Achievements in Biomass Valorization Using a Range of Boilers Made by Erpek-Romania and E-Morarit

Mihaescu Lucian*., Prof. PhD, eng. Bartha S**., eng. Enache E**., Prisecaru Tudor*. Prof. PhD., eng. Berbece Viorel*., Pisa Ionel*., Lect. PhD

*-Politehnica University of Bucharest

**-SC ERPEK SA – Baraolt, Romania

*** - S.C. ENACHE-MORARIT S.R.L. – Husi, Romania

1. Issues on straw energy valorization

In Europe straw energy valorization dimension varies from bale size, to maxi briquettes (80÷100 mm in diameter, 80÷160 mm in length, density 240÷1000 kg/m3 range), to briquettes and pellets.

Romania's estimated annual energy potential of wheat straw of 6÷12 million of tons.

Research up to date:

- burning of straw maxi briquettes form in a 55 kW pilot boiler;

- co-combustion of certain mixtures of straw, wood, coal in a 55 kW pilot boiler;

- determination of pollutant emissions and of steel endurance in the heat exchangers;

- achieving an 80kW boiler with automated feed of straws in the form of maxi briquettes or briquette chops.

Straw maxi briquettes used by E.Morarit 100 kW new boiler compared with coal and wood

Characteristic	Coal (pit coal)	Straw 1	Straw 2	Wood	Coal (lignite)
Soaking humidity, W^i_i, %	3,00	6,80	6,90	6,40	24,5
Hygroscopic humidity, W^i_h,%	2,40	5,40	6,70	1,40	17
Total humidity totală, W^i_t, %	5,40	12,20	13,60	7,10	41,5
Ash, A^i %	14,20	5,47	5,60	0,10	25,7
Carbon, C^i, %	63,86	40,44	40,2	44,96	22,8
Hidrogen, H, %	4,19	5,79	4,99	5,83	2,6
Nitrogen, N^i, %	1,90	0,71	0,62	0,7	0,5
Total Sulphur, S^i_t, %	0,26	0,193	0,18	0,083	-
Combustible Sulphur, $S^i_{comb,}$ %	0,20	0,19	0,18	0,08	0,7
Chloride, %	0	0,36	0,28	0,06	-
Volatile Matter, V^i, %	29,05	71,30	70,3	77,80	29,9
Lower Heat Value, KJ/kg	24650	14458	14212	15645	8765

The straw used for briquettes production quality:

- lower than 17% humidity, usually under 14%;

- heat value between 14200 kJ/kg and 16800 kJ/kg.

A 100 kW, 80% efficiency boiler consumes 30 kg of straw per hour (with a heat value of 15000 kJ/kg)

An area of around 42 ha is necessary for a 4 month wintertime straw consumption of approximately 85 tons.

Boiler availability is 7 to 10 days, after that a boiler cleaning operation (manually or using compressed air) is required, especially for the interior of the fumes tubes.

When burning 1 kilogram of straw, 0.042÷0.045 kg of slag is obtained.

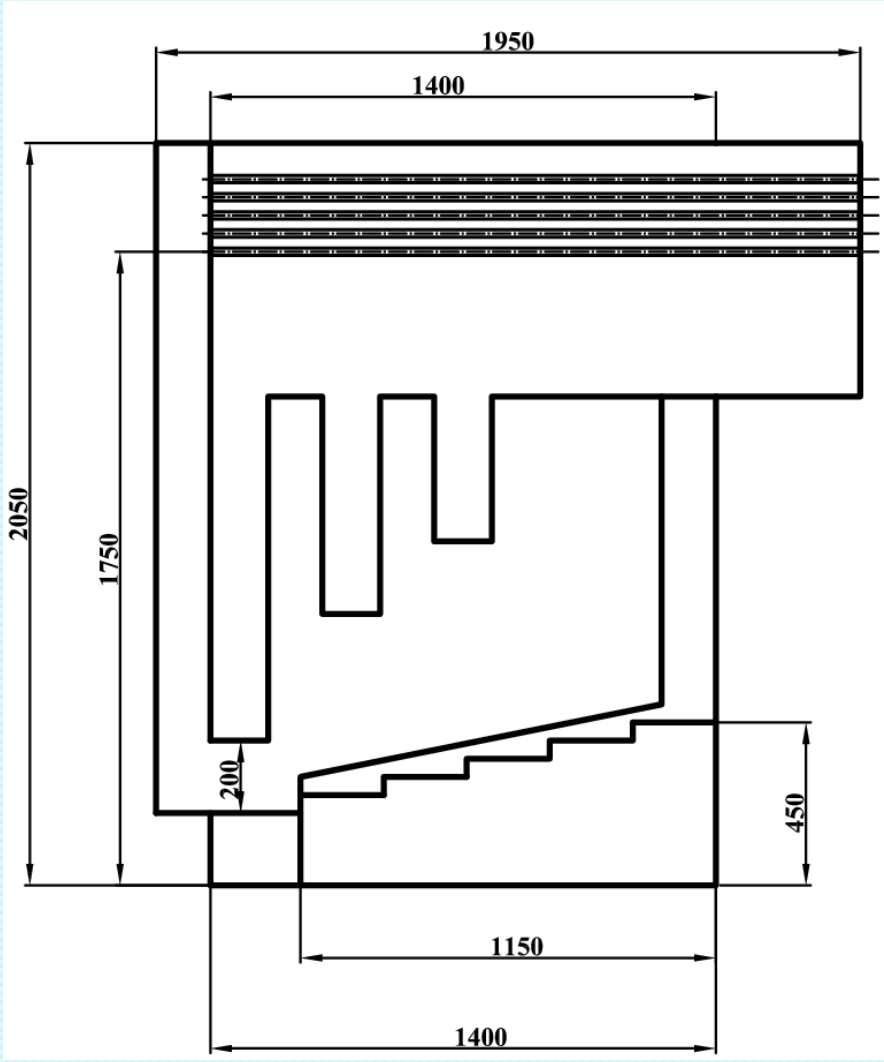
The retained slag can be used as fertilizer (K2O = 7.95% and P2O3=3.7%).

