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A Theoretical Model of the Gasification Rate of Biomass and Its Experimental Confirmation

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Abstract: The gasification rate of fuel, biomass gasification in particular, is an important parameter which is worth considering in the process of creating a gasifier with a continuous operation process. The gasification of biomass is a complex thermochemical process. The theoretical and practical studies of the gasification rate of biomass are complicated because of a high thermochemical rate of reactions in the functioning zones of a gasifier. The complexity of the study prevents the achievement of the required accuracy of the analytical model of the gasification rate of biomass. The known theoretical models of the gasification rate only partially describe the dynamics of the gasification rate of biomass. Moreover, most scientific studies are focused on establishing the effects of gasifier parameters and the gasification process on the quality indicators of the received gas but not on the gasification rate of fuel. To build an accurate model of the gasification rate the authors propose a series of experimental studies in a well-defined range of the parameters of a gasifier. The paper suggests a simple mathematical model of the gasification rate of biomass, which is proportional to the amount of plant biomass that remained non-gasified. The coefficients of the gasification rate for straw pellets, wood pellets and wood in pieces have been determined. Under a minimal air supply into an active zone of a gasifier (0.00088 m^3/s) a coefficient of gasification rate is nearly the same for the test fuel materials and it differs by 4.7% between wood pellets and straw pellets. When the air supply increases, the gap between the coefficients increases as well and it reaches 9.44×10^{-5} c^{-1} for wood pellets, 1.05×10^{-4} c^{-1} for straw pellets and 8.64×10^{-5} c^{-1} for wood in pieces under air supply into an active zone of a gas generator of 0.01169 m^3/s. Straw pellets have the highest gasification rate and wood in pieces has the lowest gasification rate.

Keywords: straw; wood; biomass; pellets; coefficient; gasification; rate; mathematical model

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1. Introduction

Greenhouse gas emissions from using fossil fuel (natural gas, diesel fuel, coal, etc.) do considerable harm to the environment [1,2]. However, the decrease in the use of fossil fuel can rock the power safety of a country or of an area [3]. That being said, the balanced and effective use of the renewable sources of energy can offset the decrease in the use of fossil fuels in the countries of the European Union and around the world [4].

The use of pellets, briquettes, rolls, bails of spike crops and miscanthus, sunflower husk, sawdust, firewood, reed plant, etc., [5,6] as raw materials for renewable fuel production is possible. It is feasible to obtain energy from such raw materials [7,8]. However, direct biomass burning causes problems related to biomass heterogeneity, a relatively high moisture content, low energy density and a low temperature of ash melting. To obtain a permanent supply of energy for consumers when burning plant biomass, it would be expedient to use gasifiers, which by means of thermo-chemical reactions transform solid biomass into a combustible gas, known as generator gas [9–11]. Studies [12] have shown that generator gas is used as fuel for internal combustion engines and that generator gas obtained from biomass is more efficient than just biomass burning.

Except gasification, an efficient way of converting biomass is pyrolysis [13]. Pyrolysis makes it possible to obtain not only gas but also biochar, a bio-oil [14]. However, pyrolysis units are more complicated when compared with gasifiers and they require more energy consumption for the pyrolysis process.

The analysis of scientific studies proves that biomass gasification is a complicated process, which is based on the equations of thermo-chemical equilibrium, kinetics, heat transfer and mass transfer based on the rate of biomass gasification.

There is rather interesting research related to the processing of microalgae into biofuels [15], as well as research related to solid plastic waste recycling [16]. The use of the gasification or pyrolysis is also expedient in these cases. The analysis of scientific studies confirms that the gasification or pyrolysis of biomass is a complex thermochemical process. The theoretical and practical studies of gasification rates or the pyrolysis of biomass are complicated because of the high thermochemical rate of reactions in the functioning zones of a gasifier.

The effects of parameters such as functioning temperatures in oxidization and renewal zones [17,18], moisture [19] and other biomass characteristics [20], as well as air supply mode [21–23], on the process of the work of a gasifier have been substantiated in scientific works.

Some researchers [24] have studied small-scale gasifiers and come to the conclusion that the rate of fuel gasification (burning) is an important indicator. There are some studies of small-scale gasifiers [25], which defined the influence of the technological parameters of the process on generator gas quality. However, they did not study the effects of fuel characteristics on the rate of the process. The effects of the construction components of a gasifier on the quality of the received gas [26] have been studied. However, there are no studies as to the effects of the construction characteristics of the renewable zone on the rate of biomass gasification. The mode of air supply as well as its influence on the gasification process have been studied in research [27,28], but there are no studies as to the correlation of air supply mode and the rate of biomass gasification. Similar studies have been carried out for pyrolysis units as well.

