

REVIEW

By Assoc. Prof. Eng. Kalin Simeonov Krumov, PhD

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Of a dissertation for the acquisition of an educational and scientific degree “Doctor”

**Topic: “EFFICIENCY OF THE COMBUSTION PROCESS WHEN
BURNING PELLETS AND WASTE RAW MATERIALS IN BOILERS”**

Author: Nevena Milcheva Mileva

Scientific field: 5. Technical sciences

Professional field: 5.4. Energetics

Doctoral program: Thermal Engineering

1. Actuality of the problem developed in the dissertation in scientific and scientifically applied terms. Degree and scale of the actuality of the problem and the specific tasks developed in the dissertation.

Biomass, as an energy source, occupies an important part of the global transition to sustainable energy production. Research shows that this type of fuel, in addition to being renewable and reducing the use of fossil fuels, also has significant potential to reduce the carbon footprint. The use of pellets and waste solid fuel raw materials demonstrates high energy efficiency and economic attractiveness, especially when using local resources. In addition, the use of biomass supports the local economy, reduces its energy dependence on imported raw materials and supports the creation of a circular economy where waste is seen as a resource.

All this makes the topic particularly relevant in a scientific and scientific-applied sense. The aim of the dissertation is to evaluate the efficiency of the combustion process when burning pellets and waste raw materials in boilers. To achieve this goal, the following main tasks have been solved:

1. Carrying out a comparative analysis of the fuel characteristics of pellets from different waste raw materials, using classical methods for determining moisture and ash content, and calorific value, as well as thermal analysis methods (TG, DTA, DSK) for a detailed study of thermal properties of fuels.

2. Numerical modeling of a domestic pellet boiler with the aim of simulating the combustion process under different air supply modes and optimizing the ratio between primary and secondary air. The simulations allow evaluation of combustion efficiency and flue gas emissions under different conditions.

3. Analysis of the effectiveness of an experimental cogeneration system with an organic Rankine cycle, which will be tailored to the characteristics of the incinerated waste raw materials. The system analyzes the direction of its energy efficiency and the possibilities of capturing and converting waste heat into electrical energy.

4. Statistical processing of the experimental and simulation data to assess the significance of the main factors that influence the efficiency of the combustion process and the operation of the cogeneration system. By solving the tasks set in this way, a step forward has been made in the study of the physicochemical processes taking place during the burning of biomass and waste raw materials.

2. Does the PhD student know the state of the problem and does she creatively evaluate the literary material?

The dissertation contains 178 pages, including 84 figures, 36 tables and 2 appendices, organized into 6 chapters, general conclusions, a list of the author's publications and a list of the used literature including 141 titles, of which 36 in Cyrillic, 97 in Latin and 8 Internet sources. Findings, summaries and conclusions are made at the end of each chapter.

The analysis of the exhibition shows a high level of knowledge and mastery of the research methods - experimental, statistical and simulation of the issues under consideration. The high degree of knowledge of the state of the problem is also proven by the scientific publications made on the dissertation work.

The made critical analysis shows that the doctoral student has developed her abilities for creative evaluation of the available literary material.

3. Can the chosen research methodology provide an answer to the goals and objectives of the dissertation?

The approach to the study of the considered problem and the used methodology definitely allow achieving the defined goals and tasks of the dissertation work. The

integration of experimental research, thermal analysis, numerical modeling and computer simulation lead to significant improvements in the energy efficiency and sustainability of combustion processes.

4. Brief analytical description of the nature and assessment of the reliability of the material on which the contributions of the dissertation are built

In the introduction of the dissertation, the doctoral student presents the topic of the research, indicates its relevance, degree of development, defines the purpose and tasks of the research. The dissertation offers an integrated methodology for the evaluation and optimization of the combustion process in the combustion of pellets and waste raw materials. The main goal is to achieve an optimal energy balance with minimal emissions, corresponding to modern environmental standards and the needs of the industry. The development offers sustainable and environmentally friendly solutions that increase the efficiency of heating systems and contribute to global efforts for sustainable development.

The dissertation is divided into six main chapters.

In Chapter 1, the status and development of research on the combustion of pellets and waste raw materials in boilers is reviewed. The existing research on the problem is reviewed, the properties of biomass as a fuel, the theory of combustion processes and types of thermal analysis, available fuel technologies and innovations are discussed. The conclusions drawn from the literature review in relation to the topicality of the topic are defined and the purpose of the present dissertation.

Chapter 2 is a description of the research methods used. The choice of materials and prospective test samples, the methods of thermal analysis, the methods of researching the main energy characteristics of the pellets and measuring the flue gases are described. It is concluded that the used methods and equipment provide the necessary basis for the implementation of the considered tasks, thus the main goal of the dissertation work will be achieved.

Chapter 3 presents the results of a study of the fuel characteristics of the pellets - calorific value, moisture content and ash content, as well as a statistical study of these parameters. The results of studies of the energy and thermal characteristics of pellets

were obtained in an accredited laboratory, which guarantees their high reliability and credibility. A general conclusion is made that the results emphasize the need for optimization of raw materials and production processes to improve the energy and environmental characteristics of the pellets.

