Article

Potential Water Recovery from Biomass Boilers: Parametric Analysis

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Abstract: A fundamental component of the losses of convection boilers is localized in the warm fumes that are expelled. In the warm fumes, not only energy is lost, but water is also formed from the combustion reaction in the form of steam which is expelled through the exhaust. Modern fuel boilers recover both the heat from the fumes and the latent heat of condensation from water vapor. Depending on the chemical composition of the fuel, different amounts of steam are produced together with heat and different combustion conditions, such as air in excess. In this article, a computational tool was established to simulate a combustion system mainly (but not only) focusing on the prediction of the amount of water produced. In fact, while steam in fossil fuel boilers is commonly condensed, this is not so when the fuel is a biomass. Furthermore, biomasses could contain moisture in different amounts, thus affecting the production of water and the heat of combustion. The study shows that a ten-fold amount of water is formed from biomass combustion with respect to fossil fuels (when the same energy output is produced). As a result, the recovery of water is amenable in biomasses, both from the energetic point of view and for liquid water production. In fact, the water recovered from the fumes might be also reused in other processes such as the cleaning of fumes or agriculture (after treatment).

Keywords: warm fumes; combustion; fossil fuels; biomass; moisture; recovery of water

1. Introduction

From the point of view of the chemical composition of lignocellulosic biomasses, the most abundant biopolymers in plants are those that make up the cell wall, such as cellulose, hemicellulose and lignin. The cellulose content in the softwood biomass is approximately 43–47%, the hemicelluloses content 25–27%, while the lignin content is close to 27–28%. The higher content of cellulose (47–49%) and hemicelluloses (28–39%) with the reduced content of lignin 8–11.5% is related to herbaceous biomass (birdseed), while the reduced content of cellulose (36–43%) and lignin (17–24%) with the highest hemicellulose content compared to softwood biomass is typical of willow biomass and agricultural residues [1].

Xylan comprises up to 10 and 30% of all hemicelluloses found in soft and hard woods, respectively [1]. Lignin is a highly substituted mononuclear aromatic polymer and is often found to be attached to adjacent cellulose fibers to form a lignocellulosic complex. The lignin content of various biomasses, including both softwood and hardwood, generally range from 10 to 40% of the total dry mass [2]. The physicochemical properties of lignin largely depend on the plant species and isolation processes [3]. Table 1 lists the approximate composition percentages of some biomass species.

Table 1. Approximate chemical composition of European wood.

Fuel Sample	Hemicelluloses (%)	Cellulose (%)	Lignin (%)
Beech wood [4]	31.2	45.3	21.9
Spruce wood [4]	20.7	49.8	27.0
Olive husk [4]	23.6	24.0	48.4
Spruce [5]	27.6	45.6	26.9
Pine [5]	28.0	43.2	26.6
Beech [5]	35.3	39.2	20.9
Oak [5]	29.0	38.0	25.0

Lignin is characterized by its high heating power, which can be used to produce thermal and/or electrical energy. The calorific value of the same type of wood varies according to the volume of moisture content [6]. As a comparison, Table 2 lists the lower heating value (LHV) of fuels commonly used in boilers.

Table 2. LHV of the main fuels used in boilers.

Fuel	LHV (MJ/kg)
Methane	50.00 [7]
Diesel	42.82 [8]
Propane	46.34 [9]
Lignin (biomass Kanto Chemical Co)	20.40 [a] [2]
Lignin (a.v in wood)	25.00 [10]
Cellulose (a.v in wood)	17.64 [10]
Cellulose (α-cellulose-fiber form)	16.50 [a] [2]
Xylan (beachwood)	13.90 [a] [2]
Firewood w = 20%	16.20 [10]
Wood chips w = 23.1%	12.24 [10]
Briquettes w $\leq$ 15%	16.92 [10]
Pellets w = 8–12%	18.00 [10]

[a] is on dry basis. w = water content.

If the moisture content in the biomass is high, direct combustion is somewhat unfavorable because the moisture content is too high for stable combustion [2].