There is interesting research related to obtaining gases with an increased hydrogen content via the biomass gasification [8,29]. The paper analyses the influence of gasifier construction, temperature and tension and the steam to biomass ratio as well as the rate of the steam flow, moisture and the size of biomass particles on the quality composition of the received gas. However, the gasification rate of the biomass was not studied, although it is an important parameter related to the fuel consumption in a gasifier.

A study [28] proposed three equations of the gasification rate of the biomass, which depend on the amount of fuel that undergoes gasification. Theoretical and practical studies have been carried out on the basis of the assumptions as to the fact that the gasification rate of the biomass depends on the change of the fuel mass during the gasification process. However, all the models had some deviations from the experimental studies on the values of the changes of the fuel mass during the gasifier operations, as they did not take into account the ash mass which remained after fuel gasification. In a study [30], it was demonstrated that temperature, the type of biomass, fuel size and equivalence ratio (ER) affect the gasification process but the mathematical models of these effects are not given. In paper [31], the model of the proportional change of the fuel mass to the process temperature is given but the experimental research is not presented.

The analysis of the scientific research shows that it is difficult to study the rate of biomass gasification in a theoretical study because of the complexity and the great number of reactions in the active zones of a gasifier [30,32–35]. This complication does not allow theoretical models to achieve the required exactness for the optimization of a gasification process [35,36]. Many models contain inappropriate values and units [37]. The complication of the research prevents the achievement of the required exactness of the analytical models of the gasification rate of the biomass. The known gasification models only partially describe the dynamics of the gasification rate of the biomass [38]. The studies allow us to state that the rate of the process of biomass gasification is an important criterion when designing the gasifier with a continuous functioning process [39,40], as well as in the process of non-organic fuel gasification [41]. Research [42] has examined the effects of the rate of fuel supply into a gasifier on the quality of the produced gas but the gasification rate has not been studied. Moreover, the rate of fuel transformation is of great importance in the pyrolysis process [43].

It was noted in paper [44] that fuel consumption is a very important characteristic of a gasifier and is extant in three modes of fuel supply—proportional (intermittent), semi-intermittent and constant. The gasification rate of the biomass is an important parameter for determining the design parameters of a gasifier, the geometric sizes of a bunker for fuel and a cross-sectional area for an active zone of a gasifier, in particular, among other things. The harmonization of the fuel supply and the gasification rate of the biomass reduce the formation of tars [45].

The gasification rate of a fuel allows the determination of the appropriate air supply into a gasifier in order to receive an equivalence ratio (ER) during the process of the gasification of the refuse-derived fuel (RDF) [46]. Keeping to the optimal equivalence ratio allows the achievement of minimal harmful emissions and the obtaining of high-quality gas.

The study of the gasification rate of the biomass or pyrolysis of biomass allows the determination of the rate of fuel consumption at the biomass power plants [47]. In turn, it provides small agricultural communities with energy from the refuse-derived biomass in order to reduce the negative impact on the environment and to increase the economic efficiency of the waste management practices in the agricultural communities.

Thus, it is necessary to accumulate the data in an actual range of operation parameters of a gasifier as well as to design simple mathematical models, which can adequately describe the rate of biomass gasification.

2. Materials and Methods

2.1. Mathematical Model

If the gasification rate of the biomass is proportional to the weight of the biomass, the kinetic equation of the gasification rate in a differential form looks like this:

$$\frac{dm}{d\tau} = -k(m - m^*), \tag{1}$$

where:

- m—the content of plant biomass, which has not been gasified at a specific point of gasification, kg;
- m^*—the amount of a mineral constituent (ash) that remained non-gasified, kg;
- k—a parameter of a gasification process that characterises its rate (coefficient of gasification rate), c^{-1};
- τ—gasification time, c.

Having performed the mathematical transformations and the integration of a differential equation within the biomass content from the initial indicator to a specific indicator, we obtain a one-parameter equation of the gasification process, which calculates a plant biomass content that has not been gasified at a given point:

$$m = m^* + (m_0 - m^*)\ \exp(-k\tau), \tag{2}$$

where:

- m_0—the amount of plant biomass at the beginning of gasification, kg.

