Gasifying zostera marina instead of burning trees

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24.12. 2022

Usually, the plant zostera marina is not considered a combustible due to its poor flammability. We present the first instance of gasification of zostera marina in a solar carbon gasifier.

1. Introduction

In most countries each year large amounts of biomass are produced and left decaying to CO2, emitting heat energy. In large part this biomass is produced by the agrarian sector – only about half of the produced biomass is food, but there are also other sources of “waste biomass”, like for instance the green cut collected in towns, or the sea grass zostera marina collected at the beaches at many seaside resorts. Since the price per kg of combustion material is very roughly as high as the price for food material, the value of the energy discarded as “waste biomass” would be as large as the value of the whole agrarian production, if one could obtain energy from it.
Instead, these biomasses are not being used because they either do not burn, or do require expensive and inefficient ways of processing in order to become useful combustibles.
For instance, pyrolysis can transform biomass to biochar [1], by heating the biomass to a temperature of above 300°C, in absence of oxygen. In order to provide this heat, a part of the biomass is burned. typically 30%. This causes a first inefficiency. Furthermore, when heated to high temperatures, the volatile components of the biomass are released, and with them about half of the energy content of the biomass or more. So that the production of biochar all in all has an efficiency of about 30% or less (depending on the temperature).
In addition, both the production as well as the combustion of biochar tend to be expensive. As a consequence up to today the preferred biomass for providing heat energy still is wood.
In order to substitute wood as a combustion material, a more efficient way of using “waste biomass” is needed, and furthermore this material should be a standard material, which can be used in a simple standard combustion device, similar to how fossil fuels can be burned in standard ways, regardless of their provenience.

2. Solar carbon

It is true, that biochar burns in an open fire at high temperature and with little smoke. While instead the raw material from which it is made would burn with a colder flame and with more smoke production.
In a gasifier instead, the very same raw material can be burned with a very hot and clean flame, too – provided only, that it can be gasified.
Many kinds of biomass in their natural state can of course not be gasified in such a gasifier, like green cut, potatoes, yogurt, used coffee powder or cow manure. But when these materials are first torrefied or roasted at a low temperature of about 130°C to 150°C, they can subsequently be gasified (more details in chapter 4).

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The torrefaction of the biomass can be done in a most simple way by means of hot air from solar energy, for instance provided by a Linear Mirror system [2], [3]. A first system for the solar torrefaction of biomass suited for a small industry (25 kW thermal power) has been constructed, and it performed well [4]. This technology has been presented and discussed at ESOF2020 (science in the city) in detail [5]. Since the torrefied material, together with a suited gasifier can substitute fossil fuels, we refer to it as “solar carbon” [6].
During solar torrefaction no part of the material is lost in combustion, and no volatiles are emitted, it is therefore very efficient from an energetic point of view. Furthermore it is a most convenient way for storing solar energy for long periods of time.

3. Purpose of this study

The goal must then be to torrefy different kinds of biomass each at such a temperature, as is needed in order to obtain a standard solar carbon material, which can always be gasified in a standard gasifier, independently of its provenience. For instance for high quality wood no torrefaction may be necessary at all, while materials of low flammability might require a higher torrefaction temperature in order to become a combustible of the same quality as wood.
As a very first exploratory step towards such a complete study we want to investigate, whether a kind of biomass which is considered a very poor combustible becomes a high quality combustible when roasted to a moderate temperature and gasified in our gasifier for solar carbon. We choose for this test the sea grass “zostera marina”. It is so difficult to inflame, that it is even certified as construction material for the isolation of homes [7]. If it is possible to gasify zostera, then it would be hard to imagine a biomass which cannot be gasified.
At many sea resorts zostera marina is considered a severe problem [8]. For instance the seaside resort Grado collects each year about 7.000 tons of material (not only zostera) for a cost of about 400.000 €. [9]. This same amount of Zostera could instead provide 3 MW of heating 100 days per year, saving 750 tons of heating oil.

4. Test setup

For our tests we have constructed a very simple gasifier, equipped with an conveyor screw which automatically feeds biomass into the gasification volume, which is the end part of the conveyor tube, just after the conveyor screw. So the design is of extreme simplicity, as for instance the Linear Mirror system itself is of total simplicity.

Figure 1: gasifier for solar carbon, thermal power 25 kW.

