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CONTROL OF THE BURNING OF STRAW BRIQUETTES AT THE END OF THE FURNACE FOR THE INCREASE OF THE EFFICIENCY

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Abstract: *Cereal straws represent the most difficult energy fuel from agricultural waste, although the lower calorific value is very high. The initial difficulties come from the very low bulk density, which implies the densification in the form of briquettes or pellets, with difficult and expensive operations. The difficulty is represented by the high tendency of slagging, with deposits with a high adhesion on the metal parts, especially in the final area of the furnace.*

In order to eliminate the slag it is mandatory to limit the temperature in the furnace below 1000K, which is achieved by increasing the cooling of the furnace, the main solution being the burning in the flame tube immersed in water.

Limiting the temperature in the furnace reduces the burning speed, so that for a complete burning of the straw briquettes, a mechanical installation was designed that controls the progress of the briquettes in the final area of the grate, until all of them have been burned. The work presents the conceptual design of this installation and the performances achieved for combustion.

Keywords: *cereal straw briquettes, burning control, furnace efficiency.*

INTRODUCTION

The potential and energy quality of cereal straws in Romania

The energy potential of straw in Romania represents an amount of up to 7 million tones, which represents about 740 · 103tep (the quantity used internally was not considered). This potential results from the total amount of straw, which is about 2300-3000 kg / ha.

The determination of the energy characteristics for the straws in the north of Moldova indicates:

- elemental analysis:

C^i=41-42%; H^i=5.2-6.3%; N^i=0.4-0.62%; O^i=32-36.5%; W_t^i=9.9-11.7%; A^i=4.3-6.1%.

- lower calorific value:

H_i^i =15000-17500 kJ/kg.

- ash composition:

SiO_2-52-60%; Al_2O_3=4.4-5.8%; Fe_2O_3=0.8-1.5%; MgO=2.1-3.3%; CaO=2.8-3.7%; Zn=10-18 ppm; Pb=8.7-12ppm.

The content of potassium and phosphorus from the ash transforms this residue into a weak agricultural fertilizer.

In Romania, the research and construction of cereal straw boilers started in 2009, with successive 80, 100, 150 and 450 boilers (500) kW. All produce hot water and excepting the first boiler are built in the variant with a fire tube flame placed in water.

The combustion installation for briquettes includes a mobile grate, with water cooling of the fixed bars. For pellets, the horizontal flame burner solution was used.

The briquetting was performed with a piston, at a pressure of 100-200 bar and a temperature of 200-250ºC.

The briquettes have dimensions (width / length) of 80 / 100mm or 80/160 mm. The density used is very high, being in the range 900-1000 kg / m^3, the specific consumption of electricity at briquetting was 0.033-0.037 kWh / kg.

EXPOSITION

The installation for controlling the burning of straw briquettes

The installation has double actuation, realizing the speed control of the straw briquettes on the grate, as well as the evacuation of the ashes resulting from the burning.

The combustion speed for straw pellets is 0.28-0.33 mm /s, and for briquettes it has been considered in the range 0.1-0.2 mm / s. According to these values, the adjustments of the installation for the control of the combustion were made.

When adjusting the burning in the final combustion zones, the decrease of the oxygen concentration must be taken into account. Figure 1 shows the variation of the oxygen concentration along the grate.

As the speed of oxygen consumption depends on the height of the briquette layer, the adjustment of the constrol system will have to take into account also this aspect, the bases of the adjustment system being presented in Figure 2.

