JOURNAL OF SCIENTIFIC RESEARCH, MODERN VIEWS AND INNOVATIONS
Volume 1, May, 2025
https://spaceknowladge.com

ENHANCING THE EFFICIENCY OF THE TWO-STAGE COMBUSTION PROCESS IN PYROLYSIS SYSTEMS.

Karimov Elbek [1]
[1] *Assistant of Jizzakh Polytechnic Institute*
eltnkr98@gmail.com

ARTICLE INFO

ARTICLE HISTORY:
Received:16.05.2025
Revised: 17.05.2025
Accepted:18.05.2025

KEYWORDS:
Pirolysis, two-stage combustion biomass, energy efficiency, thermal energy, environmental safety, thermochemical processes, exhaust gases, fuel gases, renewable energy.

ABSTRACT:

This article explores the possibilities of improving the structural and functional aspects of a two-stage combustion system in the process of pyrolysis based on biomass. To ensure the complete and efficient combustion of combustible gases and solid residues formed as a result of pyrolysis, it is important to use a two-stage combustion technology. In this technology, in the first stage, pyrolytic gas is created in a low-oxygen environment, and in the second stage, this gas is completely burned under optimal conditions by supplying additional air. The article provides a theoretical analysis of the influence of this system on the temperature regime, gas flow direction, air distribution, and the design of the combustion chamber. The ecological advantages of the amount of heat released during two-stage combustion and the composition of exhaust gases will also be considered. The proposed solutions will contribute to the effective organization of the use of renewable energy sources, ensuring environmental safety in the processes of energy production for industrial and domestic needs.

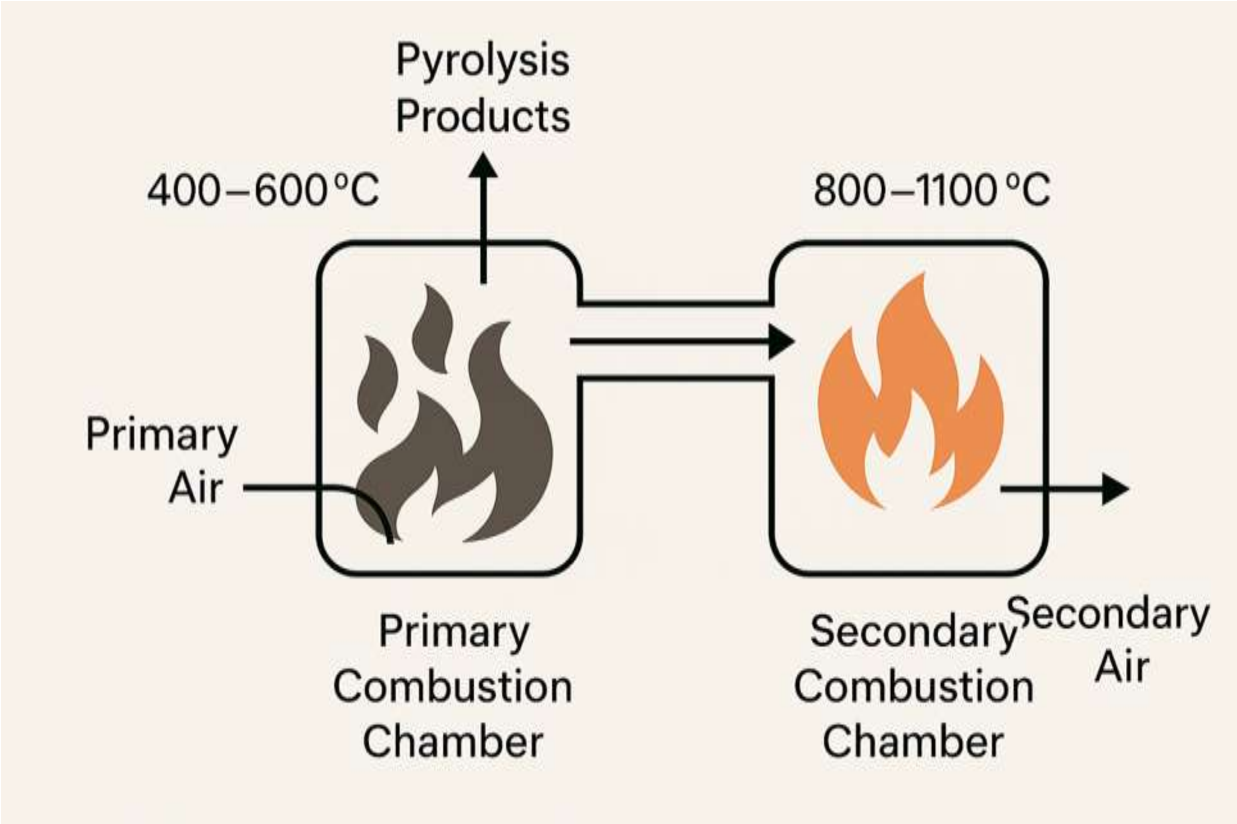
INTRODUCTION. Biomass is a natural resource of organic origin, consisting mainly of plant and animal remains, which can be widely used as a source of energy. One of the main advantages of biomass is that it is a renewable resource and is constantly generated naturally. Unlike traditional fossil fuels, biomass energy causes less environmental damage and is carbon neutral, meaning the carbon dioxide released during combustion is reabsorbed through plant photosynthesis. Today, energy security, climate change, and waste reduction are among the pressing issues. From this point of view, biomass energy deserves special attention as an alternative source that serves to solve these problems. Especially through the possibility of processing agricultural and household waste as an energy resource, a reduction in waste and the stability of energy production will be ensured.

