Torrefaction reactor – status

So far only pellets of spruce and pellets of spruce tops & branches (GROT) have been torrefied. The following material has been produced:

- GROT light torrefaction (225 °C, 30 min. holdup time)
- GROT severe torrefaction (275 °C, 30 min. holdup time)
- Wood chips light torrefaction (225 °C, 30 min. holdup time)
- Wood chips severe torrefaction (275 °C, 30 min. holdup time)

These materials have been used internally in STOP and CenBio deliverables. In addition, the same torrefied material has been delivered to the Catalonia Institute for Energy Research (IREC). Currently the reactor is producing batches of the same fuels to Sandia National Laboratories. These institutes will be gasifying these torrefied fuels using 2 different technologies, a fluidized bed and an entrained flow reactor. Gasification at various conditions (temperature, pressure and different catalysts) will be performed. The results will be part of deliverables in the GasBio project. In late December we have plans to further test the reactor with different fuels. Shredded tops and branches from spruce will be torrefied at different temperatures. The challenge, compared to what has been done so far, is that shredded fuels usually have a wide particle size distribution (ranging from a couple of centimeters and down to 1 mm). An FTIR might also be used in order to quantify gases from the different screw sections in the torrefaction reactor.

Deliverable progress update

The work on the torrefaction of birch and spruce in a macro-TGA has been finalized. An article with the title "Torrefaction of Norwegian birch and spruce – an experimental study using macro-TGA" has been published in the journal Energy & Fuels. This work assessed the characteristics of two types of wood (hardwood and softwood) at different torrefaction temperatures, residence times and initial particle sizes (prior to torrefaction).

energy&fuels — Article
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Torrefaction of Norwegian Birch and Spruce: An Experimental Study Using Macro-TGA

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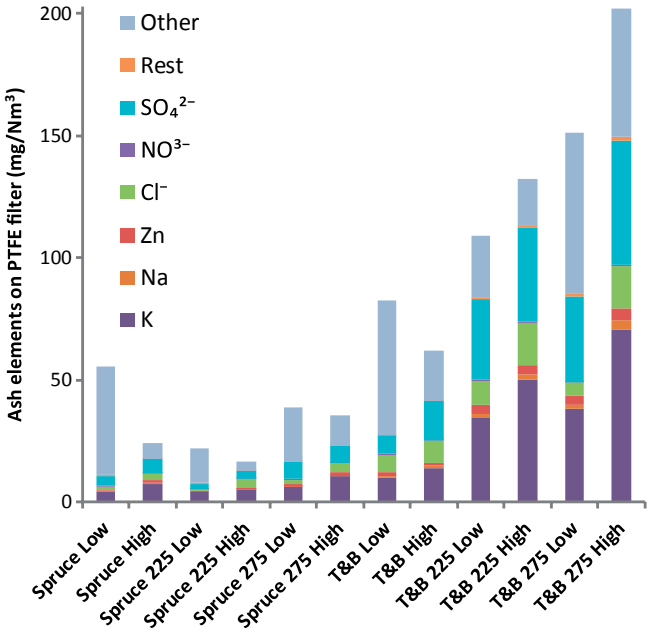
The work on combustion kinetics of the aforementioned fuels has been finalized and a paper has been submitted to the journal Energy & Fuels. A total of 36 TGA combustion experiments (both in air and at reduced O_2 concentration (5 % O_2)) have been evaluated.

This year's primary deliverable focuses on the performance of a small scale pellets combustion unit for residential heating. The pellets that were mentioned under "Torrefaction reactor – status" were combusted at 2 different loads. The results were compared to the combustion of the same "untorrefied" pellets. This study concentrated on looking in detail at the flue gas and inorganic particulate emissions. Fuel type (clean wood chips and GROT) and torrefaction degree were assessed in terms of combustion efficiency and emissions. In particular, great attention was given to the effect of torrefaction on the fly ash size distribution and composition.



Composition of ash elements on the Teflon filter ($PM_{1.0}$) in mg/Nm³.

A simple Aspen Plus model for a torrefaction process has been developed for the calculation of mass and energy balances. The model includes a biomass rotary drum dryer, a torrefaction reactor and heat exchangers for the optimization of excess heat utilization. The model also integrates combustion of gases and liquids produced in the torrefaction step. The heat produced is recycled in order to provide energy for the torrefaction and drying steps.

