Challenges and advantages in recovering waste energy from flue gases from biomass boilers

Provocări și avantaje în recuperarea energiei reziduale din gazele de ardere de la cazane cu funcționare pe biomasă

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DOI: 10.37789/rjce.2024.15.4.14

Abstract. *Currently, the burning of biomass for energy purposes is carried out with a low yield due to the fact that the chimney emits hot gases into the atmosphere that have a residual energy potential that can be used for energy purposes. The political context of the European Union and the ambitions to solve the problem of greenhouse gas emissions, relaunch new challenges both for the research community and for equipment manufacturers to offer viable solutions to increase the energy efficiency of plants that use biomass for energy purposes.*

Key words: Biomass flue gas recovery system, flue gas purification system, energy efficient biomass boiler

Rezumat. *În prezent, arderea biomasei in scop energetic se realizeaza cu un randament scazut datorita faptului ca pe cosul de fum sunt emise in atmosfera gaze fierbinti care au un potential de energie reziduala posibil a fi folosita in scop energetic. Contextul politic al Uniunii Europene si ambitiile pentru solutionarea problemei emisiilor gazelor cu efect de sera, relanseaza noi provocari atat pentru comunitatea cercetatorilor cat si pentru producatorii de echipamente pentru oferirea de solutii viabile pentru cresterea eficientei energetice a instalatiilor care folosesc biomasa in scop energetic.*

Cuvinte cheie: Sistem de recuperare a gazelor de ardere din biomasă, sistem de purificare a gazelor arse, cazan de biomasă eficient energetic

1. Introduction

Considering the ambitious objectives of the European Union to reduce greenhouse gas emissions, in addition to the first step that must be taken, namely the attempt to use renewable energy sources, it is also necessary to try to increase the efficiency of combustion plants by using energy which until now was considered as residual energy and was discharged into the atmosphere in the form of hot gases [1], [2].

The article presents the issues that need to be solved for the sustainable and efficient use of waste energy from the flue gases of current biomass burning plants.

The article was received on 30.03.2024, accepted on 10.08.2024 and published on 01.10.2024.

The article also presents the major advantages of using mixed systems for the recovery and purification of combustion gases resulting from the combustion of biomass. This is particularly important for the energy utilization of biomass grown on former industrial lands that have been contaminated over time with various materials resulting from industrial, mining or energy processes.

2.Theoretical notions regarding the technological challenges and advantages resulting from the recovery of residual energy from combustion gases from boilers operating on biomass

The main problem of plants that capitalize on the energy potential of biomass is primarily represented by the fact that they have to maintain a high temperature of the flue gases discharged into the atmosphere in order to pre-encounter the problems that may appear on the flue gas exhaust system: the deposition of soot, tar or the appearance of acid condensation on the inner surface of the gas ducts, situations that can cause clogging of the gas ducts and the appearance of the phenomenon of chemical corrosion of the gas ducts or the chimney.

It is precisely this high temperature of the flue gases discharged into the chimney, which causes a low global yield at the biomass combustion plant, and therefore economically efficient solutions must be found to extract as much energy as possible from the flue gases that are going to be discharged into the flue and to use this recovered energy for energy purposes to increase the overall efficiency of the combustion plant and implicitly reduce carbon dioxide emissions.

Considering the constructive complexity of the equipment that can extract and energetically utilize the residual energy of the combustion gases from the biomass boilers, in the current conditions, they can become effective only in the situation where the beneficiary of the plant has a cheap source of biomass, for example, biomass grown on lands that cannot be exploited for agricultural purposes due to their industrial history.

However, this biomass can be contaminated with various chemical elements extracted from the soil in which it was cultivated and thus, the residual heat recovery systems can also fulfill the role of purifier of the gases that will be discharged into the atmosphere.

Considering the diversity of the respective biomass fuels: logs, wood waste, wood chips, pellets or sawdust and implicitly their quality in terms of calorific value, ash content or moisture, chemical composition and moisture content of flue gases depends on each case and must be analyzed and known before starting the design process of the waste energy recovery system.

It is also indicated to carry out a representative energy balance for an annual operating cycle of the combustion plant to determine the energy potential that is possible to be recovered and to carry out on the basis of this potential the cost-benefit analysis of a potential energy recovery plant from the combustion gases.

The use of flue gas energy recovery equipment for boilers operating with biomass involves:

- the use of corrosion-resistant materials;

- the use of automatic systems for periodic cleaning of the recovery system;
- the use of flue gas monitoring plants;
- the use of combustion gas flow and purification schemes so that, depending on their composition, they can be put in contact with various solutions with the role of neutralizing and retaining potentially toxic substances;
- implementation of a complementary system for exhausting and dispersing combustion gases into the atmosphere to compensate for the decrease in kinetic energy and gas temperature in the recovery system;
- the preparation and evacuation of residues so that they do not present a potential hazard for the surrounding environment.

To further increase the energy efficiency of the recovery system, an absorption heat pump can be used to extract thermal energy from the flue gas circuit and raise the parameters of the heating agent so that it can be used for space heating or preparing domestic hot water [3].

In order to have an energy with as little carbon footprint as possible, the electrical energy required to drive the heat pump and the heat recovery system, is preferably obtained in as a high as possible percentage from a system combining photovoltaic - electrical energy storage system.

3. Conclusions

In the future, all the problems raised in this article will need to be studied in order to find effective solutions to be offered to equipment manufacturers so that technological progress determines the most efficient use of energy resulting from biomass burning.

Also, the developed technology will be able to allow the safe use of cultivated biomass, on contaminated land, for energy purposes with a positive impact on both local communities and economic agents that own such land. By growing biomass on land with an industrial history, other land can be made available for agricultural use.

Through a good collaboration of all the factors involved, biomass producers, energy consumers, the population of communities, the efficient use of biomass for energy purposes can lead to a model of good practice for the sustainable use of energy resources and in a wider sense and to achieving the objectives of the European Union to reduce greenhouse gas emissions.

References

[1] European Parliament, “Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955”, Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ%3AJOL_2023_231_R_0001&qid=1695186598766, Accessed: 29.03.2024.

[2] European Parliament, „Fit for 55 Package”, Available at: https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=CELEX%3A52021DC0550, Accessed: 15.03.2024.

[3] C. Schweigler, Research Project, Biomass-fired Boilers with Condensing Heat Utilization by Means of a Sorption Heat Pump-https://www.hm.edu/en/research/projects/project_details/schweigler/brebisorp.en.html