Therefore, in many cases it is considered important that the moisture content of the wood is reduced to be used as fuel, since it leads to a loss of heat in the flue gases in the form of water vapor because it absorbs energy in combustion [11]. Table 3 lists some typical moisture percentages for some types of wood.

Table 3. Humidity values for biomass.

Biomass	W (%)
Woody biomass [10]	50
Pellet [10]	8–12
Lignin [1]	6.4
Deciduous wood [6]	15
Coniferous wood [6]	15
Logs (spruce pine 50/50%) [6]	30
Wood chips (oak, beech, spruce, pine) [6]	10–30

The combustion process that occurs in the boilers needs an amount of air in excess with respect to the stoichiometric balance, because in practice, to reach a complete oxidation, a greater quantity than the theoretical is needed, in Table 4, where the percentages of air excess are listed for some fuels.

Table 4. Percentages of air excess for some fuels.

Fuel	Ea (%)
Methane [12]	10–30
Diesel [12]	30–40
Propane [12]	20–40
Lignin [1]	123
Palletized biomass [1]	95–147
Wood [1]	10–200
Pellet [13]	43–163

The chemical reaction of combustion from boilers, furnaces, etc. generates a large amount of combustion gases [14] and water in the form of steam, which are then discharged into the environment; however, it could be condensed, it would be reused for some useful and economic purposes.

In fact, water is a fundamental, integral resource for human well-being, the environment, ecological and social activities, transportation and industrial development including energy production [15] being the fluid mostly used for heating processes, due to its availability and high heat capacity. A large amount of water is used in the industrial sector around the world, where much of it is wasted in the process or is released to the environment as a waste stream [16]. In recent decades, climate change and human socio-economic development have enormously changed global hydrological cycles, threatening human water security, the health of aquatic environments and the biodiversity of rivers [17,18] with water scarcity being a widespread problem in many parts of the world.

For this reason, the amount of energy and water that is lost represents a quantity of great importance that could be recovered to reduce the amounts of primary fuel or be used in other processes. The exhaust energy from the boiler can generally be used to heat air and water from the heating network [19]. Instead, the condensed water from the exhaust gases could have different uses depending on its chemical composition.

Generally, for fossil fuels, up to 8% of the volume fraction of the combustion products is water vapor. If the temperature of the flue gases is reduced below the dew point, the water vapor in the flue gases will condense and both the sensible heat and the latent heat thus released can be recovered [20].

In a coal-fired boiler, the thermal energy of the exhaust gases represents approximately 50–80% of the thermal loss and 4–8% of the heat content of the fuel is ultimately converted into thermal energy carried by the exhaust gases combustion [19]. If the remaining heat can be recovered, it would significantly improve the thermal efficiency of the boiler. This has led to the development of numerous waste heat recovery strategies [21–24].

Recovering energy from exhaust gases can also help reduce CO_2 emissions by approximately 100 million tons/yeargenerating huge economic and social benefits [19].

For the purposes of this discussion, in order to carry out a comparative analysis to produce the same amount of energy, the fuels normally used in the energy sector have been considered in the form of combustion reactions, heating value, excess air, humidity for biomass determining the real amount of fuel and air necessary for the combustion reaction; and as products, the amount of water and carbon dioxide. It is essential that a serious and concrete effort is made to conserve this water and use it in other processes.

2. Materials and Methods

2.1. Calculation of the Raw Material Required for Combustion

The experimental design generated with the Excel software and used in this work was a series of spreadsheets, composed of the combustion reactions of the different fuels used in the boilers based on their heating value, and setting the required energy to be produced as the basis of calculation, to determine the different parameters. The excel sheet is available as Supplementary Materials.

In order to make a comparison among the considered fuels, fixing the energy required (E_r) to be produced in order to calculate the mass needed.