At the same time, the amount of plant biomass which has been gasified at a specific point equals:

$$m_0 - m = (m_0 - m^*)[1 - \exp(-k\tau)], \tag{3}$$

therefore, the coefficient of gasification rate equals:

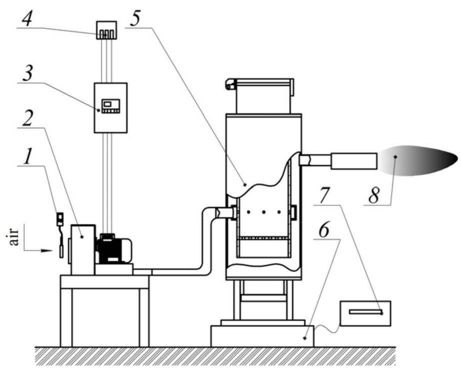
$$k = \frac{1}{\tau} \ln \frac{m_0 - m^*}{m - m^*}. \tag{4}$$

The coefficient of the gasification rate must be calculated experimentally for each kind of fuel as well as for a gas generator construction.

2.2. Experimental Facility (Facility for Conducting Experiments)

To calculate the rate of the coefficient and to confirm the theoretical equations, a specially designed facility was used (Figure 1a,b) [28]. The facility contained a downdraft gasifier. The gasifier construction parameters had to provide the highest combustion heat (quality) of a generator gas. The diameter of a renewal zone equalled 200 mm and the height of a renewal zone equaled 110 mm and was determined according to studies described in [10]. The number of nozzle holes equalled 12 and their diameter equalled 10 mm. Air supply into a gasifier was in the range of 0.0009 to 0.012 m^3/s and was regulated using the blower efficiency by means of a frequency converter. Before each experiment, the ash was removed from the gasifier and a new amount of fuel was loaded. The gasifier was installed on calibrated scales in order to control the changes in fuel mass. Functionality was recorded using permanently burning gas torch.

(a)



(b)

Figure 1. General view (**a**) and schematic diagram (**b**) of an experimental facility: 1—anemometer Tenmars TM-402; 2—blower Goorui GHBH-0D5-34-1R2; 3—frequency converter Hitachi-3G3JX-A4075-EF; 4—power supply 0.4 kW; 5—downdraft gasifier; 6—scales; 7—scales indicator; 8—generator gas torch.

Wood pellets, straw pellets and wood in pieces were used as fuel. The fuel mass, which remained in a gasifier, was recorded by means of scales in equal time intervals. The moment the combustible gas torch went out was taken as the final point of time during the experiment. Furthermore, the fuel as well as the ash mass were recorded, which remained in a gasifier. To receive reliable results, each experiment was repeated three times for each type of fuel and for each air supply.

3. Results and Discussion

According to the results of the experimental research (Tables 1–3) the coefficients of the gasification rate were calculated and corresponding diagrams were built. Table 1 gives the experimental and theoretical indicators of the gasification rates of wood pellets.

The anlysis of data from Table 1 demonstrates that the gasification rate of wood pellets can be described by means of a theoretical model, according to which the rate of the gasification of plant biomass is proportional to the fuel mass that remained non-gasified. Thus, the suggested model takes into account the final amount of obtained ash.

Table 1. Indicators of theoretical and experimental studies of the gasification rate of wood pellets.

Indicator	Fuel Mass, Initial, kg					
	5					
Air supply 0.01169 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.7
Ash mass, kg	0	0.03	0.05	0.08	0.1	0.15
Gasifier run time, s	0	102	240	402	675	770
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.2
Ash content, %	0	0.6	1	1.6	2	3
Coefficient of gasification rate, s^{-1}	9.44×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.94	2.91	1.99	1.06	0.39
Air supply 0.00628 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.63
Ash mass, kg	0	0.03	0.05	0.08	0.1	0.15
Gasifier run time, s	0	120	267	439	715	890
Fuel mass which remained solid according to experimental research, kg	5	4	3	2	1	0.22
Ash content, %	0	0.6	1	1.6	2	3
Coefficient of gasification rate, s^{-1}	8.92×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.96	2.93	1.93	0.94	0.21
Air supply 0.00088 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.6
Ash mass, kg	0	0.03	0.06	0.09	0.11	0.15
Gasifier run time, s	0	265	590	1006	1705	2011
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.25
Ash content, %	0	0.6	1.2	1.8	2.2	3
Coefficient of gasification rate, s^{-1}	4.28×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.96	2.93	1.92	0.94	0.24

When the air supply into an active zone of a gasifier increases 13-fold, the coefficient of gasification rate of wood pellets increases 2.2-fold. There is also the full accordance of the experimental data and those which were calculated theoretically (Figure 2) by the Equation (2) when taking into account the gasification coefficient calculated by the Equation (4) and when using the values received by the experiment. During the final stage of the gasification reaction there are some deviations in theoretical and experimental values when the air supply indicator is high. It can be explained through the instability of the process because of a low content of fuel in a functioning zone of a gasifier. The ash content when using wood pellets equaled 3%.

