Grass Combustion – LEI Bioburner BB100

Purpose: The purpose of this publication is to describe grass pellet combustion in the LEI Bioburner BB100 pellet boiler.

Appliance Description

The LEI Bioburner (BB100) is an approved indoor or outdoor boiler, rated at 30 kw/h (100,000 BTU). The fuel bin is external, with augers to remove fuel from the bin and elevate fuel into the combustion chamber. Ignition is accomplished using propane or natural gas, which can be used as a back-up fuel source.

Fig. 1. LEI Bioburner with fuel bin.

The Bioburner has a fuel stirring "T-shaped" pipe in the burn chamber (Fig. 2). Vertical heat exchanger tubes have turbulators, cleaned by attaching a hand or power drill to the top of each turbulator. The exhaust system includes a mini-cyclone for separation of some of the particulates before exhaust reaches the flue. Ash is removed manually by inserting an auger into the clean-out port and operating by hand.

Control Panel

The BB100 has touch screen computer control of all functions. Combustion temperature, flue exhaust temperature, and heat exchanger temperature can be displayed or graphed over time. There are control settings for minimum air flow rate and maximum air flow rate, which only functions if combustion temperature setting is maximum.

Settings of 3 seconds ON and 20-25 OFF at the maximum combustion temperature setting of 1600^{o} F permitted continuous running for all three fuels tested. If maximum combustion temperature is restricted to around 1350^{o} F, melting of ash to form clinkers will be prevented or minimized. When combustion temperature is restricted, the boiler goes into standby mode (ceases pellet feed) until combustion temperature drops back below the high temperature limit.

Fig. 2. Fuel-stirring pipe in the burn chamber before and after burning reed canarygrass pellets at a combustion temperature setting of 1600^{o} F. Note melted ash.

Pellet Feeding

This boiler was developed primarily for burning undensified feedstocks (1 ¼" chips or smaller), with a large feed auger and relatively high fuel delivery rate. Pellet fuel delivery is controlled by pulsed feeding, adjusting the ON and OFF times for the feed auger, with a minimum 3 second ON time. Maximum OFF time is around 20-25 seconds, if longer OFF times are selected, burning can become erratic.

Combustion Measurements

A Testo 350XL emissions measurement system determined CO, CO2, O2, H2, NO, NO2, and SO2 concentrations in the flue exhaust. Runs were restricted to 10-15 minutes in duration, to eliminate the possibility of overloading the CO sensor. After each run the probe filter was backwashed, and the Testo was allowed to rinse detection cells for at least 10 minutes, depending on the CO concentrations of the past run. The SO2 cell was inconsistent and readings are not reported. All emissions measurements varied with feed rate for all 3 fuels. All emissions tests were run in triplicate.

Pellet Feed Rates

High ash grass pellets averaged 5.5% ash and 7891 BTU/lb. Low ash grass pellets averaged 3.0% ash and 7749 BTU/lb. Premium wood pellets averaged 1.1% ash and 8202 BTU/lb. The BTU values are on an "as is" basis.

Initially, the highest pellet feed rate that allowed continuous feeding (no standby events) differed slightly, and was determined for each feedstock. Wood pellets (3 ON, 23 OFF); high ash grass pellets (3 ON, 25 OFF); low ash grass pellets (3 ON, 22 OFF). These settings were considered the nominal rate. The reduced rate was 3 ON, 20 OFF for all fuels with combustion temperature set at 1350°F.

Actual pellet feed rates for the three fuels averaged 10.5 lbs/h at the reduced rate and 13.0 lbs/h at the nominal feed rate. Smoke spot readings for all fuel/pellet feed rate combinations averaged 1.9, relatively low.

Emissions Results

Low ash grass pellets were lower in CO emissions than wood pellets, just as they were with pellet stoves tested (Table 1). However, high ash grass pellets when burned at a maximum boiler temperature of 1350°F produced very high CO emissions. As expected, NOx emissions were higher with grass pellets compared to wood.

Table 1. Average emissions readings for wood, low ash and high grass pellets at settings of 1350° and 1600° F. (Ave. of 3 runs).

Fuel	Setting	CO	NOx	CO_2
	°F	ppm	ppm	%
Wood	1350°	709	57	1.01
	1600°	105	65	1.14
Grass, low	1350°	215	128	1.00
	1600°	48	118	1.15
Grass, high	1350°	1531	125	0.99
	1600°	94	143	1.17

Concerns with Grass Pellets

Restricting maximum boiler temperature to 1350°F to avoid ash melting resulted in cycling in and out of standby mode. Combustion efficiency dropped greatly when the boiler was in standby mode (Fig. 4 vs. Fig. 3).

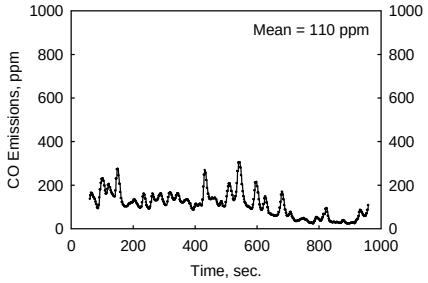

Fig. 3. High ash grass pellets at nominal feed rate (3 sec. ON/25 sec. OFF), at 1600°F setting.

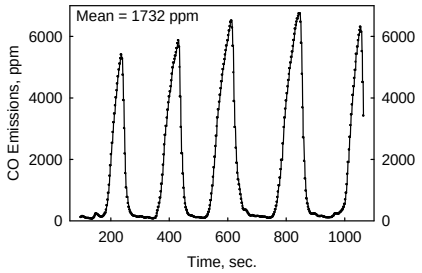

Fig. 4. High ash grass pellets at lower feed rate (3 sec. ON/20 sec. OFF), at 1350°F setting.

Summary

The LEI Bioburner that we tested was designed for feeding burning of undensified wood and other biomass. The feeding mechanism and programming were not optimized for pelleted fuels. Newer models are addressing this issue.

Additional Resources

Cherney, J.H. and K.M. Paddock. 2013. Basic emissions testing for residential appliances. Bioenergy Information Sheet #18. www.grassbioenergy.org.

Acknowledgments

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For more information

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