Development of torrefaction technologies and impacts on global bioenergy use and international bioenergy trade

This workshop on the development of biomass torrefaction technologies was held as a joint initiative of IEA Bioenergy Task 32, Task 40 and the EU FP7 project 'SECTOR', as a parallel session within the Central European Biomass Conference 2014 in Graz, Austria.

Introduction ; Jaap Koppejan

Jaap Koppejan (Task leader of Task 32) gave a brief introduction on torrefaction and why there is a large interest in the topic. Torrefaction is a thermo-chemical process for the upgrading of biomass that is usually run at temperatures ranging from 250 to about 300°C in the absence of oxygen and at ambient pressure. It is generally regarded as an interesting pre-treatment technology for biomass before pelletisation and/or combustion as it is claimed to changes tenacious and hydrophilic biomass with low energy densities into brittle and hydrophobic biomass with high energy densities.

In 2011, Task 32 and 40 organised a similar workshop on torrefaction at the same conference. By that time, there was a large interest in the topic, with several torrefaction companies making claims on the rapid growth of torrefaction. In reality however, only little progress has been observed. In this workshop, the current technology status and expected developments in commercialisation of torrefaction technologies are being evaluated.

International overall view of developments in the torrefaction sector, Michael Wild, Internat. Biomass Torrefaction Council, Brussels, Belgium

Michael Wild (Wild and Partner) is both active in IEA Bioenergy Task 40 and the International Biomass Torrefaction Council (ITBC, a stakeholder organisation established to promote the uptake of torrefaction technologies in the market by addressing common issues in the market). He gave an overview presentation of the developments of torrefaction in the last few years.

According to Michael Wild, torrefied biomass fuels are entering the market right now commercially, with a number of plants in commercial operation today. Several issues have been addressed through R&D efforts and resolved (such as the technical performance of the torrefaction process itself, safety of production and handling of torrefied materials, indoor storage aspects), while a number of issues (such as densification, acceptance at heat appliances, outdoor storage) still need further work.

As it takes time to develop new production factories, the volumes currently available and used are relatively small (several hundred thousands of tons per year) on the scale of coal consumption, but progress is made. In 2014, several test burns are planned at full scale and significant quantities.

Within ISO 238 WG 2, work is currently performed to develop quality standards for graded torrefied pellets. It is expected that the ISO standard is available soon.

With regard to health and safety aspects, REACH registration has been performed and MSDS sheets have been developed. Based on extensive safety tests carried out, the US Department of Homeland Security has issued a 3-years permit to allow for shipment of torrefied biomass.

With regard to hydrophobicity, it appears that during rainfall, water may enter through minor cracks in the outside surface of biomass pellets or briquettes and weaken a biomass particle. It is therefore important to establish a smooth surface after densification.

Densification of torrefied materials, Wolfgang Stelte, Danish Technological Institute, Taastrup, Denmark

Wolfgang Stelte of DTI elaborated on the specific issue of densification of torrefied material. Research on this matter was done in the framework of the FP7 SECTOR project. This project with a budget of 10 million Euros deals with the whole chain of the torrefaction process, from raw materials, process development, applications, product quality assessment and sustainability.

In general, densification of torrefied biomass is challenging due to the high energy requirements and friction in the pellet mill, leading to increased risk of fire/dust explosion and wear of the pellet mill. Process conditions, biomass feedstock and pelletisation settings however have a large influence on this aspect. A higher torrefaction degree results in more friction. An increase in moisture content on the other hand results in lower friction and improved mechanical strength of pellets. This also depends on the wood species used. The press channel length is one of the most important parameters to vary in this respect.

Characteristics of torrefied products and their dependence on process conditions, Ute Wolfesberger-Schwabl, OFI Technologie & Innovation GmbH, Austria

Ute Wolfesberger-Schwabl of OFI is also active in the FP7 project SECTOR. In this project, OFI is responsible for the analysis and characterisation of (torrefied) biomass, therefore OFI has a good overview of the relevant parameters that determine the quality of the products and the appropriateness of various analysis methods.

Within SECTOR, the applicability of several existing analysis methods for biomass have been tested through a Round Robin test. This gave valuable results. A number of new test methods have been identified for analysis of grindability, leaching behaviour, hardness, hydrophobicity and storage, which will be tested in a second Round Robin.

Advantages and drawbacks for international trade of torrefied products, Mark Beekes, DNV GL, Arnhem, Netherlands

Mark Beekes of DNV GL (formerly KEMA) shared the results of an economic analysis in which the costs and CO2 emission for shipment of torrefied biomass from US to Western Europe was compared to wood pellets. With the assumptions taken, this study showed that the increased production costs for torrefied pellets are more or less counterbalanced by savings in logistical costs. Fossil CO_2 emissions are mainly due to the preparation of biomass from the forest to the torrefaction plant. About 10-30% of total fossil CO2 emissions is due to ocean freight. The results of course strongly depend on the assumptions taken. In reality it is therefore crucial to analyse the specific performance of an envisaged supply chain.

First experiences from large-scale combustion and co-firing tests with refined biomass Fuels, Nader Padban, Vattenfall, Stockholm, Sweden

Vattenfall is one of the few electricity companies in the world with actual practical experience in the use of torrefied material at full scale. Nader Padban of Vattenfall shared some of the experience in co-gasifying torrefied biomass at the Willem Alexander Centrale gasifier plant of NUON in Buggenum, the Netherlands. In this plant, about 1500 tons of torrefied biomass and 5000 tons of steam exploded biomass have been tested.

In a 24 h test campaign where 1200 tons of torrefied biomass were cofired, about 70% of the coal was replaced. No big technical challenges were observed during conveying, sluicing and milling of the 70% mixture. It was estimated to be possible to achieve 90% of the plant nominal capacity without major modification in fuel feeding system.

