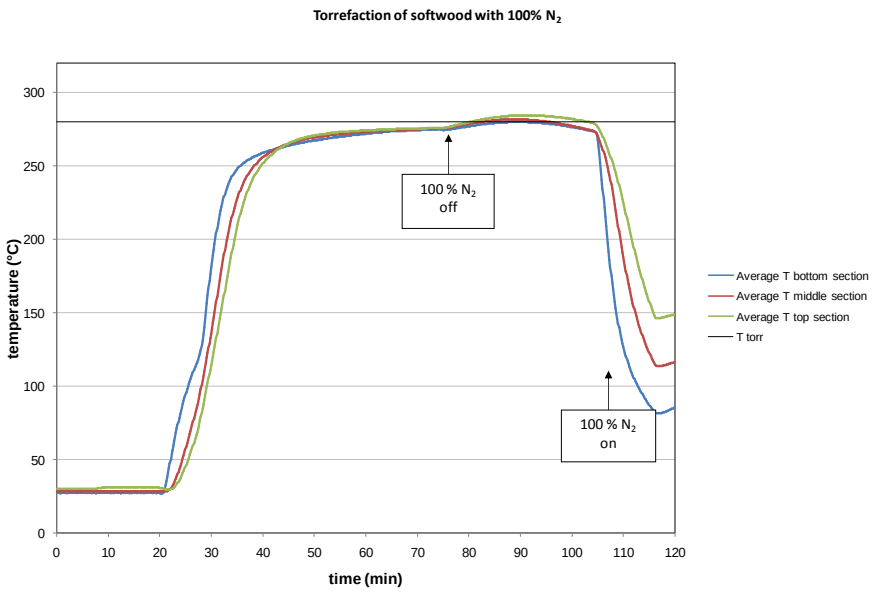


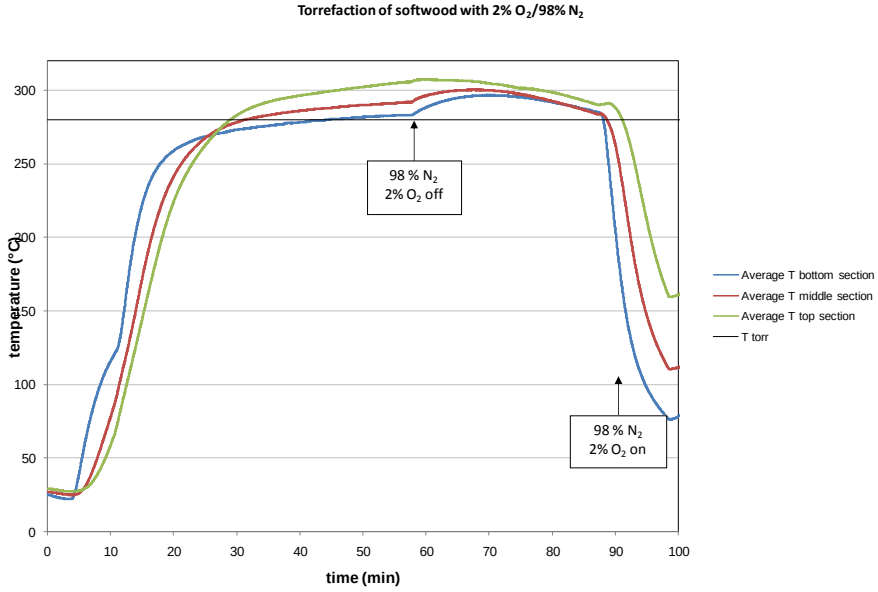
Results from single-particle testing



1. Thermal ceramic bricks
2. Screws
3. Glass sphere cut by the middle
4. Woody ball
5. Themocouples and their inlet
6. Gas inlet-outlet
7. Steel ball with double tube to act as inlet and outlet
8. Gas heater

Exothermicity – tests in batch reactor





Conclusion:

- 2% O_2 in the Torgas has significant effect on torrefaction process
- Temperature increase of > 30 °C measured in batch reactor

Exothermicity - summary

- Torrefaction reaction is exothermal
- Temperature profile in moving bed reactor
- Temperature increase depends on biomass type and O_2 in Torgas
- Temperature difference between particle centre and surface
- More research is needed to better understand the phenomenon

Self heating properties of torrefied biomass

- After torrefaction the torrefied material must be exposed to air in a controlled way
- If not properly handled, spontaneous combustion of torrefied materials may arise

ECN, March 2008

Smoke – 24 Minutes

Fire – 32 Minutes

Self-heating properties

- Self-heating properties determined using *Bowes-Cameron cage test* as described in the UN Recommendations on the Transport of Dangerous Goods:
  - Filled wire mesh cube placed in oven
  - Oven temperatures 100, 120 or 140 °C
  - If sample exceeds oven temp by 60 °C, than: self heating
- 3 Samples tested: pellets from torrefied wood chips, EFB and OPF


Wood chips


Empty Fruit Bunches


Oil Palm Fronds

Self-heating properties

- Results:
  - **Crushed pellets from torrefied wood chips:** not classified as a self-heating substance
  - **Torrefied OPF pellets:** not classified as a self-heating substance
  - **Torrefied EFB pellets:** has self-heating properties. Consequently, the material needs to be classified as a self-heating substance

25/2/2012: Fire in Dutch torrefaction plant

Self heating??

