

PRODUCING BIOCHAR BY SEVERE TORREFACTION OF OAK, TO SUBSTITUTE FOSSIL COAL IN METALLURGY INDUSTRY. LABORATORY AND PILOT SCALE INVESTIGATIONS.

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1. Keywords

Wood, fixed carbon content, multiple hearths furnace, torrefaction, fire risk

2. Highlights

- Production of torrefied wood with high carbon content in a pilot scale oven
- TGA study of oak thermal decomposition, in the temperature range from 250 to 350°C.
- Mass and energy balances for each tested condition.
- Risk of fire during large scale torrefaction of wood chips at elevated temperature

3. Purpose

In the overall efforts to reduce fossil CO₂ emissions, in which EU has taken engagements, industry will have a prominent contribution. In this context, the CIRMET European project aims at evaluating the use of torrefied biomass as heating source and reducing agent in metallurgy furnaces. So far, coal or coke are used for that purpose.

Torrefaction is a thermal process which changes biomass into a solid with properties closer to coal. Therefore, producing a substitute for coal by torrefaction of biomass could be a relevant option. To be used as reducing agent in metallurgy processes requires the biochar to have a fixed carbon content above 85% and to contain as few inorganics as possible [1]. Such requirements can preferably be met after torrefaction of wood operated under severe conditions.

This work is focused on the preparation of a high carbon content biochar, by torrefaction of oak wood chips at 300 and 350°C. This treatment is performed in a pilot scale furnace. Prior to those large scale operations, some experimental investigations have been carried out with TGA to identify optimal conditions for the thermal treatment.

4. Materials and methods

Oak wood is supplied under the form of "P31" chips (French normalization). The water content is lower than 23%, and the ash content is lower than 2%db. The fixed carbon content is 20%db.

The elementary composition has been measured by using an Elementar Vario EL device. The ash content measurement has been subcontracted to an accredited laboratory. Lab-scale torrefaction has been carried out into a SETARAM instrumentation TGA-92 furnace (TGA).

Torrefaction at pilot scale has been carried out in the biomass research platform of CEA (Grenoble, France). The torrefaction unit has been presented elsewhere [2] . The oven is a 6-hearth furnace, provided by CMI (Seraing, Belgium), with a capacity of 150 kg/h of wood chips (inlet capacity). It is heated by 12 gas burners (2 at each floor).

5. Results and discussion

Fire risk

After torrefaction, the wood chips are stored into several big-bags, in a parking. Several hours after torrefaction of the first batch, a fire occurred, which quickly propagated to the different big-bags. The fire ignited in the big-bag filled with oak chips torrefied at 350°C. This kind of event regularly occurs in the biocoal manufacturing. It is due to the oxidation reactions which occur when the char is put in contact with air. These reactions are slightly exothermal and as the heat released inside the bed of wood chips is quite hard to extract, the temperature increases until they undergo self ignition.

As this fire damaged all the torrefied wood chips, it has been necessary to perform again the production of torrefied oak, at 300 and at 350°C. To better control the exothermal reactions which happen while air (oxygen actually) contacts torrefied wood, the temperature in the bed of particles is continuously monitored and air is smoothly injected. As soon as temperature increases, injection of air is stopped, until temperature is cooled down to the ambient level. By doing this, no other fire occurred.

Torrefaction

Torrefaction in the pilot has been carried out at 300 and 350°C and with a residence time of 45 minutes. As the production of the first campaign has burnt (see before), a second campaign has been performed. The data about inlet and outlet flowrates of solid, for each condition (excepted for the first torrefaction campaign at 350°C), are summarized in Table 1.

Table 1 : Experimental conditions of each test of torrefaction in the pilot. In this table, each figure is an averaged value calculated over steady state periods.

Tests	Inlet flow	Outlet flow	Anhydric Weight Loss	Fixed carbon content
	kg/h moist basis	kg/h	%	(%db)
Oak 300°C, 45 min	101	53	41	27
Oak 350°C, 45 min	68	23	62	59

The composition of solid, permanent gases and tars are measured for each condition. Furthermore, mass and energy balances are calculated for each tested condition.

6. Conclusions and perspectives

This work gives an overview of torrefaction tests of oak wood chips at pilot scale operated under quite severe conditions, to maximize the Fixed carbon content in the solid. Torrefied wood with fixed carbon content as high as 60% has been produced.

The risk of fire is a major issue for the torrefaction industry. The event arisen in this experimental campaign confirms this observation. It has been shown that particular attention has to be paid when oxygen comes in contact with torrefied wood chips.

The perspectives of this work are firstly to test the torrefied oak wood as reducing agent in a metallurgy oven, and secondly to test other types of biomass to identify which resource would be the most suitable to this particular end-use.

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The official website of CIRMET project is: <https://www.spire2030.eu/cirmet>

7. References

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