UPSCALLING A NOVEL TECHNOLOGY FOR THE PRODUCTION OF HIGH QUALITY STRAW PELLETS

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In the Biomass Department of CENER (National Center for Renewable Energies), we are developing a technology to produce reliable and competitive straw pellets. The ultimate goal is to develop and validate a technology that improves the properties of low-quality residual biomass to produce a quality fuel that is environmentally sustainable and economically competitive.

The reasons that have led CENER to bet on this strategic line are based on the future perspective of the evolution of the bioenergy market. Among others, there is the growing demand for biomass in multiple sectors, which creates tensions on its availability, linked to the need to avoid competition with the wood fiber market and other applications. In this sense, feedstock demand for wood pellets production is increasing and therefore the pressure on the procurement prices for the higher quality feedstock. This trend within the scope of sustainability is defined by the principle of cascade use of biomass, which could restrict the use of quality biomass for energy applications. In fact, in the projections of the European Roadmap Horizon 2050 [1], the projected growth in biomass consumption in Europe is based on residual biomass. For example, the potential of agricultural waste in Europe is around 440 million dry tons, of which 74% corresponds to cereal straw [2]. Therefore, agricultural residues, such as cereal straw, are highly promising for use energy production owing to its potential is similar than the sum of both forest and non-forest woody residues [3]. As consequence the consumption of lower quality and cheaper feedstocks for pellet production will increase drastically in next years.

However, several issues regarding of both the energy content (density and net calorific value) and the inorganic compounds melting behavior must be solved in order to establish them on the same level as certificated wood pellet. This will allow pellets market to be thrived when being able to produce agripellets with quality and supply guarantees. This has motivated the Biomass Department of CENER, under the umbrella of the Horizon 2020 project CLARA [4], to develop a new and enhanced concept for pre-treatment process for cereal straw. The technology combines the torrefaction of residual biomass with processes for the elimination of certain unwanted inorganic elements and the use of additives that improve the high temperature behavior of the mineral fraction. The result is a solid biofuel with high calorific value, very high energy density, low level of emissions and a high ash melting temperature. The process is optimized in each case based on the characteristics of the raw material, considering the evaluation of production costs and the requirements of each application.Whole pre-treatment process combine several steps with synergic effects between them.

Biomass density increase through a physical pre-treatment based on chopping is a common alternative. However, bulk density is too low after this process (< 100 kg/m^3), being able to make necessary further densification. Pelletizing is an alternative for raising the straw density, which would allow in turn decreasing energy demands in subsequent steps as well as to be made easier its handling, transport and storage.

Biomass energetic content could be maximized through torrefaction, since it is able to increase the biomass net calorific value through its exposition at temperatures in ranging 250-300 ºC. Torrefaction allows financial and energy effective to be achieved intensifying the energy density, since it reaches the required heat for process from released volatile gases. Furthermore, torrefaction can be considered as a de-chlorinating process [5], which would aid to prevent the corrosion during fuel conversion. In spite of this, the high chlorine concentration in the straw ash could require a further removery through other processing. In the same way, the high potassium content in straw ash could require to be also released, since the presence of both inorganic components promotes low ash melting point during fuel conversion at high temperature. A washing step, either before or after torrefaction processing, could be applied in order to remove maximize inorganic matter through their leachability [6]. This would allow process reliability and efficiency to be boosted, preventing the appearance of fouling, corrosion and sintering phenomenon.

Once torrefied and washed or not, the wheat straw leaves from these steps in powder shape, which implies a density decrease and low volumetric energy content. Its pelleting could result an suitable strategy in order to achieve reducing transport costs. Moreover, a additivation of the biomass could be considered during this step in order to act on the aluminum silicates compounds, which arraies low melting temperatures [7]. A suitable additive can modify the elemental molar ratios in the feedstock, which would enhance ash melting behavior and thus prevent any problem caused by ash sintering.

Torrefaction pilot plant at BIO2C (www.bio2c.es) from CENER

Torrefied straw pellets producced at BIO2C from CENER

By applying an optimized combination of process steps the following achievemnets have been reached so far:

- Reduction of 70% of the potassium content (based on the energy content of the fuel; that is, in mg / kWh), 80% in the case of chlorine and 35% in the case of sulphur.
- Increase in the energy content of the product, in terms of net calorific value of 20% up to 20 MJ / kg. If the energy density of the product (MWh / m3) is also considered, it increases by 700% to approximately 3.9 MWh / m3. Consequently reflecting a very positive impact on logistics costs.
- The fusibility of the bottom ash increases by + 300ºC until it reaches values above 1,100ºC, thus matching the behavior of woody biomass.
- Lastly, regarding emissions and species that cause fouling and corrosion in the convective sections of the boilers, reductions of 70% in the volatilization of KCl have been obtained.

The current work is focused on the scaling up tests of the entire integrated cereal straw pretreatment process at the BIO2C facilities (www.bio2c.es) to produce ton size batches, the techno-economic study to evaluate the cost of production and the product validation tests in medium size heating boilers.

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