

STOP

STable OPerating conditions for biomass combustion plants

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Torrefaction reactor – status

The first torrefied pellets have been produced with the torrefaction reactor. The torrefied biomass was wood pellets and was torrefied at a temperature of 225 °C.

The early operation of the reactor was proven quite challenging due to the high number of measuring nodes which had to be either logged or controlled. Most of the early reactor faulty behavior has been corrected with the exception of few that will be taken care of in the near future.

The reactor will be first used to produce torrefied materials from different biomass sources and at different torrefaction temperatures. These processed fuels will be used at a later stage in a small-scale pellets combustor. The details of this work are explained in more details below.

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" was submitted to the journal Energy & Fuels. This work accessed the characteristics of two wood types of woods (hardwood and softwood) at different torrefaction temperatures, residence times and initial particle size (prior to torrefaction).

The combustion kinetics of these torrefied fuels has also been studied. A total of 42 TGA combustion experiments (both in air & at reduced O₂ concentration (5 % O₂)) have been performed with raw and torrefied spruce and birch. Three different temperature programs were used (linear, constant reaction rate and modular) in order to investigate the reaction kinetics in a wide temperature range. A journal paper based on this work is now being finalized.

In another work, the **torrefaction kinetics** for the same fuels has been studied in a TGA. The purpose of this work is to compare the thermal degradation behavior between the macro- and micro-TGA. The results are planned to be published later this year.

This year's primary deliverable will concentrate on producing pellets from different fuels using the torrefaction reactor and testing the combustion properties of these fuels in a small-scale pellets combustor.

The combustion properties of two raw fuels (a clean wood, and a biomass with high ash content) and their torrefied counterparts will be assessed. This combustion study will concentrate on looking in detail at the flue gas emissions from these fuels at different combustor loads. In particular, great attention will be given to study the effect of torrefaction on the fly ash size distribution and composition.

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 will attempt at estimating the costs of torrefaction per kg produced torrefied material. A sensitivity analysis will include the variation of important parameters such as plant size, torrefaction temperature, moisture content in the initial fuel, etc. The results will be presented at the project's annual workshop which will be arranged by the end of this year.

PhD work progress

So far this work has concentrated on studying wet torrefaction in a laboratory reactor. The fuels that have been studied are the same as the ones used for the dry torrefaction experiments. The purpose of this work is to compare the dry and wet torrefaction in terms of product quality. These results will be part of the PhD of Quang Vu Bach. Updates regarding this work will be also presented later this year at the STOP workshop.



Wet torrefaction reactor.

Other news

IEA Task 32 Biomass Combustion and Cofiring

Torrefaction is receiving considerable interest these days, and is also one of the subjects addressed in Task 32. The workshop on torrefaction technologies arranged in Graz January 2011 will be followed up in connection with this year's European Biomass Conference and Exhibition, see below.

IEA Task 33 Thermal Gasification of Biomass

Torrefaction has been lately regarded as a pretreatment step that gives several benefits for a gasification process. Keeping track on the progress of gasification is therefore also important from a torrefaction perspective.

The last IEA task 33 meeting was arranged in Istanbul, Turkey, 17 – 19 April 2012. The first day of the meeting was devoted to 11 country updates by the participating member representatives. The status of biomass gasification (for both fuel and power purposes) in each country was discussed, and industry and research were presented in the member countries. At the end of the day, some interesting and desired tasks to be carried out during the next triennium were discussed.

The Task33 webpage (www.ieatask33.org) contains a gasification database, which was presented briefly. Now, a total of 87 biomass gasification facilities are registered in the database, of which 68 facilities are in member countries.

The gasifiers can be divided by three parameters: technology (co-firing, CHP, synthesis, other innovative), type (pilot, demo, commercial) and status (planned, announced, under construction, under commissioning, operational, on hold). Most of the gasification facilities are used for CHP (44%) and synthesis (39%) purposes, while only 4% for co-firing. Other innovative technologies are covered by the remaining 13%. There are 48% commercial gasifiers, 27% pilot plants and 25% demonstration plants for gasification facilities in the database. 59% of the gasifiers are in operation.

The second day, the country representatives participated at the expert workshop on "Challenges related to bed material", and the third day the gasification and combustion facilities at TUBTAK – MAM were visited.

Torrefaction of biomass workshop in Leeds

The workshop on torrefaction took place on Wednesday 28th March 2012 at the University of Leeds. This workshop forms part of the initial dissemination activities of the project: "Premium Upgraded Biomass Solid Fuels- Fundamentals of torrefaction and performance of torrefied fuels", which is financed by the Energy Programme, Grant EP/H048839/1. The Energy Programme is a Research Councils UK cross council initiative led by EPSRC (Engineering and Physical Sciences Research Council).

SINTEF gave a presentation detailing some of the results that have been obtained through the STOP project. Information on the GasBio project was also given due to the existing link between the two projects.

The workshop included many interesting talks from different European companies and research institutes. Among these are:

- Rotawave, presented their torrefaction process based on microwave technology
- ECN, presented their moving bed technology
- SSE, Ferrybridge Power Station, talked about their experience on the use of torrefied material in large scale boilers
- Several studies on torrefaction were also presented (fundamental research)
- Technoeconomic studies
- Issues in utilization

3rd International Conference on Biomass and Waste Combustion

was arranged on the 24 - 25 April 2012 in London, UK. The Conference focused mainly on the technical aspects of biomass and waste combustion. The Conference was arranged by SINTEF, KEMA and Vattenfall and followed up on the success of the two previously arranged conferences in Milano (2008) and Oslo (2010). The conference gathered 52 participants from 11 European countries representing universities, research institutes and different industries.

The conference covered the following 5 important themes:

- Best practices
- Novel fuels and fuel related challenges
- Advanced conversion and efficiency improvements
- Ash and emissions
- Advanced monitoring and control

Technoport Renewable Energy Research Conference 2012

This scientific conference was arranged 16 - 17 April 2012, in Trondheim, and focused on renewable energy technologies. In addition to interesting lectures on general issues concerning renewable energy, there was 13 detailed scientific parallel sessions. One session was devoted to bioenergy including heat, cooling and/or power generation from biomass at which the results of the fundamental torrefaction research performed through STOP was presented. The conference was arranged by SFFE - Centre for renewable energy. (<http://2012.technoport.no>)

20th European Bioenergy Conference and Exhibition

This annual conference is this year arranged in Milan from the 18th to the 22nd of June. Results from the STOP project will be presented in three presentations, one on kinetics and two on wet torrefaction. IEA Task 32 – Biomass Combustion and Cofiring will arrange a torrefaction workshop during the conference, with invited presentations on several torrefaction related aspects.

Aebiom European Bioenergy Conference 2012

This conference is arranged by the European Biomass Association in Brussels 25-27 June 2012. The focus of this year's event will be: EU legislation, sustainable feedstock supply and market opportunities. This is the third edition of the growing series. (www.aebiom.org)

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Contact: Roger Khalil • Roger.A.Khalil@sintef.no
SINTEF Energi AS (SINTEF Energy Research) • Trondheim, Norway • Phone: + 47 73 59 72 00 • www.sintef.no/energi