Three temperature sensors are placed at different positions in contact to the wall of the gasifier. They are read by a Siemens “Logo” plc, which uses this information for the control of the conveyor screw, moving it in such a way as to keep the temperatures within standard operational conditions.
The gasifier is equipped with a storage container which is fed by hand. The air flow for gasification is provided by two ventilators ebm-papst series RLF35, with an electrical power input of 8.6 W generating a flow of $10m^3/h$ at a pressure of 120 Pa.
In our test setup, the gas produced by the gasifier is burned in a flame outside of the gasifier, as shown in figure 2. The flame has a temperature of 1200°C, it does not produce visible smoke. According to engineers from the company A2A, the flame would be well suited to substitute the flame from fossil coal combustion in conventional coal power plants [9].

Figure 2: flame from the gasifier

We have collected a sample of zostera marina at the beach of Staranzano (Monfcalone, Italy). The zostera was heated to 130°C without any previous treatment, for instance it was not washed (in order to remove the salt) or cleaned from sand. After roasting, the zostera was processed through a wood chipper, since otherwise the conveyor screw would have problems to transport it evenly.

5. Results

For comparison we first gasified wood pellets, recording the temperatures of the three temperature sensors, as shown in figure 3. After 80 minutes of operation the wood pellets were consumed and the roasted zostera marina was instead fed into the gasifier without interrupting gasifier operation.

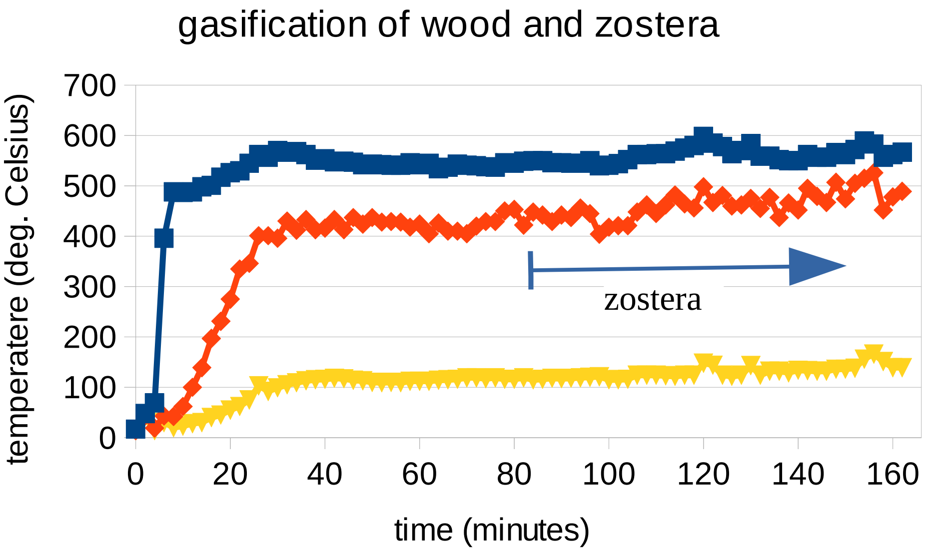

Figure 3: temperatures in the gasifier during the gasification of wood pellets (first 80 minutes) and zostera marina.

When the gasifier was fed with zostera instead with wood, it continued operation without any apparent changes, also the temperatures recorded did not change significantly. This indicates that zostera – which has about the same energy content as wood – is an excellent material for the production of solar carbon.
It is possible, that zostera produces more ashes, compared to wood. For studying this in a future measurement, a cyclone will be used. While this will be an important measurement, it is not expected to be of direct relevance for the gasification process itself, for this kind of gasifier construction.

Conclusion

We have successfully gasified a sample of roasted zostera marina for the first time. It gasifies very well in a very simple gasifier made for processing solar carbon. A comparison to the gasification of wood pellets does not show any significant differences at this first stage of our study.
The goal of our work is the definition of a standard solar carbon material, similar to the standardization of fossil fuels. Many more tests are needed in order to arrive there. However, since zostera marina is considered a very poor combustible, difficult to inflame, this first test indicates, that also many other kinds of biomass should be well suited for the production of solar carbon, and that a standardized solar carbon material is possible.
The production as well as the use of solar carbon mimic parts of the closed cycle of live on our planet, therefore they are techniques in harmony with nature. They are also economic, since many millions of tons of “waste biomass” are already being produced each year, but discarded as if they were waste.
Furthermore, the technology of solar carbon can be integrated with existing technologies, for instance for making conventional coal power plants CO2 neutral – without cutting the forests.

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