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THE CHARACTERISTIC VALUES OF WOOD FUEL, NATURAL GAS AND PROPANE-BUTANE MIX COFIRING

KURINĀMĀS KOKSNES, DABASGĀZES UN PROPĀNA-BUTĀNA MAISĪJUMA KOMBINĒTĀS DEGŠANAS PROCESU RAKSTUROJOŠIE LIELUMI

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Introduction

Wood fuel, natural gas and mix of propane-butane are very common fuels to provide heating and hot water supply. Some figures to characterize the combustion of these fuels are presented in the article and the comparison of combustion air and flue gas to produce 1 MWh of heat is carried out for the natural gas and wood fuel cofiring.

It is assumed that natural gas composition is following (in vol. %): methane - 97,6%, ethane - 1,00%, propane - 0,35%, butane - 0,13%, pentane - 0,02%, hexane - 0,01%, carbon dioxide - 0,05%, nitrogen - 0,84%. For this composition theoretically necessary combustion air V^o=9,59 m^3/m^3, volume of CO_2 - V_{CO_2}=1,01 m^3/m^3, theoretical nitrogen volume $V^o_{N_2}$=7,59 m^3/m^3, theoretical water vapor volume $V^o_{H_2O}$=2,17 m^3/m^3, theoretical total volume of flue gas $V^o_{d.g.}$=10,77 m^3/m^3. If to burn natural gas with air excess α=1,05, then actual total volume of flue gas $V_{d.g.}$=11,26 m^3/m^3.

The lower heating value for natural gas Q_z=9,37 kWh/m^3. The consumption of natural gas to produce 1 MWh of heat is depending on boiler efficiency (Table 1).

Table 1.

The amount of natural gas to produce 1 MWh of heat

Boiler efficiency η_k	0,88	0,90	0,92
The consumption of natural gas B, m^3/MWh	121,3	118,6	116,0

If to improve boiler efficiency and respectively to reduce the consumption of natural gas then the volume of flue gas components is decreasing too (Table 2).

Table 2.

The volume of flue gas components

Air excess α=1,05			
Boiler efficiency η_k	0,88	0,90	0,92
$V_{CO_2\,1MWh}$	122,9	120,2	117,6
$V_{N_2\,1MWh}$	966,2	944,7	924,2

The changes of air excess influence the maximal temperature to be reached in the combustion process (Table 3).

Table 3.

The maximal temperature in the combustion process of the natural gas

Air excess α=1,00	Air excess α=1,05	Air excess α=1,10
1904,6	1836,8	1774,2

Wood fuel and natural gas can be used in various proportions if to organize cofiring process. Let us suppose that total amount of heat produced during cofiring process Q=1 MWh (3600000 kJ). The quantities of wood fuel with moisture 40% and natural gas to produce mentioned above Q=1 MWh are presented in table 4. It is assumed that boiler efficiency is 0,8 for wood combustion and 0,9 for natural gas combustion.

Table 4.

The consumption of wood fuel and natural gas in cofiring process

The fraction of natural gas	Heat produced from natural gas, kJ	Consumption of natural gas, m^3	Heat produced from wood, kJ	Consumption of wood fuel to be burnt, kg
1,0	3600000	118,59	0	0,0
0,8	2880000	94,87	720000	87,5
0,6	2160000	71,15	1440000	175,0
0,4	1440000	47,44	2160000	262,5
0,2	720000	23,72	2880000	350,0
0,0	0	0,00	3600000	437,5

Figures 1 and 2 are giving the total volumes of carbon dioxide $V_{CO_2\,1MWh}$ and nitrogen $V_{N_2\,1MWh}$ corresponding to the various proportions of natural gas and wood fuel.