Therefore, by fixing its value:

$$E_r = 1000 \text{ MJ} \tag{1}$$

From the energy to be produced, and the LHV of each fuel:

$$Mass_{fuel-nec} = \frac{E_r}{LHV} \tag{2}$$

2.2. Stoichiometric Balance of Combustion Reaction

By means of the combustion reaction, of generic fuel, to depend on the fuel average molecular mass, determining the balanced combustion reaction (here balanced for 1 mole):

$$C_{X1} H_{X2} O_{X3} + \left(X_1 + \frac{X_2}{4} - \frac{X_3}{2} \right) O_2 \rightarrow X_1 C O_2 + \frac{X_2}{2} H_2 O \tag{3}$$
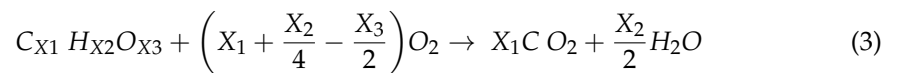
where X_1, X_2, X_3 corresponds to the stoichiometric values of the fuel formula.

2.3. Determination of the Amount of Water Produced Depending on the Composition of the Biomass

Introducing the initial mass (M_{fuel}) and the percentage of humidity ($\%W$), the quantity of water (M_{water}) can be determined as follows:

$$n_{water} = \frac{X_2}{2} * \frac{M_{fuel\ without-w}}{MM_{fuel}} \tag{4}$$

$$M_{water} = n_{water} * MM_{water} + M_{fuel} * \frac{\%W}{100} \tag{5}$$

where n_{water} represents the moles of water, $M_{fuel\ without-w}$ is the amount of fuel without humidity, MM_{water} represents the molecular weight of water and MM_{fuel} represents weight of fuel.

As for carbon dioxide and stoichiometric oxygen required:

$$n_{co2} = X_1 * \frac{M_{fuel\ without-w}}{MM_{fuel}} \tag{6}$$

$$M_{co2} = n_{co2} * MM_{co2} \tag{7}$$

$$n_{o2} = (X_1 + \frac{X_2}{4} - \frac{X_3}{2}) * \frac{M_{fuel\ without-w}}{MM_{fuel}} \tag{8}$$

$$M_{o2} = n_{o2} * MM_{o2} \tag{9}$$

where n_{co2} and n_{o2} represent, respectively, the moles of carbon dioxide and oxygen, M_{co2} and M_{o2} represent, respectively, the amount of carbon dioxide produced and oxygen consumed, MM_{co2} is the molecular weight of CO_2 and MM_{o2} is the molecular weight of O_2.

For biomass-like pellets, chips, briquettes and wood, the averaged chemical composition of lignin, hemicellulose and cellulose was considered to determine the mass of each component to carry out the combustion reactions.

Thus far, given the composition of any wood, denominated synthetic wood, the dry mass of this wood ($M_{Lsynt-dry}$), the corrected heating value for the moisture (w) content and quantity of water produced were calculated.

2.4. Calculation of the Heating Value of Synthetic Wood

In this way, it is possible to predict the heating value of any wood and quantity of residual water, and on a base of biomass' wet mass ($M_{Lsynt-w}$) and the LHV of the synthetic wood:

$$M_{Lsynt-dry} = M_{Lsynt-w} - \left(\frac{w}{100}\right) \tag{10}$$

To determine the heating value of any known wood composition as a function of the amount of water present, the water content was introduced in this way indicating the idric content (w) if this increases the heating value of the firewood, this leads to a decrease because a certain amount of energy is spent for the vaporization of absorbed water, indicating with *LHVu* the heating value of wet wood and with *LHVa*, that of dry wood can be written, that:

$$LHV = LHVu = (1 - M) \cdot LHVa - \Delta H_{water} \cdot w \tag{11}$$

where ΔH_{water} = 2.44 MJ/kg [25] is the latent heat of vaporization of water at 25 °C.

Therefore, the heating value of synthetic wood (LHV_{Lsynt}) determined depends on the calorific value of all components weight averaged:

$$LHV_{Lsynt} = M_{Lsynt-dry} \left\{ \left(\frac{\%Lign}{100} LHV_{Lign}\right) + \left(\frac{\%Cel}{100} LHV_{cel}\right) + \left(\frac{\%Xyl}{100} LHV_{xyl}\right) \right\}$$
$$- \left\{ \left(M_{Lsynt-w} - M_{Lsynt-dry}\right)(\Delta H_{water}) \right\} \tag{12}$$

where *%Lign*, *%Cel*, *%Xyl* are the composition percentages of the wood, respectively, of lignin, cellulose and hemicellulose; and LHV_{Lign}, LHV_{cel}, LHV_{xyl} represent, respectively, their lower heating value.