In Chapter 4, a study of the combustion of pellets in a domestic boiler is carried out. An analysis of the combustion processes in household boilers when burning pellets has been made, a mathematical model of the ongoing processes in a specific household water heating boiler has been described and numerically solved in the computer code Ansys. Variants were modeled using three types of pellets – wood, sunflower and mixed, and a different ratio (40/60 and 60/40) of primary and secondary air supplied for solid fuel combustion. An analysis of the convergence of the solutions in the computer simulations for burning the different wood pellets and ratios of primary and secondary air is presented. Adequate conclusions are drawn at the end of the chapter.

In Chapter 5, an analysis of the efficiency of an experimental cogeneration system with a thermal oil boiler and an ORC module as an option for the recovery of waste raw materials is considered. The benefits of the project are described and a technical-economic analysis of the investment is made and the saved emissions of harmful gases are calculated. The summary conclusions given at the end of the chapter correspond to the previously made analyzes and conclusions.

Chapter 6 presents the main conclusions and suggestions for practice from the work done in developing the dissertation work. At the same time, the scientific - applied, applied and methodical contributions are also listed.

5. What are the scientific or scientific-applied contributions of the dissertation?

Five scientific and applied contributions are presented in the dissertation, for which the doctoral student claims to enrich theory, science and practice in the context of improving the efficiency of the combustion process when burning pellets and waste raw materials in boilers. In addition, three applied and two methodological contributions useful for engineering practice and student training are presented.

Proving by new means essential new aspects in existing scientific problems:

- A detailed study of key properties of specific prospective biomass samples, which have a critical impact on the efficiency of combustion processes, was carried out.
- Use of thermal methods (TG, DTA, DSC) to identify temperature regimes suitable for efficient burning. These analyzes contribute to the development of fuel systems with high energy efficiency.
- Simulation models have been created to predict the behavior of the combustion systems, which prove a significant contribution to the optimization of the air distribution and the geometry of the combustion chambers, ensuring the stability and efficiency of the processes.
- An Organic Rankine Cycle (ORC) cogeneration system has been developed, which demonstrates an energy efficiency of over 85% and provides efficient utilization of waste heat for electricity production.
- A model has been developed for the automation of fuel and air supply, which significantly increases the efficiency and reduces the operating costs of the fuel systems.

Obtaining and proving new facts. Obtaining corroboratory facts.

- The influence of the air-fuel ratio on pollutant emissions (CO and NOx) was studied. The results point to sustainable management of combustion processes with minimization of the carbon footprint.
- Wood pellets have high calorific value and low ash content, making them suitable for domestic applications. For agricultural pellets, the need for pre-treatment to achieve similar characteristics has been identified.
- A universal methodology has been created that combines experimental studies, thermal analyzes and numerical simulations. This methodology provides adaptability to different types of fuels and fuel systems.

6. Can it be assessed to what extent the dissertation work and contributions represent the personal work of the dissertation?

I know the work of M.Eng. Nevena Mileva from the "Thermal Engineering" department, and the dissertation developed by her gives me reason to believe that she,

under the guidance of her supervisor and with the support of colleagues from the teaching department, has established herself as a researcher. I am convinced that she will successfully apply the gained experience in scientific research in her future teaching and research activities.

7. Evaluation of the publications on the dissertation.

The author has submitted a list of three publications, two of which are independent and the third is co-authored with the supervisor and other researchers. The results of her scientific work have been published in two peer-reviewed journals and in a collection of reports included in the Scopus database.

8. Have the results of the dissertation already been used in scientific and social practice?

The main results of the dissertation have been presented at scientific conferences and are well known to the scientific community in the country and abroad.

9. Recommendations for the future use of scientific and scientific-applied contributions.

The possibilities of the created methodology, which combines experimental studies, thermal analyzes and numerical simulations, to be widely popularized among industrial enterprises with the aim of its practical use.

10. Abstract

The presented abstract is compiled according to the requirements, its content corresponds to the dissertation and correctly reflects all its main parts. Its volume is 52 pages.

11. Critical notes on the dissertation, including on the candidate's literary awareness.

I have no critical remarks and questions about the submitted work, as they have already been discussed and corrected.

CONCLUSION

The dissertation of M.Eng. Nevena Mileva touches on a current problem related to the use of biomass as a renewable energy resource and increasing the efficiency of the combustion process when burning pellets and waste raw materials in boilers. The

combination of experimental research, thermal analysis and computer modeling allows to significantly increase the sustainability and efficiency of combustion processes.

I believe that the presented work complies with the Law on the Development of the Academic Staff, the Regulations for its implementation and the Procedural Rules of the Technical University of Varna. All this gives me reason to declare my positive assessment of M.Eng. Nevena Milcheva Mileva and to propose to the scientific jury to award her the educational and scientific degree of Doctor in the field of higher education 5.Technical sciences, Professional field 5.4.Energetics, Doctoral program: Thermal Engineering.

24.02.2025

Sofia

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