Energy can be obtained from biomass through various technologies, such as pyrolysis, gasification, biogas, and combustion. It is the pyrolysis process that plays an important role in separating the chemical energy contained in the biomass into products in gaseous, liquid, and solid states, converting them into heat or electrical energy. In this case, the integration of two-stage combustion systems ensures complete and efficient combustion of pyrolysis products and serves to reduce the amount of exhaust gases.

Thus, biomass is considered not only a source of alternative energy, but also of strategic importance in solving environmental problems and saving resources.

Energy and environmental advantages of pyrolysis technology. Pyrolysis is a thermochemical process that represents the decomposition of organic materials at high temperatures in an oxygen-free or very limited oxygen environment, which is an effective technology for converting biomass and other organic waste into energy. In the pyrolysis process, pyrolytic gas (syngas), liquid fuels (pyrolytic oil), and solid residue (biochar) are formed as the main products. These products can be used as thermal energy, electricity generation, or recyclable fuel. From an energy perspective, pyrolysis technology allows for a high degree of biomass energy utilization. The high caloric value of pyrolysis gas and its controlled combustion properties make it a highly efficient energy source. At the same time, biochar can be used in agriculture to increase soil fertility or as an alternative to coal. Pyrolysis products also have advantages in terms of storage and transportation, and they can be stored for use throughout the year.

Ecologically, pyrolysis allows for a reduction in emissions and minimization of harmful gases released into the atmosphere. Compared to fossil fuels, the carbon footprint can be significantly reduced. In addition, biochar plays an important role in combating climate change by capturing atmospheric carbon in the soil. Also, the amount of dioxins and other toxic substances in the pyrolysis process is practically non-existent, which increases the level of environmental safety.



https://images.esi.info/Images/134247_1516814523274_PF.jpg?tr=w-1200,h-800,c-at_max

Pyrolysis stage: temperature range and heat transfer characteristics. The pyrolysis stage is the stage of thermochemical decomposition of organic compounds in biomass at high temperatures, in the absence of oxygen, or in very low amounts. In this process, biomass is broken down into solid (biochar), liquid (pyrolytic oil), and gaseous (syngas) products.

Low-temperature pyrolysis (300-500°C): suitable for obtaining more biochar. Energy release will be relatively low.

Mid-temperature pyrolysis (500-700°C): liquid and gaseous products are formed in equilibrium.

High-temperature pyrolysis (>700°C): primarily suitable for obtaining syngas (pyrolytic gases), with high energy release.

Heat transfer characteristics: In pyrolysis, heat is transferred through conduction (thermal conductivity), convection (transfer through moving gas/liquid), and sometimes radiation. The shape, moisture content, density, and granulometry (particle size) of the biomass directly affect effective heat transfer. For rapid pyrolysis, high temperature and rapid heat supply are necessary; this situation primarily facilitates the production of liquid products. In slow pyrolysis, heat is supplied gradually, producing more biochar.