Table 2. Indicators of experimental and theoretical studies of the rate of straw pellet gasification.

Indicator	Fuel Mass, Initial, kg					
	5					
Air supply 0.01169 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.60
Ash mass, kg	0	0.04	0.08	0.12	0.16	0.2
Gasifier run time, s	0	130	252	447	650	827
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.20
Ash content, %		0.8	1.6	2.4	3.2	4.0
Coefficient of gasification rate, s^{-1}	1.05×10^{-4}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.96	2.96	2.02	1.15	0.52
Air supply 0.00628 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.55
Ash mass, kg	0	0.04	0.08	0.12	0.16	0.2
Gasifier run time, s	0	145	310	490	790	1005
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.25
Ash content, %	0	0.8	1.6	2.4	3.2	4
Coefficient of gasification rate, s^{-1}	9.795×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.94	2.91	1.91	0.94	0.25
Air supply 0.00088 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.59
Ash mass, kg	0	0.03	0.06	0.09	0.11	0.15
Gasifier run time, s	0	245	547	985	1670	1965
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.26
Ash content, %	0	0.8	1.6	2.4	3.2	4
Coefficient of gasification rate, s^{-1}	4.495×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.96	2.93	1.92	0.94	0.25

Table 3. Indicators of theoretical and experimental studies of the gasification rate of wood in pieces.

Indicator	Fuel Mass, Initial, kg					
	5					
Air supply 0.01169 m^3/s						
Fuel mass which was gasified,kg	0	1	2	3	4	4.67
Ash mass, kg	0	0.04	0.08	0.12	0.16	0.2
Gasifier run time, s	0	123	245	412	627	824
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.13
Ash content, %	0	0.8	1.6	2.4	3.2	4.0
Coefficient of gasification rate, s^{-1}	8.64×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.97	2.97	2.01	1.12	0.40
Air supply 0.00628 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.63
Ash mass, kg	0	0.04	0.08	0.12	0.16	0.2
Gasifier run time, s	0	145	290	492	753	998
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.17
Ash content, %	0	0.8	1.6	2.4	3.2	4
Coefficient of gasification rate, s^{-1}	8.038×10^{-5}					
Fuel mass which remained solid, according to theoretical research, kg	5	3.95	2.93	1.93	0.95	0.17
Air supply 0.00088 m^3/s						
Fuel mass which was gasified, kg	0	1	2	3	4	4.59
Ash mass, kg	0	0.04	0.08	0.12	0.16	0.2
Gasifier run time, s	0	299	630	1055	1647	2068
Fuel mass which remained solid, according to experimental research, kg	5	4	3	2	1	0.21
Ash content, %	0	0.8	1.6	2.4	3.2	4
Coefficient of gasification rate, s^{-1}	4.318×10^{-5}					
Fuel mass which remained according to theoretical research, kg	5	3.95	2.92	1.92	0.94	0.21

Table 2 presents experimental and theoretical indicators of the gasification rate of straw pellets. The analysis of the data from Table 2 demonstrates that the gasification rate of straw pellets can be described by means of a theoretical model, according to which the rate of the gasification of plant biomass is proportional to the fuel mass that remained non-gasified.

The coefficient of the straw pellet gasification increases only 2.3-fold, while the air supply into an active zone of a gasifier increases 13-fold. There is also the full accordance of the experimental data and those that were calculated theoretically (Figure 3) through Equation (2), while taking into account the gasification coefficient calculated by the Equation (4) and while using the values obtained by the experiment. Regarding the final stages of the gasification reactions there are some deviations in the theoretical and experimental values when the indicator values of the air supply are high. The ash content when using straw pellets equalled 4%.