The amount of water produced ($Water_{tot}$) by synthetic wood can be determined as the amount of water due to humidity ($water_w$) in addition to the amount of water produced by each single compound of the wood ($water_{comp}$):

$$Water_{tot} = water_w + \sum water_{comp} \tag{13}$$

$$Water_{tot} = M_{Lsynt-dry} \left\{ \left(\frac{\%Lign}{100} water_{Lign}\right) + \left(\frac{\%Cel}{100} water_{cel}\right) + \left(\frac{\%Xyl}{100} water_{xyl}\right) \right\} + \frac{W}{100}$$

where $water_{Lign}$, $water_{cel}$, $water_{xyl}$ represent the amount of water produced by each single principal compound, lignin, cellulose and hemicellulose.

Together with oxygen consumed (M_{O_2}):

$$M_{O_2} = M_{Lsynt-dry} \left\{ \left(\frac{\%Lign}{100} O_{2\,Lign}\right) + \left(\frac{\%Cel}{100} O_{2\,Cel}\right) + \left(\frac{\%Xyl}{100} O_{2\,xyl}\right) \right\} \tag{14}$$

where $O_{2\,Lign}$, $O_{2\,Cel}$, $O_{2\,xyl}$ represent the amount of oxygen consumed by lignin, cellulose and hemicellulose, respectively.

Additionally, carbon dioxide produced (M_{CO_2}):

$$M_{CO_2} = M_{Lsynt-dry} \left\{ \left(\frac{\%Lign}{100} CO_{2\,Lign}\right) + \left(\frac{\%Cel}{100} CO_{2\,Cel}\right) + \left(\frac{\%Xyl}{100} CO_{2\,xyl}\right) \right\} \tag{15}$$

where $CO_{2\,Lign}$, $CO_{2\,Cel}$, $CO_{2\,xyl}$ represent the amount of carbon dioxide produced by lignin, cellulose and hemicellulose, respectively.

To obtain the final amount with respect to the amount of energy to be produced from the reaction products, ($Mf_{C\,O_2}$ and $Water_{tot}\,f$) and the amount of oxygen reagent (Mf_{O_2}) required to produce the required energy, it is necessary to bring these values to the required mass of fuel:

$$Mf_{C\,O_2} = Mass_{fuel-nec} * M_{CO_2} \tag{16}$$

$$Water_{tot} \, f = Mass_{\,fuel-nec} * Water_{tot} \tag{17}$$

$$Mf_{O_2} = Mass_{fuel-nec} * M_{O_2} \tag{18}$$

In this way, the calculations for the theoretical amount of air ($Air_{theoric}$) were developed, knowing that oxygen represents, in terms of mass, around 23.3% in the air, meaning that the relation should be:

$$Air_{theoric} = 4.29 * Mf_{O_2} \tag{19}$$

The necessary excess of air (%*Ea* Table 4) for a complete combustion prevents negative consequences both from the point of view of safety (carbon monoxide formation) and energy (production reaction carbon monoxide is endothermic) and environmental (unburnt carbon particles that are expelled into the atmosphere):

$$Air_{real} = Air_{theoric} + Air_{theoric} \frac{\%Ea}{100} \tag{20}$$

where Air_{real} represents the amount of real air.

3. Results and Discussion

3.1. Calculation of the Raw Material Required for Combustion

The mass of raw material was calculated based on the heating value of each fuel, setting an energy value to reach 1000 MJ. Table 5 shows the results for biomass which requires a greater quantity of material, influenced by the presence of humidity.

Table 5. Mass of fuel required to produce 1000 MJ.