- **The temperature and air balance in the primary and secondary combustion chambers will be as follows:** The two-stage combustion system is aimed at reducing the environmental risk of exhaust gases and increasing energy efficiency through complete and efficient combustion of pyrolytic gases. The pyrolysis product is formed in the primary combustion chamber. Primarily low-oxygen conditions are created (≤10% air). The temperature is usually around 400-600°C. Here, gases are separated into liquid and solid products, but the gases are not yet fully burned. In the secondary combustion chamber, pyrolytic gases pass into the second chamber, where a sufficient amount of oxygen is supplied (additional air). The temperature reaches **800-1100°C** - it is under these conditions that complete combustion occurs. At this stage, combustible gases such as CO, CH4, are converted into CO2 and H2O. The air balance is also divided into two groups: primary and secondary air:

- **Default air:** minimum (5-15%) for pyrolysis.
- **Secondary air:** sufficient (85-95%) for complete combustion of pyrolytic gases.

Air balance expressed by **lambda coefficient (λ)** :

- $\lambda < 1$ - air deficit (pyrolysis stage).
- $\lambda \approx 1\text{-}1.2$ - optimal medium for complete combustion (secondary stage).

From a scientific point of view, the temperature difference in this two-stage system directly affects the quality of combustion. The high-temperature secondary stage leads to a decrease in harmful gases such as dioxins and formaldehyde.

Conclusion. In this study, the scientific and theoretical foundations of improving the pyrolysis process using a two-stage combustion system for obtaining energy based on biomass were studied. The analysis showed that the two-stage combustion system ensures complete and efficient combustion of pyrolytic gases and significantly reduces the harmful content of exhaust gases. A clear definition of the temperature range, heat transfer characteristics, and air balance parameters of the pyrolysis process plays an important role in increasing the efficiency of the system. The primary combustion chamber produces pyrolytic gases in a low-oxygen and relatively low-temperature environment, while the secondary combustion chamber ensures the complete combustion of these gases through high temperature and optimal air supply. This leads to maximum release of thermal energy, reduction of CO, CH4 and other harmful components in exhaust gases. The research results show that the structural and functional optimization of the two-stage combustion system serves as an important basis for increasing the efficiency of obtaining renewable energy based on biomass, ensuring environmental safety, and further development of waste energy conversion technology. In the future, it is advisable to model and develop a prototype of this system based on practical experience.

References:

1. Decree of the President of the Republic of Uzbekistan dated 23.10.2019 No. UP-5853 "On Approving the Strategy for the Development of Agriculture of the Republic of Uzbekistan for 2020-2030."
2. On Additional Measures for Further Improvement of the Drinking Water Supply and Sewerage System. 24.10.2023.
3. Nazirov S.U. (2024) International Scientific-Practical Conference "GGlobal water scarcity and the impact of the water scarcity problem on the regions of Uzbekistan," "The consequences of global climate change, the current state and prospects of mitigating water scarcity" pages 145-148 March 19-20, 2024.
4. Morozova, K.M. Principles of calculating wastewater biological treatment systems [Text] / K.M. Morozova // Water Supply and Sanitary Equipment. - 2009. Pages 26-31.
5. Karimov, E. T. (2023). CAR IN OUR COUNTRY DISCHARGE OF WASTEWATER FROM WASHING STATIONS DEVELOPMENT OF NEW SYSTEMS. Educational Research in Universal Sciences, 2 (11), 263-267.
6. Sattorov, A., & Karimov, E. (2023). PROCESSING BUILDING MATERIALS COMBUSTION OF GAS FUEL IN INDUSTRIAL FIRES FORMULATION OF THEORETICAL EQUATIONS OF HEAT QUANTITIES. Educational Research in Universal Sciences, 2 (11), 313-317.
7. Sattorov, A., & Karimov, E. (2023). IN THE AIRCHANGE SYSTEM THE VALUE OF HEAT CONSUMED FOR HEATING THE HOUSE. CALCULATION. Educational Research in Universal Sciences, 2 (11), 318-321.