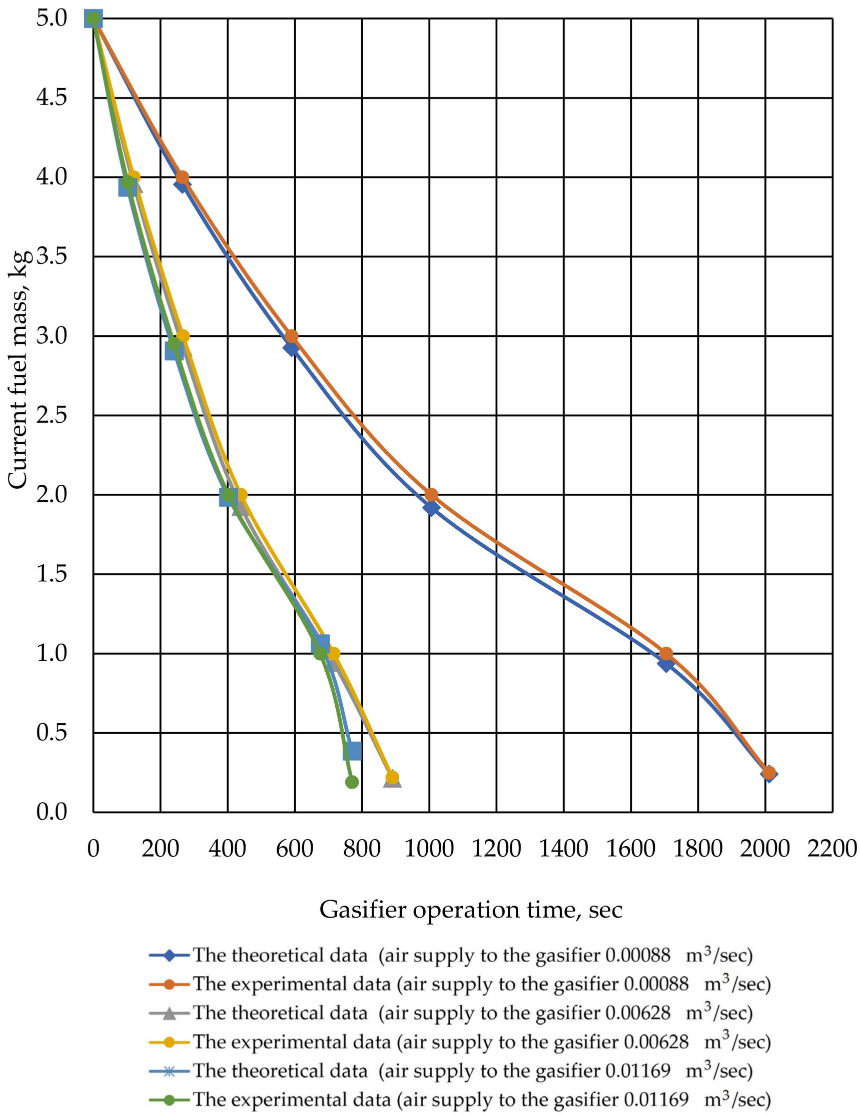


Figure 2. Comparison of the experimental and theoretical indicators of the change of fuel mass when using wood pellets.

Table 3 presents the experimental and theoretical indicators of the gasification rate of wood in pieces. The analysis of the data from Table 3 demonstrates that the gasification rate of wood in pieces can be described by means of a theoretical model, according to which the rate of the gasification of plant biomass is proportional to the fuel mass that remained non-gasified.

The coefficient of wood in pieces gasification increases only 2-fold, while the air supply to an active zone of a gasifier increases 13-fold. There is also the full accordance of the experimental data and those that were calculated theoretically (Figure 4) by Equation (2) when taking into account the gasification coefficient calculated by Equation (4) and when using the values received by the experiment. In the final stages of a gasification reaction there are some deviations in the theoretical and experimental values when the indicator values of air supply are high. The ash content when using wood in pieces equalled 4%.