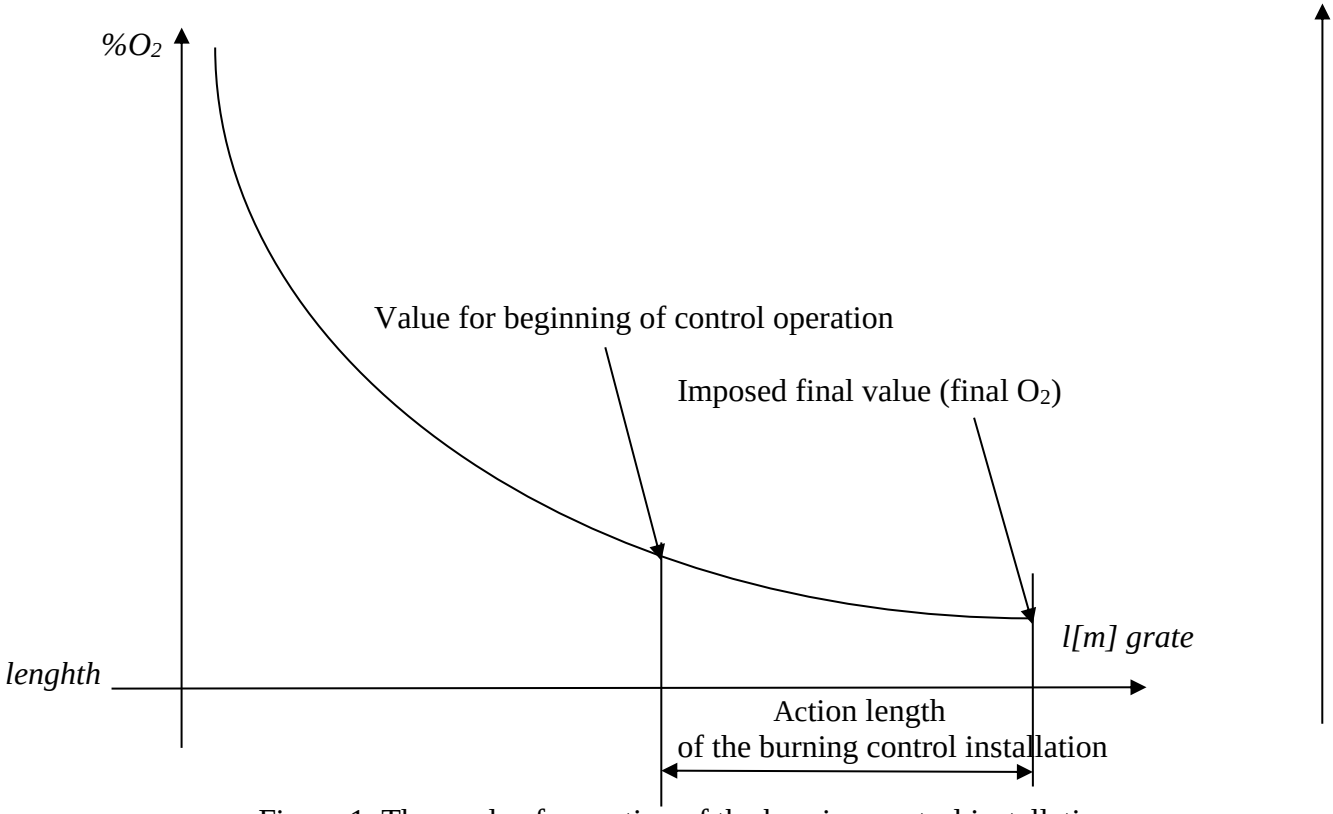

Figure 1. The mode of operation of the burning control installation

The burning control installation was introduced at the 150 kW and the 450 kW boilers for cereal straw briquettes, manufactured by E. Morarit Husi, Romania.

