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# Gasification of torrefied fuel at power generation for decentralized consumers

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**Abstract**. The increasing need of satisfaction of the existing needs of the population and the industry for electric energy, especially in the areas remote from the centralized energy supply, results in need of development of "small-scale energy generation". At the same time, the basis in these regions is made by the energy stations, using imported fuel, which involve a problem of increase in cost and transportation of fuel to the place of consumption. The solution of this task is the use of the torrefied waste of woodworking and agricultural industry as fuel. The influence of temperature of torrefaction of wood fuel on the developed electric generator power is considered in the article. As a result of the experiments, it is revealed that at gasification of torrefied fuel from vegetable raw material, the generating gas with the increased content of hydrogen and carbon oxide, in comparison with gasification of the raw materials, is produced. Owing to this, the engine capacity increases that exerts direct impact on power generation by the electric generator.

## 1. Introduction

More than 60% of territory of the Russian Federation is out of a zone of centralized heat and power supply nowadays. In this regard, there is an urgent need of development of the "small-scale energy generation" having a number of indisputable advantages in comparison with the centralized systems – the reasonable price and the minimum terms of construction. As a rule, the main share of "small-scale energy generation" is made by the power stations with internal combustion engines, using oil fuel. However, further development of "small-scale energy generation" is complicated by a problem of the increase in cost and transportation of fuel resources to the place of consumption. The solution of this problem is the use of an alternative energy source – waste of the woodworking and agricultural industry, as fuel.

One of the perspective options of rational use of waste of biomass is production of fuel granules which can make the worthy competition to traditional power sources [1]. Many works are devoted to the solution of the matter. N. Saracoglu and G. Gunduz have executed the researches on definition of efficiency of use of wood pellet as fuel. It has been established that the use of wood pellet as a power source reduces the number of emissions of $CO_2$ and other greenhouse gases in the atmosphere [2].

Preliminary heat treatment of vegetable raw materials at temperatures of 180-300 °C in the airless environment [3-6] became the further development of the direction of use of waste of biomass as solid fuel.

Physical and energy properties of fuel granules subjected to various temperatures of processing without oxygen access have been investigated in work [7]. It is revealed that at increase in temperature of heat treatment of wood raw materials the calorific ability of fuel granules increases.

The scientific group under the direction of S.S. Vincent etc. has conducted the researches on definition of efficiency of heat treatment of biomass. It is revealed that carrying out of this technology allows receiving fuel from agricultural waste with calorific ability to $24 \cdot 10^3$ kJ/kg [8] and that the processing temperature has the greatest impact on the process of a torrefaction, than duration and the sizes of particles [9].

However, the use of solid fuel in processes of receiving the electric power often requires its preliminary gasification with the subsequent combustion of generating gas in the internal combustion engine.

Thus, the task of definition of influence of temperature of torrefaction of fuel from biomass on receiving the generating gas with the subsequent production of electric energy has been set in the offered work.

## 2. Materials and methods

With a research objective of the influence of temperature of heat treatment of fuel on electricity generation the pilot energy complex for power generation from the generating gas, received as a result of gasification of the granulated fuel (fig. 1), has been created [10].

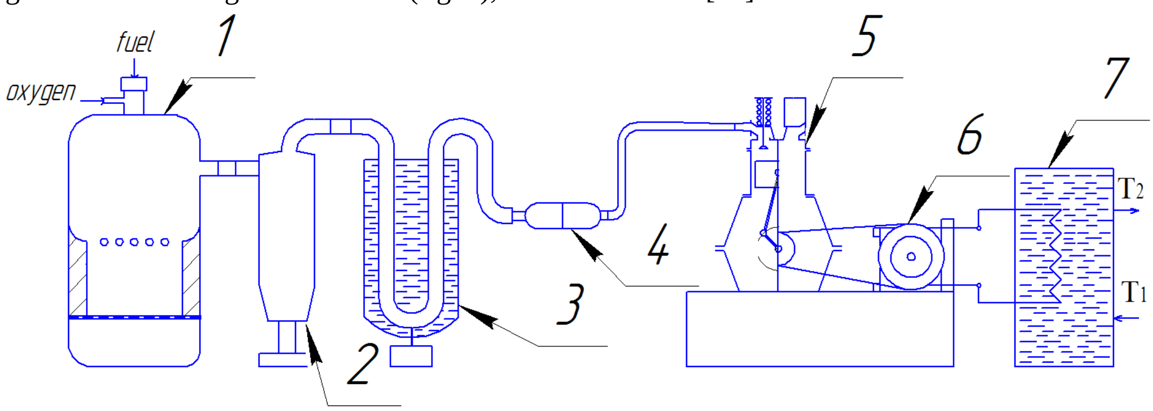


**Figure 1.** The scheme of a technological complex for development of electric energy: 1 – gas generator; 2 – cyclone for gas cooling; 3 – coiled heat exchanger; 4 – filter; 5 – internal combustion engine; 6 – electric generator; 7 – heat exchanger.

The installation works are as follows: biomass in the form of granules from the torrefied crushed wood is put in the bunker - fire chamber of a gas generator 1. For production of fuel, the raw material was exposed to preliminary heat treatment without air oxygen access at temperatures of 200-300 °C with the subsequent granulation. Further the process of gasification with receiving generating gas begins. The received gaseous fuel, after rough cleaning in a cyclone 2, cooling in the coiled heat exchanger 3 and thin cleaning in the filter 4, is used for operation of the 4-stroke internal combustion engine 5 which, in turn, puts the generator 6, developing electric current for heating of the heat carrier in the heat exchanger 7 in action.

## 3. Results and discussion

The heatphysical properties of fuels have been defined during the experiments. The fuel samples from classical wood and vegetable raw materials used in this research have been compared with biomass of the same types of fuel, subjected to heat treatment (tab. 1).

