

CONF-9606348--

Straw Pellets as Fuel in Biomass Combustion Units

Presented at the 9th European Bioenergy Conference
in Copenhagen, 27-29 June 1996

by

Peder Andreasen & Mogens G. Larsen
Danish Technological Institute
Aarhus, Denmark

Abstract

Five types of straw and wood pellets made with different binders and antislack agents were tested as fuel in five different types of boilers in test firings at 50% and 100% nominal boiler output.

Summary

In order to estimate the suitability of straw pellets as fuel in small combustion units, the Danish Technological Institute accomplished a project including a number of combustion tests in the energy laboratory.

The project was mainly financed by the Development Programme for Renewable Energy under the Ministry of Energy. Manufacturers and distributors placed combustion units at our disposal for the tests.

The project was part of the effort to reduce the use of fuel oil. Outside areas supplied with community heating services, a larger dissemination of biofuels such as straw pellets will be welcomed.

Straw pellets are only produced and used to a small extent, so very little practical experience with straw pellet combustion in small boilers is available.

The aim of the project was primarily to test straw pellets in small combustion units, including the following: -

- Ash/slag conditions when burning straw pellets
- Emission conditions
- Other operational consequences
- Necessary work performance when using straw pellets

MASTER

The tests were divided into five series. As appears from table 1, tests were carried out with five different straw pellets and wood pellets. Five combustion units were used during the test.

FC36-966010148

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

**Portions of this document may be illegible
in electronic image products. Images are
produced from the best available original
document.**

Pellets of straw and wood in test:					
No.	Biomass	Antislagn binder	Thermal heat value MJ/kg	Ash in dry matter %	Remarks
0	Straw	None 3% molasses	17,2	-	By 50% boiler output, heavy slag flakes were formed in front of the burner.
1	Straw	4% TwinHeat ¹⁾ 3,6% molasses	17,0	8,1	Together with pellet # 2 the best in test. The evaluation is based on ash and slag properties and emission data.
2	Straw	3,5% caoline 6% molasses	17,2	7,6	Pellets # 1 and 2 were selected for the main test and the long-term test, performed with boilers A and B.
3	Straw	3,9% bleach clay 6,2% molasses	17,0	8,0	Pellet quality was satisfactory with binder. During 100% output tests a tendency to form accumulations of the half burned pellets on the grate appeared.
4	Straw	4% lime soap 6% molasses	17,7	6,6	The lime soap seems to make the pellets too loose with a significant tendency to crumble.
5	Wood	None None	17,6	1,0	The wood pellets are made without neither antislagn nor binder. Wood pellets were included in the test as reference.

¹⁾ TwinHeat anti-slag is 50% calciumcarbonate and 50% caliumoxide.

Table 1: Pellets of straw and wood

The preliminary tests formed the basis of estimating the effect of the antislagn agents used, whereas the aim of the main tests was to estimate the different kinds of combustion units.

Long-term tests and repeating tests were carried out with the two boilers and pellet types which had been found most suitable during the first two test series. The aim of these tests was to examine how the boilers work during long-term operations and whether the results were incidental or systematic.

All straw pellets were made from yellow wheat straw. The pellets with Caoline or an antislagn agent from Twin Heat made a light and porous ash without slag, whereas more or less slag was recognized in the ash from the other pellets. A large part of the ash from the pellets without antislagn agent melted into a compact mass.

The results of the main tests showed that boiler A and B were most suitable for straw pellets. Boiler C and E were the least suitable for straw pellets, whereas they operated satisfactorily with wood pellets.

The long-term tests with straw pellets in boiler A and B showed that their use may result in operational problems and that a considerably larger work input when using straw pellets must be foreseen.

Boilers used for testing of pellets:						
Lt.	Type	Grate system	Feeding	Nom. output kW	Dimensions L x W x H, meter	Remarks
A	Central heating boiler	Moveable step grate	Stoker/screw	30	1,3 x 0,8 x 2,1 excl. silo	Important to adjust on/off timing so the fuel is distributed evenly on the grate.
B	Central heating boiler	Hearth	Stoker/ram	43	1,5 x 0,7 x 1,5	The level of pellets in the silo has influence on the combustion and gives fluctuations in CO ₂ emission.
C	Central heating boiler	Reactor	Stoker/screw	23	1,0 x 0,6 x 1,0 excl. pellet silo	The boiler was equipped with water cooled combustion tube (reactor). Problems with filling up of the combustion tube and poor utilisation of the fuel.
D	Central heating boiler	Hearth	Stoker/ram	23	1,2 x 0,7 x 1,5	Very sensitive to precise adjustment of combustion air.
E	Pellet oven	Hearth	Screw	abt. 8	0,7 x 0,65 x 0,8	After 1-2 hours, the burning bowl was filled up with ashes, blocking the supply of pellets.

