Grass Combustion – Woodmaster AFS100 Boiler

Purpose: The purpose of this publication is to describe grass pellet combustion in the Woodmaster AFS 1100 hydronic heater.

Appliance Description

A Woodmaster AFS 1100 pellet boiler was installed at the Town of Hunter highway garage, Hunter NY, supplemented with an oil-fired boiler. The pellet boiler is connected to the oil fired boiler hot water system using a plate heat exchanger. The Woodmaster AFS 1100 can produce up to 175,000 BTUs/hour, with a manual ignition. The burn pot consists of a trough with dual augers. The boiler has an attached 1.5 ton polybin for pellet storage. The unit burned about a half ton of grass pellets per week during the winter months for several winters.

Fig. 1. Woodmaster AFS 1100 installed at the Town of Hunter highway garage.

Pellets are delivered to the back end of a trough and are burned as they slowly make their way to the end of the augers. The plate around the augers is an air distribution plate with spaced holes. Combusted material drops in the bottom of the burn chamber, and an ash auger removes the ash to a storage bin. The unit has 11 horizontal heat exchanger tubes with turbulators, that will need to be cleaned frequently if burning high ash fuels.

Control Panel

Controls are relatively simple. The unit has a primary burn mode and an idle mode. Air flow is fixed, there are no controls for primary or secondary air. Both modes have timers to control the length of time that the feed auger is ON and OFF, and the timers are used to adjust the feed rate so that it matches up with both the particular fuel used and to the fixed rate of air movement. Estimated optimal times for wood pellets are 20 seconds ON and 30 seconds OFF. The typical feed rate for grass pellets at this site is 15 seconds ON and 15 seconds OFF.

Table 1. Boiler settings, feed rates, and smoke spot readings (ave. of 36 readings).

Fuel	Feed ON	Feed OFF	Feed rate	Smoke spot
	Sec.	Sec.	Lbs/h	0-10
Wood	10	20	11.2	3.0
	15	15	18.6	4.5
Grass	10	20	10.3	6.2
	15	15	16.1	5.2

Feedstocks Used

Wood pellets averaged 1.1% ash and 8202 BTU/lb. Miller grass pellets averaged 5.8% ash and 7591 BTU/lb (7% moisture). These BTU values are on an as-is basis, not a dry matter basis. Grass pellets were similar to premium wood pellets in physical quality. Grass pellets had only 0.35% fines, a bulk density of 38.6 lbs/cu. ft., and a pellet durability of 95.6%.

Combustion Measurements

A Testo 350XL emissions measurement system determined CO, CO_2, O_2, H_2, NO, NO_2, and SO_2 concentrations in the flue exhaust. Runs were restricted to 10 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 15 minutes.

Emissions Results

All emissions measurements varied with the feed rate for both pellet fuels. Oxygen decreased and all other measurements increased with increased feed rate. NOx increased with increased feed rate in both grass and wood.

This boiler functions the opposite of other appliances. Instead of setting the feed rate and optimizing air flow to the feed rate, air flow is fixed and the feed rate is optimized to the constant air flow. Thus, selection of a feed rate either higher or lower than optimum will negatively affect efficiency.

No gaseous sulfur was detected in grass or wood, indicating a faulty sensor. Wood often has no detectable S, but grass typically has 10-30 ppm S. CO emissions were very high in all cases, and higher at the higher feed rates. Grass produced much higher CO emissions than wood, indicating a less complete combustion for grass.

Table 2. Testo 350XL emissions readings, averages of three separate runs.

Fuel	Feed ON	Feed OFF	CO	NOx	CO_2
	Sec.	Sec.	ppm	ppm	%
Wood	10	20	1162	38	4.3
	15	15	1541	52	6.6
Grass	10	20	2990	111	3.9
	15	15	3764	126	6.4

Issues When Burning Grass Pellets

Temperature and moisture extremes can result in condensation in the pellet storage bin. Some pellets deteriorate; resulting in chunks of fuel and this may disturb or completely stop pellet feeding into the boiler. Controls are relatively simple, making the boiler easy to operate, but this also means there are fewer options to optimize the burn.

Without any independent primary or secondary air flow controls, the boiler may have only one “sweet spot” where a single combination of ON and OFF feeding times produces an optimal burn for a given type of pellet. With no automatic cleaning of the heat exchanger tubes, frequent cleaning when using high ash pellet fuels will be required for optimal results.

Fig. 2. Pellets drop onto dual augers which slowly move the fuel through the burn pot and down to the bottom, where another auger removes the ash to a storage bin.

Summary

The Woodmaster AFS 1100 hydronic heater is capable of burning high ash grass pellets. The auger system in the burn pot effective removes ash. The lack of control over combustion air, however, resulted in poor efficiency (based on CO emissions) when burning either wood or grass pellets. Some method of air flow control is needed for efficient combustion.

Additional Resources

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

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For more information

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