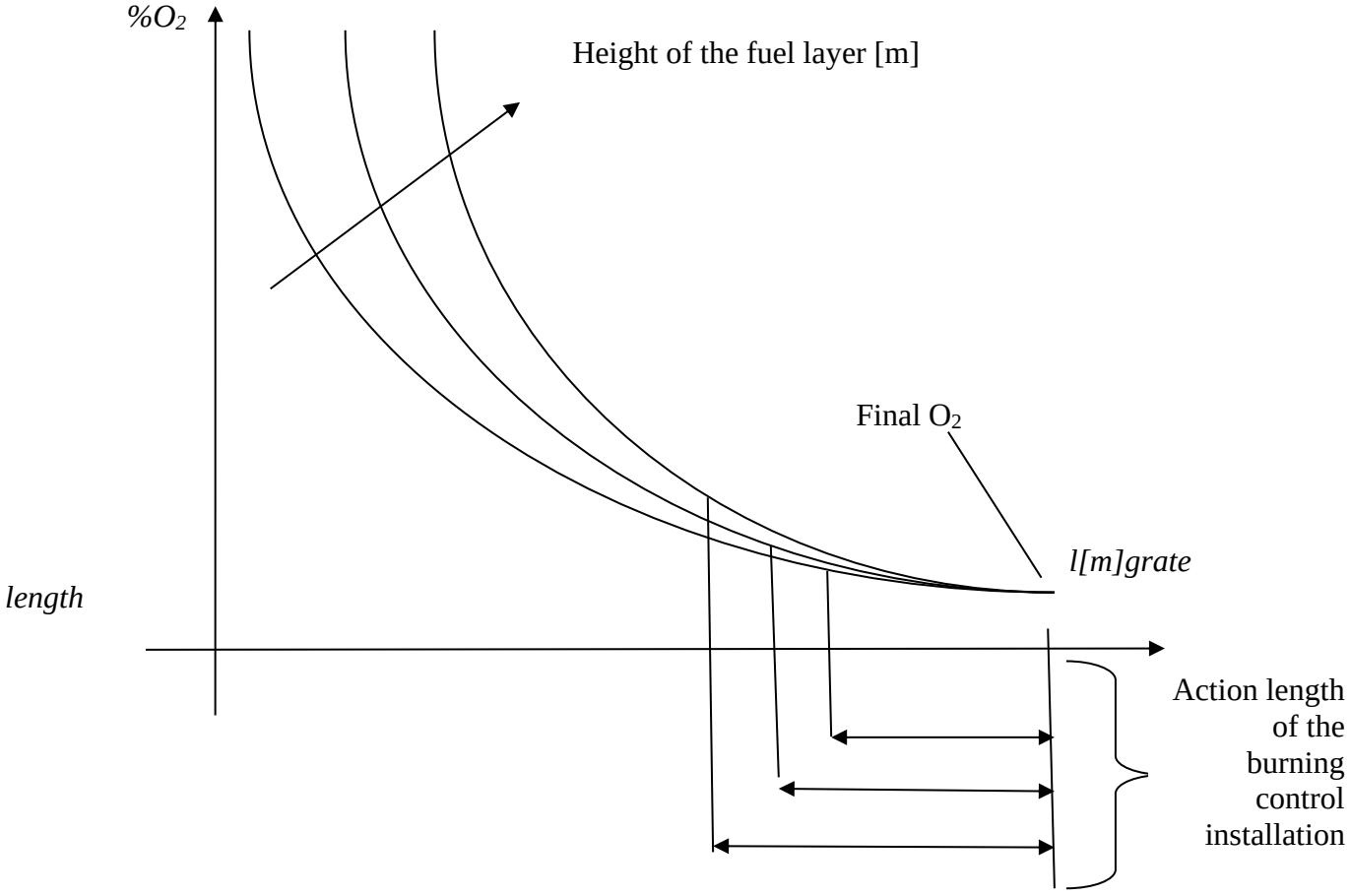

Figure 2. The influence of the fuel layer height on the length of the control of burning

The installation has application to the controlled burning of cereal straw briquettes and to automated ash evacuation from the flame tube boilers with low and medium thermal power. The installation destined to controlled burning has a 3 staged grate, two fixed cooled by the working fluid (1) and a mobile stage (2) actuated by a rack gear system, as it can be seen in Figure 3. The burning continues in the lower part of the flame tube (3) and it is controlled by the by the push device (4) with 2 stages having its own mechanical actuation (5). The fuel is push by the screw feeder (6) on the first fixed stage of the grate, from where it is taken by the mobile stage (2) made of grey cast iron grate bars and it is sent over the final fixed stage to the push device (4). This one, through a translation movement scrapes the lower part of the flame tube, between the grate and the ash disposal zone. Also, through the translation movement of the pusher, the ash (the slag) is directed to the two evacuation holes (7). The shape of the scraper stages (8) is that of circular arc with the radius identical to that of the flame tube.