**Table 1.** Thermophysical properties of fuel granules

| | Fuel granules from wood raw materials | Fuel granules from vegetable raw materials | Torrefied fuel granules from wood raw materials | Torrefied fuel granules from vegetable raw materials |
|---|---|---|---|---|
| The highest heat of combustion, J/g | 19365 | 19989 | 22564 | 23109 |
| Ash-content, % | 24,3 | 10,8 | 25,8 | 13,6 |

In the course of carrying out a research, the composition of the received generating gas, depending on temperature of torrefaction of fuel (fig. 2), has been defined. Carrying out heat treatment of fuel allows increasing contents of hydrogen and carbon oxide as a part of generating gas at simultaneous reduction of carbon dioxide.

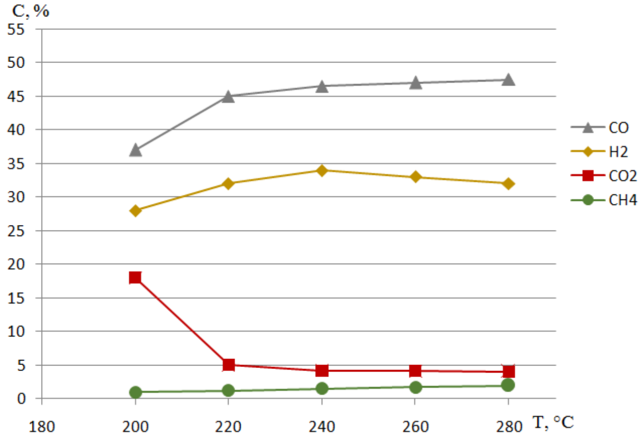


**Figure 2.** Composition of the generating gas received at gasification of torrefied fuel from biomass.

The influence of the generating gas, received at gasification of torrefied fuel on the engine capacity of internal combustion, has been defined (fig. 3). According to the graph, engine capacity increases depending on the increase in temperature of heat treatment of fuel.

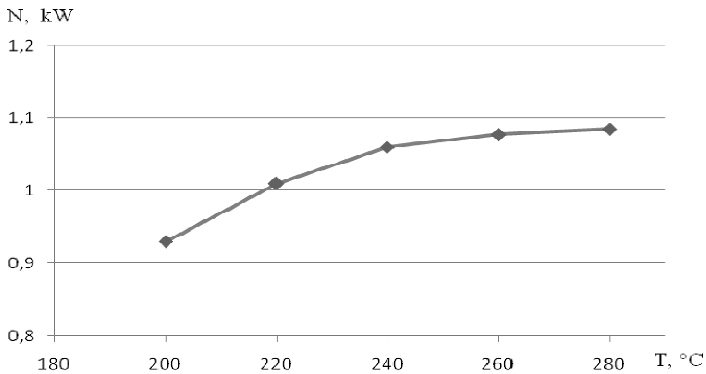


**Figure 3.** The dependence of the power of engine on the temperature of torrefaction of biomass fuels.

In addition, to confirm the energy efficiency of use of the torrefied plant material (as fuel), the researches on definition of amount of energy, produced in comparison with the fuel pellets not subjected to a heat treatment, have been conducted (fig. 4).

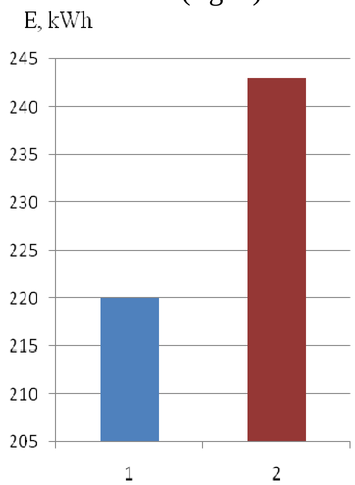


**Figure 4.** Comparative characteristics of power generation from various sources: 1 – vegetable raw materials; 2 – torrefied vegetable raw materials.

According to this graph, pre-heat treatment of fuel granules allows increasing production of electric energy in comparison with the raw fuel granules.

## 4. Conclusion
Thus, the use of torrefied fuel granules as a power source allows increasing productivity of power complex.

## 5. Acknowledgments
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## References
[1] Shayakhmetova A H, Nazipova F V, Safin R R, Timerbaeva A L, Safina A V 2015 *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management (SGEM 15th)* 53-58
[2] Saracoglu N, Gunduz G 2009 *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* **31(19)** 1708-1718
[3] Kosov V V, Sinelshchikov V A, Sytchev G A, Zaichenko V M 2014 *High Temperature* **52(6)** 907-912
[4] Sadaka S, Negi S 2009 *Environ Sustain Energy* **28** 427-434
[5] Jian Deng, Gui-jun Wang, Jiang-hong Kuang, Yun-liang Zhang, Yong-hao Luo 2009 *Journal of Analytical and Applied Pyrolysis* **86(2)** 331-337
[6] Arias B, Pevida C, Fermoso J, Plaza M G, Rubiera F, Pis J J 2008 *Fuel Processing Technology* **89(2)** 169-175
[7] Safin R R, Khasanshin R R, Timerbaeva A L, Safina A V 2015 *Journal of Engineering Physics and Thermophysics* **88(4)** 925-928
[8] Vincent S S, Mahinpey N, Mani T 2015 *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects* **37(21)** 2338-2345
[9] Garba M U, Gambo S U, Musa U, Tauheed K, Alhassan M, Adeniyi O D 2017 *Biofuels* 1-9
[10] Safin R R, Khasanshin R R, Shaikhutdinova A R, Khakimzyanov I F 2016 *IOP Conference Series: Materials Science and Engineering* **124(1)** 1-6