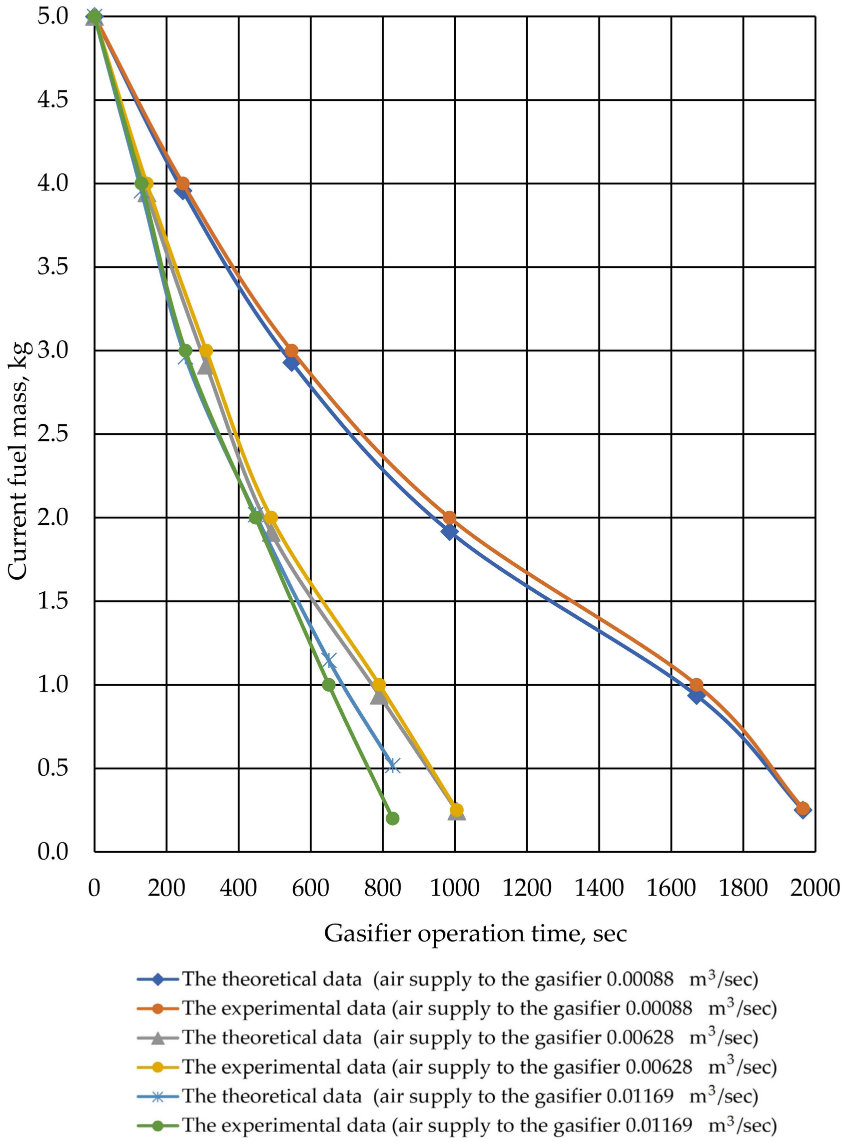


Figure 3. Comparison of the experimental and theoretical indicators of a change of fuel mass when using straw pellets.

It is necessary to admit that when the fuel mass decreases, the rate of gas generation decreases as well, which is in agreement with other studies [48], and the highest rate of gas generation was at the beginning of the process [49].

The influence of the air supply and of gasifier run times (Tables 1–3) on the fuel mass which remained in a gasifier (Table 4) was determined according to experimental research.

Table 4. The empirical equations of the influence of the air supply and of the gasifier run time on the fuel mass that remained in a gasifier.

Type of Fuel	Equation
Wood pellets	$m = 5.32 - 222.11q - 0.004\tau + 15{,}325.65Q^2 - 0.24Q\tau + 9.4 \times 10 - 7\tau^2$
Straw pellets	$m = 5.15 - 128.52q - 0.0039\tau + 8945.61Q^2 - 0.23Q\tau + 9.3 \times 9.20\tau^2$
Wood in pieces	$m = 5.27 - 174.25q - 0.0037\tau + 11{,}687.59Q^2 - 0.26Q\tau + 7.7 \times 10 - 7\tau^2$

where:

- m—the content of plant biomass, which has not been gasified at a specific point of gasification, kg;
- τ—gasification time, c.
- Q—air supply, m^3/s