Fuel	Mass$_{nec}$ (kg)	Water Produced by Combustion (kg)	Ea (%)	Real Air (kg)
Methane	20.00	45.00	20	411.84
Diesel	23.35	31.62	35	469.19
Propane	21.58	35.31	30	437.63
Lignin (biomass Kanto Chemical Co.)	49.02	29.41	123	958.75
Cellulose (α-cellulose-fiber form)	60.61	33.67	100	616.30
Xylan (Beachwood)	71.94	39.97	115	655.37
Lignin (a.v in wood)	40.00	24.00	123	782.34
Cellulose (a.v in wood)	56.69	31.49	100	576.47

Moreover, moisture reduces the energy content per unit weight, the combustion efficiency and implies higher transportation costs of biomass [26]; consequently, humidity during combustion produces more steam. In fact, in a wooden biomass such as chips or briquettes, where the composition is more complex and the humidity is higher, there will be more water.

3.2. Stoichiometric Balance of Combustion Reaction

It was established that, through the computational tool of the reaction balancer developed for this work, we could simulate a combustion system mainly (but not only) focusing on the prediction of the amount of water produced. By changing the formula, it automatically balances the reaction, and as output, it calculates the quantity of water and carbon dioxide produced and the theoretical oxygen required for combustion.

3.3. Determination of the Amount of Water Produced Depending on the Composition of the Biomass

Table 6 shows the parameters obtained after entering the bibliographic values of LHV and the mean values of the essential components of biomass: cellulose ($C_6H_{10}O_5$), lignin (as average of its three monomers: $C_9H_{10}O_2$-$C_{10}H_{12}O_3$-$C_{11}H_{14}O_4$) and hemicellulose, since these are the highly variable percentages that are considered average values for biomass of woody origin, as reported in the table, to produce the same quantity of 1000 MJ.

Table 6. Parameters obtained for the different biomass to produce 1000 MJ.

Biomass	LHV (MJ/kg)	Lignin VM (%)	Cellulose VM (%)	Xylan VM (%)	W (%)	Wet Mass (kg)	Lignin (kg)	Cellulose (kg)	Xylan (kg)	Water (kg)
Wood	16.20	28.59	39.88	31.52	20	74.07	21.18	29.54	23.35	48.49
Chips	12.24	28.59	39.88	31.52	30	106.21	30.37	42.36	33.48	74.11
Briquettes	16.92	28.59	39.88	31.52	14	67.38	19.27	26.87	21.24	42.36
Pellets	18.00	28.59	39.88	31.52	12	62.22	17.79	24.82	19.61	38.58

With the mass of each component for these biomasses, the combustion reactions of their main components are therefore valid: oxidation reactions for cellulose, for hemicellulose, and for lignin, were calculated accordingly.

3.4. Calculation of the Heating Value of Synthetic Wood

By knowing the composition of the biomass, it is possible to determine the heating value of the biomass as a weighted average of its components; the lower heating value of this biomass depends on the type of plant of origin, the greater part is strongly influenced by the water content (biomass species might have a different moisture content). Table 7 shows The LHV values, obtained as a weighted average of its components, deviate from the values given by the literature with an average error of 4%, since they are influenced by the humidity chosen within the humidity ranges reported in the literature for wood, briquettes and chips. As mentioned, moisture reduces the energy content per unit weight [26], which consequently leads to the formation of more water vapor than the hydrocarbons normally used for this purpose with the same dissipated energy.

Table 7. Calculated data: LHV, amount of water, CO_2 and O_2.

For 1 Kg of Wood	LHV_{calc}. (MJ/kg)	Err_{exp} (%)	Dry Mass (kg)	W (%)	H_2O_{comp+w} (kg)	O_2 (kg)	CO_2 (kg)
Synthetic Wood	15.48	4.4	0.8	20	0.65	1.09	1.42
Synthetic Chips	13	8.2	0.7	30	0.70	0.96	1.24
Synthetic Briquettes	17	0.5	0.86	14	0.63	1.18	1.53
Synthetic Pellets	17	4.0	0.88	12	0.62	1.12	1.56

Considering the percentages of mass of the main components of the wood, it is possible to obtain a quantity of water equal to m_{H_2O} = 0.70 kg from 1 kg of dry wood.