Source: internet

Future research programme: SECTOR

- Production of Solid Sustainable Energy Carriers from Biomass by Means of TORrefaction

- EU FP7: Large-scale European project with 21 partners from industry and science

EU FP7 project SECTOR

SECTOR

Deutsches BiomasseForschungsZentrum gemeinnützige GmbH

University of Stuttgart Germany

SLU Swedish University of Agricultural Sciences

DANISH TECHNOLOGICAL INSTITUTE

cener centro nacional de energías renovables FUNDACIÓN CENER CIEMAT

VATTENFALL

RWE The energy to lead

HELMHOLTZ CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

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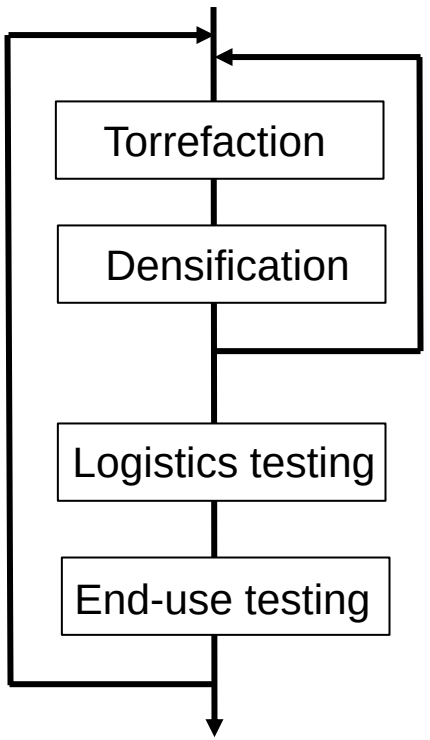
Topell Energy

bioenergy2020+

PROCEDE

Technologie- und Förderzentrum im Kompetenzzentrum für Nachwachsende Rohstoffe

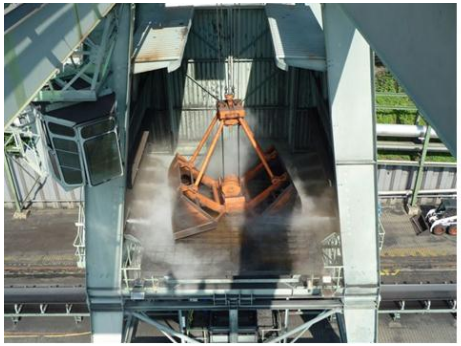
BIOENERGIESYSTEME GmbH

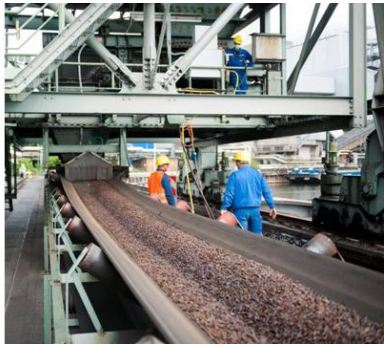


Research items

Shipment

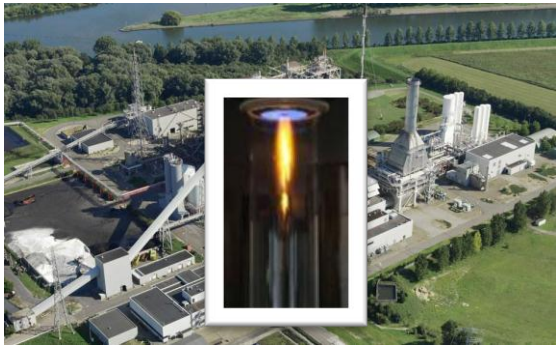
Storage & handling





Grinding & feeding

Coal EF gasification



Coal combustion

Pelletburner

In conclusion

- Torrefaction development is in the pilot/demo-phase
- Scale-up, demonstration in partnership with Andritz Oy and Vattenfall
- Exothermicity and self heating are relevant issues in torrefaction

- Future research focuses on product quality (SECTOR)

- Research items:
  - Optimizing the torrefaction and densification processes towards product quality
  - Self heating, storage, handling, biological degradation
  - Combustion, gasification
  - Small and large scale testing

Thank you for your attention!

For more information,
please contact:

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