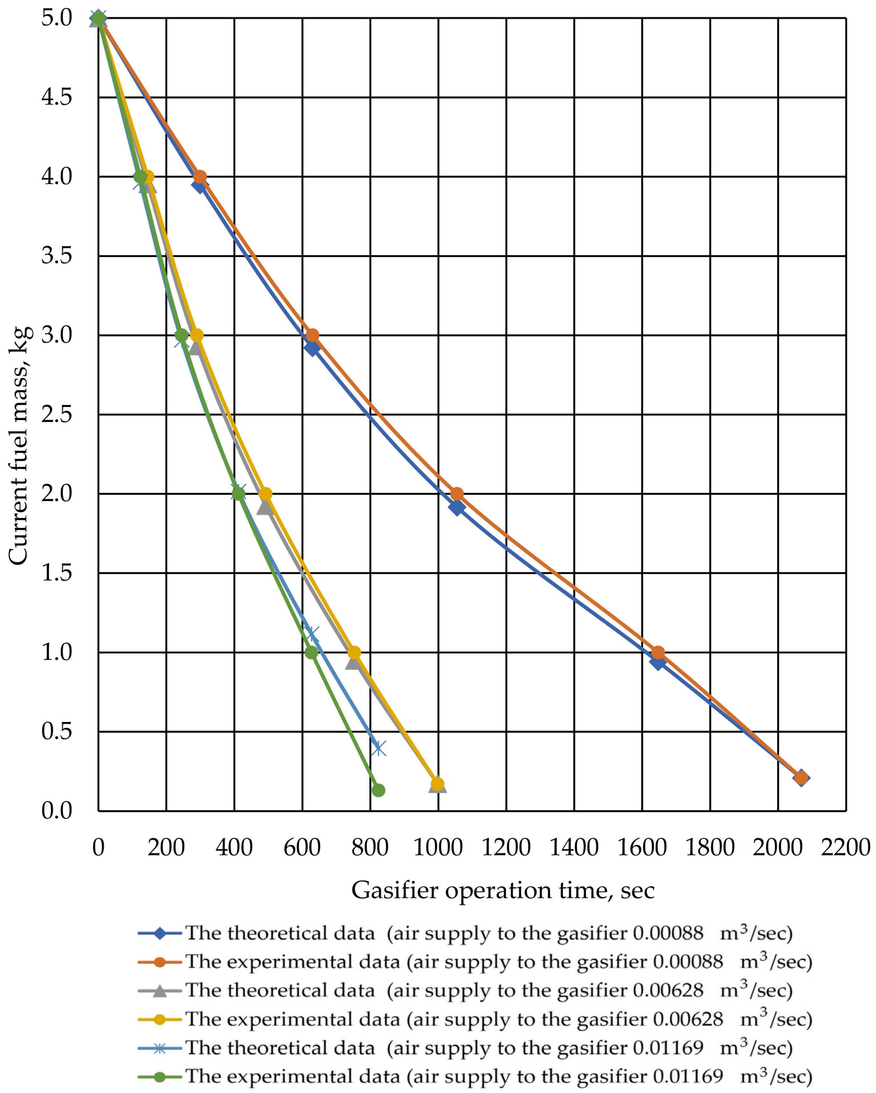


Figure 4. Comparison of the experimental and theoretical indicators of a change of fuel mass when using wood in pieces.

The empirical equations of the dependence of the coefficient of the gasification rate from the air supply into an active zone of a gasifier were formed after analysing the results of the research. The equation is given in Table 5. The change of the coefficient is shown in Figure 5.

The analysis of charts on Figure 5 demonstrates that under a minimal air supply into an active zone of a gasifier (0.00088 m^3/s) the coefficient of gasification rate is nearly the same for the tested kinds of fuel, and it differs by 4.7% between wood pellets and straw pellets.

When the air supply increases, the gap between the coefficient values increases as well, and it reaches 17.7% and equals 9.44×10^{-5} c^{-1} for wood pellets, 1.05×10^{-4} c^{-1} for straw pellets and 8.64×10^{-5} c^{-1} for wood in pieces under an air supply into an active zone of a gasifier 0.01169 m^3/s. Straw pellets have the highest gasification rate and wood in pieces has the lowest gasification rate. Thus, the gasification rate of wood pellets is also higher than that of wood in pieces.

Table 5. The empirical equations of rate coefficient of biomass gasification.

Type of Fuel	Air Supply (Q, m^3/s)			Equation
	0.00088	0.00628	0.01169	
Wood pellets	4.28×10^{-5}	8.92×10^{-5}	9.44×10^{-5}	$k = -0.6555Q^2 + 0.0133Q + 3 \times 10^{-5}$
Straw pellets	4.495×10^{-5}	9.795×10^{-5}	1.05×10^{-4}	$k = -0.6532Q^2 + 0.0143Q + 4 \times 10^{-5}$
Wood in pieces	4.318×10^{-5}	8.038×10^{-5}	8.64×10^{-5}	$k = -0.4406Q^2 + 0.01Q + 3 \times 10^{-5}$