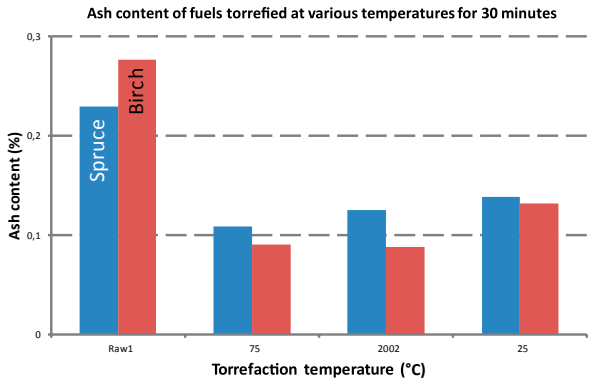
It is also possible to add a utility fuel (natural gas) in the combustion step in case more energy is needed. Data from the model is used for cost efficiency analysis of a torrefaction plant. The model attempts at estimating the costs of torrefaction per kWh produced torrefied material. A sensitivity analysis has been carried out to estimate the variation of some parameters that can influence the production costs. The effect of plant size, torrefaction temperature and moisture content in the initial fuel on the production costs was also calculated. The results were presented at the project's annual workshop which was arranged on the 5th of December. This work will be expanded next year to include a feasibility study for the use of torrefied fuels in Norwegian energy plants. We also plan on improving the accuracy of the model by providing better costs estimates.

Workshop 2012

A project workshop was arranged on the 5th of December in Trondheim. Presentations on the overall project status and the deliverables that were planned for the current year were given. These included: (**1**) D1.1.5 Characterization of torrefied fuels in macro TGA; (**2**) D2.1.2 Combustion properties of torrefied fuels; (**3**) The SINTEF Energy Research torrefaction reactor setup; (**4**) D2.1.4 Testing of torrefied fuels in small-scale units; (**5**) D2.2.2 Cost-efficiency analysis for the utilization of torrefied fuel in combustion plants; (**6**) D4.1.1 Presentation of technology developments;(**7**) PhD study activities and results overview.

PhD work progress

The work of the PhD student Quang Vu Bach has been mainly concerned with wet torrefaction (WT) of Norwegian spruce and birch. Experiments were carried out to investigate the effect of process parameters on the yield and the fuel properties of solid products. Results show similar trends to dry torrefaction (DT) where both reaction temperature and holdup time have a significant effect on the solid product yield, fuel properties, hydrophobicity and grindability. More interestingly, the ash content of wet torrefied biomass decreased significantly, a trend that is not observed in dry torrefaction.



Comparison of the ash content of raw and wet torrefied fuels torrefied at different temperatures.

This result opens up a possibility to produce solid fuels via WT that are cleaner with regards to inorganic impurities. Experiments have shown that wet torrefaction can produce a solid fuel with comparable yield to dry torrefaction at a lower temperature and shorter holdup time. The solid product was shown to have a heating value that is higher compared to dry torrefaction.

2013

The final year of the project is approaching. Several deliverables are planned; among these is a feasibility study on utilizing torrefied biomass in Norwegian energy plants. We also plan to disseminate selected project findings at international conferences. Among the conferences that we will participate at is the "21st European Biomass Conference" that will be arranged in Copenhagen from 3 – 7 June, 2013. We will also participate at the "Nordic Baltic Bioenergy Conference" which will be arranged in Oslo from 21 – 22 May, 2013.

Other news

What is buzzing in the world of torrefaction?

The list of torrefaction development projects has steadily grown lately. More than 50 projects are underway in Europe and North America. Although still only a few of these have a capacity that is higher than 5 tons/hour.

The Austrian company Andritz is to collaborate with ECN on the development of a new torrefaction technology. The new technology will be tested in a pilot plant in Denmark.

Torrefaction workshop at the EU Biomass Conference

IEA Bioenergy Task 32 Biomass Combustion and Cofiring and the EU SECTOR project jointly organized a workshop on torrefaction as a parallel event at the last European Biomass Conference, in Milan. The presentations at the workshop can be downloaded from: ***www.ieabcc.nl/workshops/task32_2012_Milan/index.html***

New report on torrefaction

A new report on torrefaction is being prepared under the auspices of IEA Bioenergy Task 32. The report gives a nice overview over the advantages of torrefaction, the different technologies that recently have been developed, applications that can draw advantages of torrefied material and economic evaluation of torrefied pellets production.

A veteran in design and testing of woodstoves has retired

Edvard Karlsvik has worked on the development of combustion technologies for wood stoves for several decades. Edvard is responsible for lowering the emissions of particles from wood stoves by an order of magnitude through many years of research and development at SINTEF. His presence will be dearly missed, but a highly qualified group of researchers in this area will keep up the good work.

STOP – STable OPerating conditions for biomass combustion

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