The grate assembly is mounted on a height between 30 and 40% of the flame tube height, starting with the first fixed stage and it occupies around one third of the overall length of the flame tube. By controlling of the actuation time the finishing burning process and the resulting ash evacuation are regulated

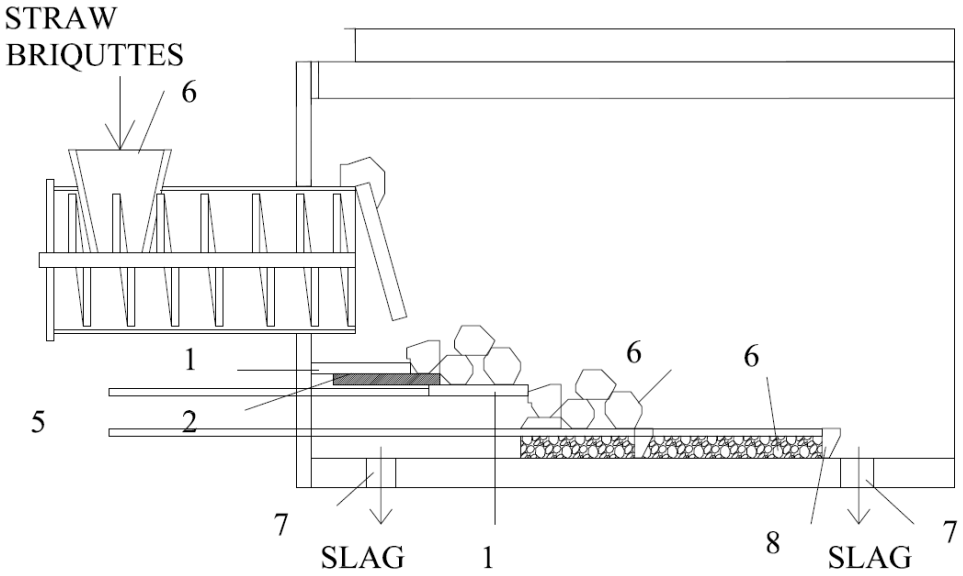

Figure 3. Schema for fuel (straw briquettes) feeding of the mobile grate with the placement of the burning control installation

In contrast to the classical technology of burning cereal straw with mobile grate, with direct push and cooling of the grate bars by the air necessary to burning, this new technology achieves a double control of burning and of the flue gas to avoid slagging and increasing the efficiency. The classical burning technologies have a series of disadvantages, as follows:

- imperfect burning control which translates into high emissions of CO (for example in automated burning also the CO emission is of 0.3-0.4% depending on the load of the boiler);
- high dust emissions (for example in automated burning the dust emission is about 0.6 mg/Nm^3);
- low values achieved for the boiler efficiency;
- increasing in the operational costs due to slagging and efficiency decrease and higher maintenance spending;

The proposed installation by this technology eliminates the above mentioned disadvantages by the double actuation of the pusher with respect to the grate, the latter by automated sequential actuation achieves the completion of the burning. The mobile grate bars framing by the fixed water cooled stages of the grate permits the reduction of the temperature in the furnace (with the corresponding of the slagging reduction). Moreover, the mobile grate bars are cooled by the primary

air blown adequately to this purpose under them and also by heat exchange to the fixed water cooled stages.

By using the proposed installation the following values were obtained in current operation:

- performance burning control characterized by a CO emission of maximum 0.15%;
- an important nitrous oxide reduction due to a lower temperature in the furnace (it's estimated a 50% lower value than in the case of the classical grates);
- the increase in boiler endurance as the slagging is avoided;
- the increase in the boiler efficiency to values of 90-92%, with the corresponding reduction in fuel (cereal straw) consumption. The high values for the efficiency are also a consequence of relative reduced humidity of the cereal straw, the fact that permits reduced values of the temperature of the ash evacuation from the boiler;
- the decrease of operation cost and of the maintenance expenditures by 40-50% (all the boiler managing operations, regardless of its size are completely automated- there is no need for an operator).

CONCLUSIONS

Manufacturing performance boilers for cereal straws represents an important objective in the trends of the use of renewable resources of biomass type.

The policy of the European Union to increase the degree of use of unconventional fuels (of which straw also belongs), will lead to the increase of the number of such boilers mounted at the level of villages and communes in the areas with significant cereal crops (the fuel for such boiler comes from hundreds of hectares). These installations will provide the necessary thermal energy for the administrative buildings of these localities, agricultural farms or houses.

One of the current applications is represented by the 150 kW boiler that provides the heating and technological water for a bread factory in the city of Husi, with a production of up to 15000 breads per day.

In general, due to the degree of automation, as well as the presence of the combustion regulator in the final zone of the furnace, the performances of the respective boiler have become very high.

The combustion control installation was patented in 2017, having at present several years of testing.

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