Figure 1 shows that the orange curve represents the variation of the heating value calculated according to the water content with the same mass of 1 kg and an indication of the values corresponding to the biomass normally used in the combustion heat generators and the blue one represents the quantity of water that could be recovered when the water content varies depending on the type of biomass.

The graph shows how humidity negatively affects the heating value since a certain amount of energy must be spent on the vaporization of the absorbed water [27,28], while the amount of water that could be recovered increases.

The water produced represents a quantity of matter and energy that can be recovered. Table 8 evidences the recoverable thermal power of only water as a product of the combustion reaction. Only the recoverable latent power is considered, this being the most significant that can be recovered, though fumes have not been considered, and consequently the temperature at which they are found and the dew point are not taken into account; therefore, considering the enthalpy of the vaporization of water vapor at 373 K, hfg = 2256.92 kJ/kg [25].
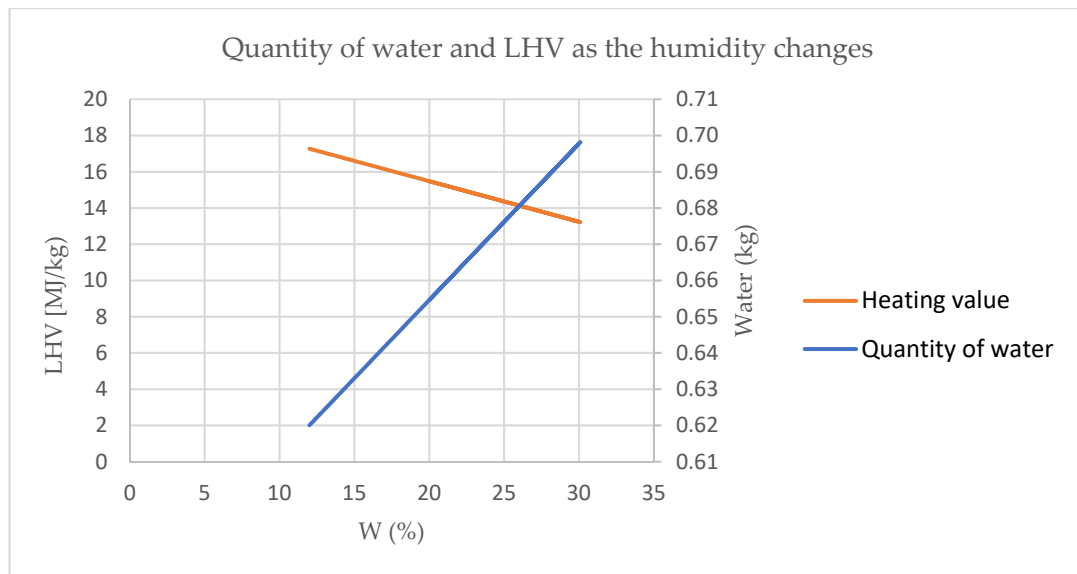
Figure 1. Quantity of water and LHV as the humidity changes.

Table 8. Quantity of water and the energy that it represents.

Calculations in Synthetic Wood (for 1000 MJ)	Mass$_{nec.}$ (kg)	Water$_{tot}$ f (kg)	Water Energy (MJ)
Synthetic wood	64.4	42	95.4
Synthetic wood chips	75.5	53	118.9
Synthetic briquettes	59.4	37	84.3
Synthetic pellets	57.9	35	81.0

It is imperative that a serious and concrete effort should be launched for conserving this energy through waste heat recovery techniques. Such a waste heat recovery would ultimately reduce the overall energy requirement and the impact on global warming. Waste heat is generated in a process by the way of fuel combustion or chemical reaction, and then dumped into the environment even though it could still be reused for some useful and economic purpose. A large quantity of hot flue gases is generated from boilers, furnaces and IC engines. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. However, much of the heat could be recovered and losses be minimized by adopting certain measures. Depending on the temperature level of the exhaust stream and the proposed application, different heat exchange devices, heat pipes and combustion equipment can be employed to facilitate the use of the recovered heat.

