

Torrefaction of ponderosa pine pellets

Submitted by:

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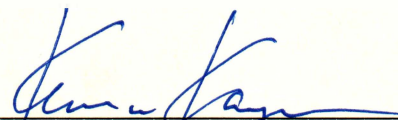
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1.0 PROJECT BACKGROUND

Oregon Torrefaction, LLC (OTL) and the US Endowment for Forestry and Communities (USFC) have formed Restoration Fuels, LLC (RF) to construct and operate a 12 ton/h kiln torrefier that targets approximately 100,000 tons of torrefied woody biomass production annually. The plant will be co-located at the Malheur Lumber Mill in John Day, Oregon. Biomass sourcing will be principally small-diameter, low-value wood from surrounding or nearby national forests including the Malheur and the Ochoco National Forests. The bulk of the woody biomass will be ponderosa pine from the dry land forests that surround John Day. Biomass coming from national forest areas have been evaluated for compliance with the US National Environmental Policy Act (NEPA) and are termed “shelf ready” for treatment. Restoration Fuels is now in the process of acquiring biomass supply to feed the torrefier. Early discussions with potential domestic and off-shore customers points to the need to have torrefied, densified test samples available for their evaluation, and it is in OTL’s interest on behalf of RF to produce a test batch of torrefied biomass that would be representative of RF’s future fuel product and to make samples available to serve customer interests. The effort is funded by the USFC and US Forest Service.

To accomplish the test sample production, the OTL provided five tons of wood pellets to the Biomass Conversion Lab (BCL) located in Coleraine, MN for a sustained torrefaction production run using ponderosa pine pellets as feedstock. The targeted heating value specification for the torrefied wood pellets as requested by OTL was 9,500 btu/lb (22.09 MJ/kg). The BCL torrefied and provided over 6,000 lbs (2,727 kg) of torrefied pellets to the OTL.

2.0 PROJECT RESULTS


The physical and chemical fuel properties of the torrefied pellets are summarized in Table 1 and Table 2.

Table 1. Summary of physical and chemical fuel properties of ponderosa pine pellets after they are torrefied in a 2 ft x 24 ft (0.61 m x 7.3 m) indirectly heated rotary kiln.

Measured Parameter	Raw Pellet as Received	Torrefied Pellets
Pellets Delivered	10,000 lbs (4,545 kg)	6,208 lb gross (2,822 kg)
Bulk Density (kg/m ³)	689	547
Calorific Value (MJ/kg)	19.76 *	22.89
Energy Density (MJ/m ³)	13,615	12,521
Tumbling Durability, % Survival	98 % *	91.59 %
Hardgrove Grindability Index (HGI)	NA	24
24 Hr immersion uptake, % by wt.	330 %	38 %

*Estimated

Table 2. Data sheet received from Twin Ports Testing from a composite of 10 barrels of torrefied pellets.



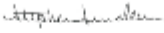
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Issue No: 3
Revised Report. Previous report is USR:W219-0198-02 issue number 2

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Stephen Sundeen
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Date of Issue: 3/28/2019

THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL

Sample Details

Sample Log No:	W219-0198-02	Sample Date:	2/20/2019
Sample Designation:	OT-T-Wood Pellets 10 BBL Composite	Sample Time:	
Sample Recognized As:	Biomass Pellets	Arrival Date:	2/28/2019

Test Results

	METHOD	UNITS	MOISTURE FREE	AS RECEIVED
Moisture Total	ASTM E871	wt. %		6.16
Ash	ASTM D1102	wt. %	0.31	0.29
Volatile Matter	ASTM D3175	wt. %	74.37	69.79
Fixed Carbon by Difference	ASTM D3172	wt. %	25.32	23.78
Sulfur	ASTM D4239	wt. %	0.008	0.008
SO ₂	Calculated	lb/mmbtu		0.012
Net Cal. Value at Const. Pressure	ISO 1928	GJ/tonne		
Net Cal. Value at Const. Pressure	ISO 1928	J/g		
Gross Cal. Value at Const. Vol.	ASTM E711	J/g	22888	21479
Gross Cal. Value at Const. Vol.	ASTM E711	Btu/lb	9841	9235
Carbon	ASTM D5373	wt. %		
Hydrogen*	ASTM D5373	wt. %		
Nitrogen	ASTM D5373	wt. %		
Oxygen*	ASTM D3176	wt. %		
*Note: As received values do not include hydrogen and oxygen in the total moisture.				
Chlorine	ASTM D8721	mg/kg		
Fluorine	ASTM D3761	mg/kg		
Mercury	ASTM D8722	mg/kg		
Hardgrove Grindability Index	ASTM D409	wt./index		24

Comments



3.0 CONCLUSIONS

1. The bulk density of the torrefied pellets was reduced from 689 kg/m^3 in the as-received state to 547 kg/m^3 in their torrefied state. This corresponds to a reduction of 20.6 %.
2. The energy content of the as-received pellets was upgraded from 19.76 MJ/kg to an average of 22.89 MJ/kg . This corresponds to an energy increase of 15.8%.
3. The volumetric energy content of the torrefied pellets was downgraded from $13,615 \text{ MJ/m}^3$ to $12,521 \text{ MJ/m}^3$ due to bulk density reduction. This corresponds to a reduction of approximately 8 %.
4. The moisture uptake profile for the torrefied pellets was upgraded significantly. The torrefied pellets absorbed only 38 % water content and still remained as pellets, whereas the raw pellets absorbed 330 % water content and completely disintegrated after being immersed in water for 24 hrs.
5. The tumbling durability survival for torrefied pellets was 91.59 % indicating more fines generation is likely.
6. The hardgrove grind ability index (HGI) of the torrefied pellets was found to be 24, which is similar to lignite-type coals.