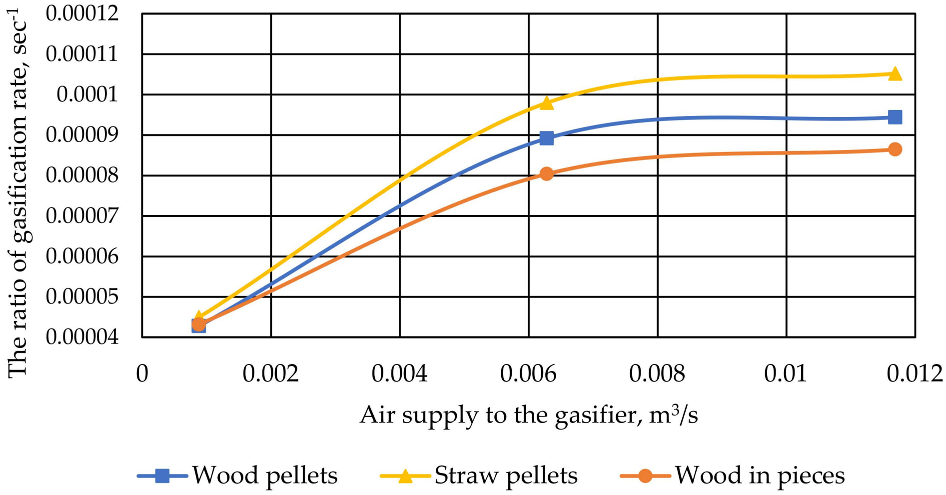


Figure 5. Change of the coefficient of gasification rate depending on air supply.

A higher gasification rate of pellets can be explained by a more active contact area and by a lower density of fuel elements. It is also necessary to admit that under a change in air supply in an active functional zone of a gasifier from 0.00088 m^3/s to 0.005–0.0055 m^3/s, the coefficient of gasification rate increases linearly. Under air supply in the range of 0.005 to 0.0055 m^3/s and 0.0085 to 0.009 m^3/s, the increase of the coefficient slows down. Under air supply in the range of 0.0085 to 0.009 m^3/s, the coefficient does not change, irrespective of a further increase in air supply. This correlates with the results of the research [50] and the slowing down of the gasification rate under a high level of air supply is explained through the agglomeration phenomenon [51].

The theoretical and experimental values of the suggested rate model of biomass gasification, which is proportional to the fuel mass that remained non-gasified, have the coefficient of determination, which equals 0.99. Additionally, the most exact model of a change of fuel mass which remained non-gasified, as seen in study [28], has a coefficient of determination which equals 0.955.

A higher gasification rate of straw pellets corresponds with other studies that show that the gasification process improves when straw-containing fuel is used [51–53]. The ash content corresponds with study [54] as well.

The determination of a gasification rate makes it possible to determine the amount of biomass supply of a functioning zone of a gasifier with a continuous operation process [38] when using different kinds of fuel [55,56].

The mathematical model of the rate of biomass gasification that was demonstrated by the authors takes into account not only fuel consumption but also the dynamics of ash formation. The assessment of ash formation is essential under the gasifier operation process under the conditions of an agrarian production for receiving biochar [57].

The studies of the gasification rate of certain types of biomass obtained a simple model of the gasification rate of the biomass. The use of this model and of the proposed method of studies determines the rational indicators of fuel consumption in the process of gasification. The determination of the gasification rate of the biomass makes it possible to establish the level of fuel consumption in the process of receiving gas. The determination of fuel consumption will help to ease the technical and economic assessment of the constructions of a gasifier as well as the technologies of biomass gasification [58].

The proposed method of determining the gasification rate of biomass allows the specification of the indicator of fuel consumption through the existing gasifiers given in a paper [59]. Therefore, a downdraft gasifier with interchangeable design parameters is used [10].

In the future, the authors are planning to conduct similar studies for other types of gasifiers as well as for pyrolysis units, because the availability of biomass in a pyrolysis zone affects the physicochemical properties of the final biofuel production [60]. The authors are planning to cover a wide range of lignocellulosic materials in further studies.

4. Conclusions

Under a minimal air supply in an active zone of a gasifier (0.00088 m^3/s), the coefficient of the gasification rate is nearly the same for the tested types of fuel and differ by 4.7% between wood pellets and straw pellets. When the air supply increases, the gap between the coefficient values increases as well, and it reaches 17.7% and equals 9.44×10^{-5} c^{-1} for wood pellets, 1.05×10^{-4} c^{-1} for straw pellets and 8.64×10^{-5} c^{-1} for wood in pieces under the air supply in an active zone of a gasifier, which equals 0.01169 m^3/s. Straw pellets have the highest gasification rate, and wood in pieces has the lowest gasification rate. Thus, the gasification rate of wood pellets is also higher than that of wood in pieces. A higher gasification rate of pellets can be explained using a more active contact area and a lower density of fuel elements. It is also necessary to admit that when the air supply into an active zone of a gasifier increases in the range of 0.00088 m^3/s to 0.005–0.0055 m^3/s, the coefficient of gasification rate increases linearly. When the air supply is in the range of 0.005 to 0.0055 m^3/s and 0.0085 to 0.009 m^3/s, the increase of the coefficient values slows down, and when the air supply is in the range of 0.0085 to 0.009 m^3/s, the coefficient does not change, irrespective of a further increase to the air supply.

The determination of the rate gasification of plant biomass is an important parameter when designing a gasifier with a continuous operation process.

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