4. Conclusions

By simple assumptions, it is possible to calculate to the lower heating value for different biomasses of woody origin considering a weighted average of their major components and moisture.

In the case of woody biomass, the increase in the amount of condensable water proves to be interesting: as can be seen, it is greater than the amount of steam obtained in the case of methane (that is the hydrocarbon having the greatest H/C ratio). This is fundamentally due to the lower heating value which, with the same dissipated energy, requires a greater quantity of material but the presence of humidity in the starting biomass, which increases the quantity of water in the fumes. This obviously leads to the formation of more water vapor than the hydrocarbons normally used for this purpose with the same dissipated energy. From this study, it is therefore evident that the introduction of a technology

capable of recovering the water produced by biomass boilers would be desirable and is still not exploited.

Moreover, the water recovered from biomass combustion could be used to clean fumes or, after purification, be employed in watering.

This study verified with sufficient approximation that the recovery of water is amenable in biomass boilers, constituting this work as a good starting point for a future technology.

Obviously, the air-to-fuel ratio should be taken into account since this could negatively affect the recovery of water when this value is high such as in biomass combustion. In order to have a better model of the real energy and water recovery from a biomass boiler, we are conducting experiments at the laboratory scale. The considerations presented here were of great importance for the design of the experiment.

Abbreviations

E_r	Energy required
LHV	Latent heat value
$M_{ass fuel-nec}$	Mass needed for produce energy required
X_1, X_2, X_3	Derived from the chemical formula of the fuel, subscripts
M_{fuel}	Initial mass of fuel
%W	Percentage of humidity
M_{water}	The quantity of water produced
n_{water}	The moles of water
$M_{fuel\ without-w}$	The amount of fuel without humidity
MM_{water}	The molecular weight of water
MM_{fuel}	The molecular weight of fuel
n_{co2}	The moles of carbon dioxide
n_{o2}	The moles of oxygen
M_{co2}	The amount of carbon dioxide produced
M_{o2}	The amount of oxygen consumed
MM_{co2}	The molecular weight of carbon dioxide
MM_{o2}	The molecular weight of oxygen
$M_{Lsynt-dry}$	The dry mass of synthetic wood
$M_{Lsynt-w}$	Wet mass of synthetic wood
LHVu	The heating value of wet wood
LHVa	The latent heat of vaporization of water
LHV_{Lsynt}	The heating value of synthetic wood
%Lign	Lignin percentages in wood
%Cel	Cellulose percentages in wood
%Xyl	Hemicellulose percentages in wood
LHV_{Lign}	Lower heating value of lignin
LHV_{cel}	Lower heating value of cellulose
LHV_{xyl}	Lower heating value hemicellulose

$Water_{tot}$	The amount of water produced
$water_w$	As amount of water due to humidity
$water_{comp}$	Water produced by each single compound of the wood
$water_{Lign}$	The amount of water produced by lignin
$water_{cel}$	The amount of water produced by cellulose
$water_{xyl}$	The amount of water produced by hemicellulose
$O_{2\ Lign}$	Represent the amount of oxygen consumed by lignin
$O_{2\ Cel}$	Represent the amount of oxygen consumed by cellulose
$O_{2\ xyl}$	Represent the amount of oxygen consumed by hemicellulose
$CO_{2\ Lign}$	Represent the amount of carbon dioxide by lignin
$CO_{2\ Cel}$	Represent the amount of carbon dioxide by cellulose
$CO_{2\ xyl}$	Represent the amount of carbon dioxide by hemicellulose
$Mf_{C\ O_2}$	The final amount of carbon dioxide produced for the required energy
$Water_{tot}\ f$	The final amount of water produced for the required energy
Mf_{O_2}	The final amount oxygen consumed for the required energy
$Air_{theoric}$	Theoretical amount of air
$\%Ea$	Excess of air
Air_{real}	The amount of real air.

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