One of the main issues faced was dust formation during onloading and handling of the material. It appeared that torrefied pellets had a lower mechanical durability than normal wood pellets resulting in a high dust formation during handling. This was addressed by water sprayers. Other conclusions of the trials are:

- The minimum ignition energy (MIE) for the dust from torrefied fuel was considered too low (lower than white wood pellets). No explanation could be found for this.
- The quality of the pellets deteriorated substantially when stored outside due to water takeup, followed by poor mechanical durability and dust problems during handling. Long term outdoor storage of torrefied material requires an improvement in weather and water resistance of the pellets.
- A higher heating value in the pellets was connected to better milling property but a less advantageous dust formation behaviour.

Andritz torrefaction technologies and summary of pilot plant operation in Austria and Denmark, Klaus Trattner, Andritz AG, Graz, Austria

Klaus Trattner of Andritz summarised their experience at the torrefaction demonstration plants in Denmark and Austria. These two facilities have been built using two different torrefaction technologies (the Vertical Reactor Design in Denmark and the ACB process in Austria).

The plant in Denmark started in 2012. This concerns a vertical pressurised reactor with moving bed with a capacity of 1 tph. As it is pressurised, heat transfer is more effective and gas velocities are relatively low. In principal this is advantageous for scaling up the size of the technology. It is claimed that plants with a capacity of up to about 700 ktons/year could be realised. After a number of tests however, the plant has been put on standby.

The ACB plant in Frohnleiten, Austria is based on a drum reactor and also has a capacity of 1 tph of briquettes. The plant has been in continuous operation (3d/w) since jan 2013. It was observed that with increasing torrefaction degree, briquette densities decrease and hydrophobicity increases. There is no clear dependency on durability.

In addition to clean wood, Andritz has also gained experience with torrefaction of more challenging biomass such as green waste, harvesting residues and herbaceous biomass.

Through adequate pre-treatment steps such as sieving and washing, such biomass types might also be suitable as input material for torrefaction.

AREVA's pathway to an industrially-proven torrefaction process, Natacha Kienlen, Areva, Paris, France

Natacha Kienlen of Areva explained the status of the AREVA torrefaction technology. In 2012 Areva acquired the Thermya torrefaction technology. A 2.5 tph demonstration plant was commissioned in 2013 to validate the industrial scale performance of a torrefaction concept developed earlier. The plant has been used for a variety of different feedstocks (e.g. wood, bagasse) and densification concepts (pellets, briquettes and nuggets.

Round table discussion: The way forward for technology suppliers, project developers, consumers

A round table discussion took place with the speakers under moderation of Sandy Ferguson (formerly from BC Bioenergy Network) to evaluate the current status of torrefaction technologies and what can be expected of torrefaction technologies in the near future.

It was concluded that 3-5 years ago, expectations about the commercialisation rate of torrefaction technologies were possibly unrealistically high. It takes several years to develop a new thermal processing technology from technology concept to full scale production and have a substantial impact on the world market.

Nevertheless, some significant progress has been achieved recently. For example, after having made several process modifications the Topell demonstration plant now produces about 8 tph of product on continuous basis. In 2013 a cofiring trial was successfully carried out at the AMER power plant in Geertruidenberg, the Netherlands with 2,500 tons of torrefied pellets from Topell. Several other companies have achieved similar progress and have demonstrated a working demonstration plant.

From the presentations it can be concluded that several torrefaction technology companies now also offer turnkey torrefaction plants at full scale. It is likely that the first full scale demonstration plants will be announced in 2014. These plants will most likely be situated in areas with large untapped resources of biomass, e.g. Brazil, Asia, Eastern Africa, etc.

The relatively low CO_2 price is often a major hurdle for the business case. In countries where biomass cofiring or 100% conversion is promoted (e.g. UK, Netherlands, Belgium), the latent demand is much higher than the possible supply for the next couple of years. For countries where interest in biomass cofiring has only recently started (eg. in Asia, South Africa, torrefied biomass could provide an option to leapfrog technology without the need to invest in significant modifications of existing plants.

Securing the financing for investment is another hurdle. Compared to the fuel requirements of and pulverised coal fired power plant, the volume of torrefied fuels that can be offered from any of the existing torrefaction companies to a single power plant is relatively small, which makes end users hesitant to absorb torrefied fuels and sign long term offtake contracts. This makes it again difficult for an investor to obtain finances to establish a torrefaction plant. A local heat market or a relatively small market for use in higher value applications (e.g. chemicals or transportation fuels after gasification) could help in this way to get rid of the chicken and egg problem.

Remaining issues to be addressed relate predominantly to densification, hydrophobicity, and dust formation in handling. With regard to hydrophobicity, it appears that during rainfall, water may enter through minor cracks in the outside surface of biomass pellets or briquettes and weaken a biomass particle, leading to unwanted dust formation during handling. It is therefore important for many torrefaction companies to improve their densification step in order to create a smooth uncracked surface after densification.

With regard to health and safety aspects, REACH registration has been performed and MSDS sheets have been developed. Based on extensive safety tests carried out, the US Department of Homeland Security has issued a 3-years permit to allow for shipment of torrefied biomass. Adequate product standards are currently developed that should provide confidence to end users that the torrefied products offered meet the customer requirements. It is expected that a new ISO standard will be made available soon.

With the above mentioned achievements, it was concluded that commercial market penentration of torrefied fuels can be expected over the next few years. The speakers agreed that the issues remaining can be addressed satisfactory through ongoing R&D programs and agreements. Market uptake by utilities and industry needs to be supported by conducive government policies.