Using *Cet* – is the cost of thermal energy, *Ccomt* – the cost of fuel, *Cce* – the cost of electrical energy, the relation for economic efficiency is proposed:

$$\eta_{economic} = \frac{C_{et}}{C_{comb} + C_{ce}} \cdot 100\%$$

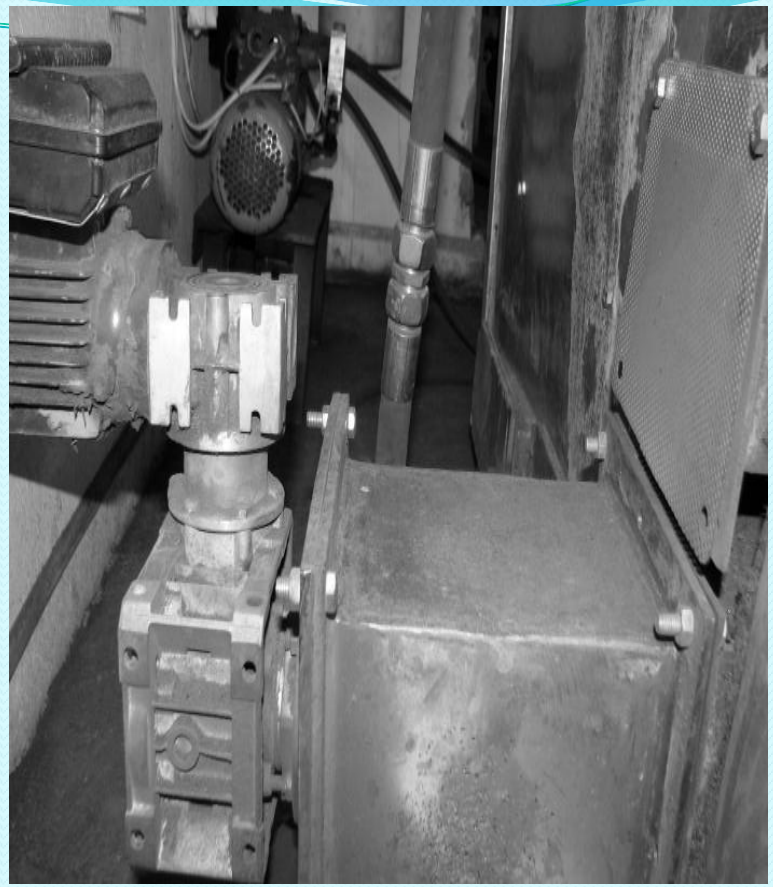
The operator cost was not considered, because the analysis is made for a fully automated boiler.An important factor is the cost of trnasportation

2. 100 kW pilot boiler concept

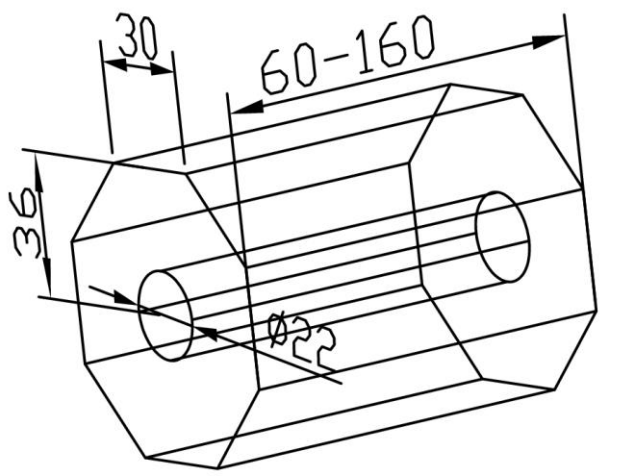


Slag prevention was experimentally determined if the temperature in the combustion area is bellow 750ºC. That could only be achieved by means of intensified cooling of the furnace chamber.