Boilers A and B were selected for the main tests and long-term tests.

Table 2: Boilers used for testing of pellets

Preface

This paper concerns a biomass project during which the Danish Technological Institute carried out combustion tests with straw and wood pellets in small combustion units. The project was accomplished from September 1992 to November 1993 and was supported by the Danish Energy Agency.

The Biotechnological Institute (BI) and Biomass and Agroindustrial Engineering ApS (BAE) in Kolding, DK, contributed expertise on antislack agents and production of the test pellets. At a

project meeting in December 1992 a proposal about pellet quality and test programme was discussed with manufacturers of boilers and pellets among others.

Background

One of the aims of the Danish energy policy is the achievement of a considerable reduction in CO₂ emission. If this is going to be carried into effect, it requires not only broader energy consciousness but also the best possible conversion from fossil fuels to CO₂ neutral biofuels.

Outside areas supplied with community heating services, energy consumption is estimated to be approx. 26 PJ a year, and 2/3 of this is individual oil fuelled which can be replaced by semi- or fully automatic combustion units fuelled with pellets of wood or straw.

During the last five years the consumption of wood pellets has increased from 0 to 150,000 tons per year, while straw pellets are only produced and used to a very limited extent.

However, a large proportion of the wood pellets are used in large combustion units (district heating plant).

In small individual heating appliances a voluntary conversion from oil to biofuels would probably require an economic incentive, but also a clarification of the uncertainties which both consumers, manufacturers and suppliers are facing.

Aim

The aim of the project was to: -

examine the suitability of straw pellets as fuel in small automatic heating units

test the effect of different antislack agents

document that wood pellets can be used without any problems in the same combustion unit, and

point out necessary initiatives to improve the condition of pellets and combustion units, if possible

Conclusion

On the basis of the test results, the following can be concluded.

Wood pellets

Wood pellets are suitable as a fuel. The tests have proved that the pellets can be used in all the boilers tested without any operational problems.

Ash quantity is less than 1%.

Emission of NO_x and dust is less than when burning straw pellets.

Results of main tests related to 10% CO ₂				
Boiler type	Pellet type	CO%	Particles mg/Nm ³	NO _x ppm
A (30 kW)	1. (TwinHeat)	0,12	0,63	186
	2. (Caoline)	0,03	0,64	160
B (43 kW)	1. (TwinHeat)	0,17	0,60	261
	2. (Caoline)	0,04	0,39	233

Table 3: Emission data, boilers A and B with two types of straw pellets

Straw pellets

Burning of straw pellets without antislack agent causes heavy slag formation.

When adding 3.5-4% Caoline or an antislack agent from Twin Heat a light and slagfree ash is obtained.

The quantity of ash from the straw pellets is 6-8%, the specific gravity of the ash being considerably smaller than the specific gravity of ash from wood pellets.

The dust content of the pellets may cause operational problems and may also increase dust emission.

Straw pellets are dependent on the boiler and must be characterized as unsuitable as fuel for two of the boilers tested.

NO_x and dust emission are considerably higher than when burning wood pellets.

Combustion units

All the combustion units tested are suitable for wood pellets, and a satisfying combustion quality does not seem to depend on or be conditional on the type of boiler.

Two of the combustion units tested must be characterized as unsuitable for straw pellets. Satisfactory combustion results can be obtained with the other three.

When burning straw pellets, combustion stability and emission do not appear to depend on whether the combustion principle in the boiler is a hearth or a moveable grate.

When burning straw pellets, construction parts in the boilers are apparently exposed to a larger effect than when burning wood pellets - maybe primarily because of higher temperatures in the firebox.

Because of too high minimum output and risk of counterflow combustion, the combustion units are not suitable for operation in summer.

Operation

When using wood pellets, daily maintenance is limited to pellet intake. Sweeping the boiler with normal cleaning tools must be carried out about once a week. Time consumption is estimated to be 1-3 hours per week.

When using straw pellets, daily maintenance, besides pellet intake, also includes 2-4 ash magazine emptyings and fire tube sweeping about once every 24 hours. Furthermore, extraordinary cleaning of grate and retarders in fire tubes with special tools must be expected about once a week. Time consumption is estimated to be 10-15 hours per week.

Recommendations

To be able to characterize the best combustion unit as suitable for straw pellets, the following conditions must be improved: -

A considerable reduction in necessary work. This will probably require automatic ash removal and automatic cleaning of the fire tube or development of pellets minimizing the deposits in the fire tubes.

Change of construction parts in order to obtain a satisfactory duration time.

Without regard to pellet type, a lower minimum output at the boilers is desirable. Additionally, the counterflow combustion risk must be minimized.

Fuel pellets must be produced with as low a dust percentage as possible and at the same time prove stable against mechanical influence.