The mobile grill

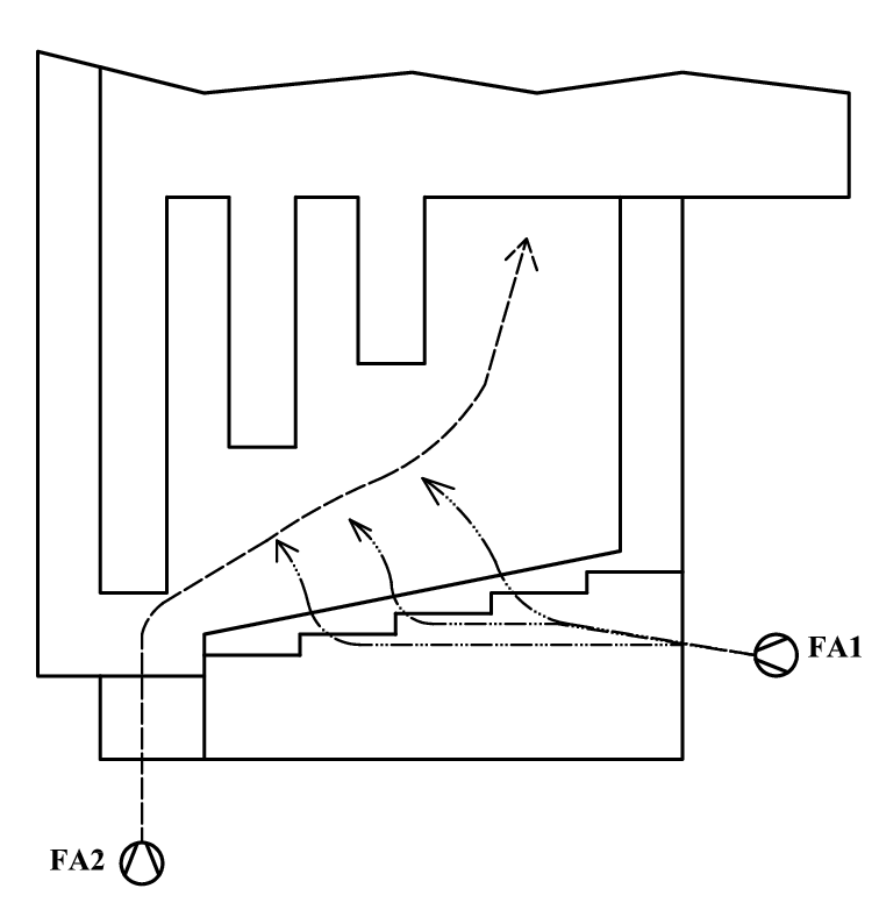


The piston feeder



The briquette geometry

The weight of a briquette is about 0.61÷0.63 kg. Briquettes are obtained by compressing the straw to a very high density, about 1000 kg/m3.



The circulation schema for the secondary air

3. Experimental tests results

Measured Value	Results			
	1	2	3	4
Thermal power, P_t, kW	68	68	67	70
Water temperature t_m, ^{0}C	45	45	46	48
Returned water temperature, ^{0}C	40	40	40	40
Oxygen content, O_2, %	15,9	13,3	15,3	14,9
CO emission, ppm	1541	688	1384	1161
CO_2 emission, %	4,9	7,4	5,5	5,9
NO_x emission, ppm	86	134	81	114
Air excess ratio, λ	4,12	2,73	3,68	3,44
Stack temperature, ^{0}C	142	196	145	152
Primary air temperature, ^{0}C	7,2	12,5	7,4	4,9
Secondary air temperature, ^{0}C	190	190	200	200
Efficiency, %	83,1	84,2	84,4	84,4

With a reference oxygen content of O_2 = 7%, the pollutant emissions were:

CO = 1250 - 4230 ppm NO_x = 235 - 306 ppm

The fuel elemental analysis composition:

C^i = 42,8%, H^i = 6,5%, N^i = 0,64%, O^i= 33,1%, W^i_t = 11,97%, A^i = 4,99%

Lower heat value: Q^i_i =17464 KJ/kg

Slag composition: S_iO_2 = 58,84; Al_2O_3 = 4,3; Fe_2O_3 = 1,03; MgO = 2,9; CaO = 3,4%; Zn = 13 ppm; Pb = 9,7 ppm, …

The fuel consumption for the nominal thermal power, the experimental heat value and maximal admitted efficiency of 84,4% is:

B=25.4 kg/h

The volume thermal load of the furnace (1.150 m long, 0, 4 m wide and a medium height of 0.4 m) was very high:

q_v=650 kW/m^3

4. Conclusions

- For a maximal efficiency and an operation with no slag, a volume thermal load of 450 470 KW/m^3 is needed.

- Also, an increase in the furnace length to 1.38 m is to be considered.

- The cyclone filter efficiency (the dust particles retention efficiency):

$$\eta_c = 0{,}72\%$$

The dust particles concentration in the flue gas (O_2 = 7% content):

$$C_{pulb} = 32\, mg/m^3$$