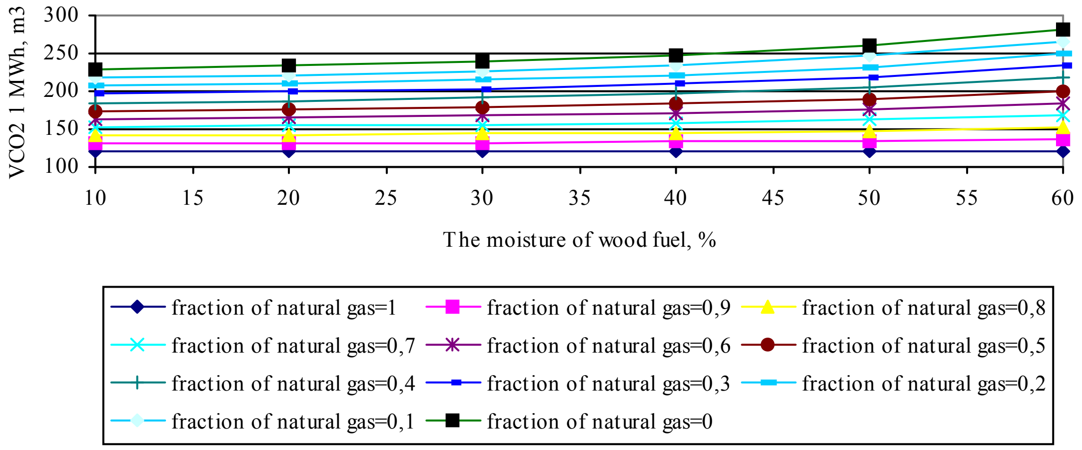

Figure 1. The total volumes of carbon dioxide $V_{CO_2\,1\,MWh}$

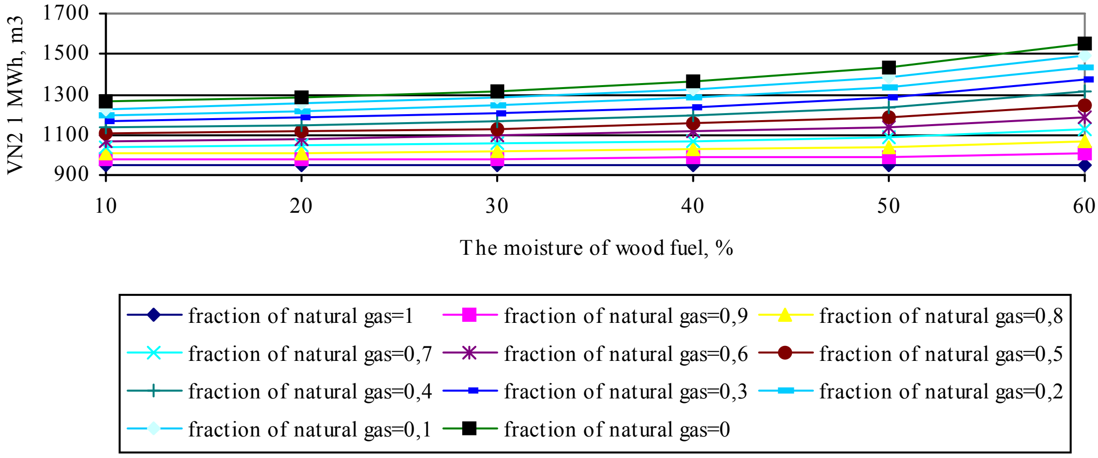

Figure. 2. The actual total volumes of $V_{N_2\,1\,MWh}$

Air excess for natural gas α=1,05, for wood fuel α=1,4

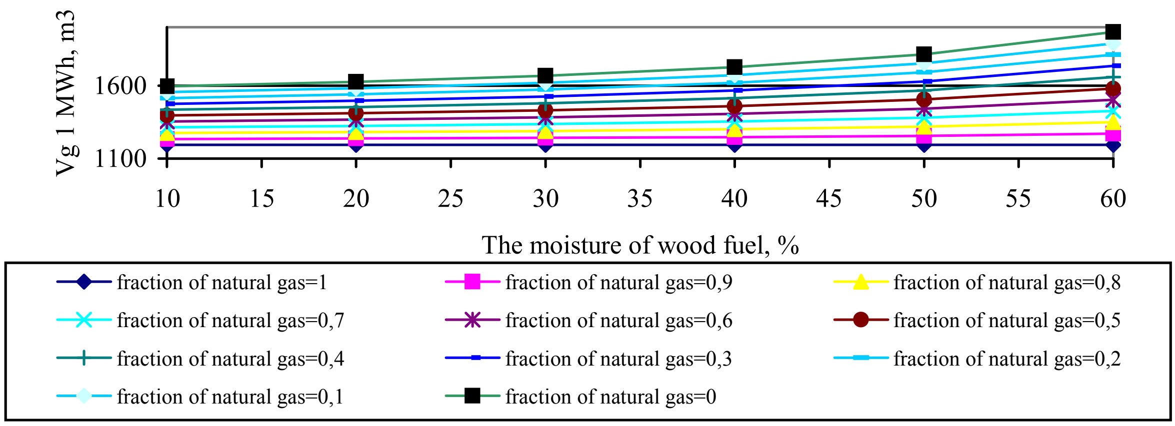

Figure. 3. The changes of combustion air volumes as function of natural gas fraction and wood fuel moisture

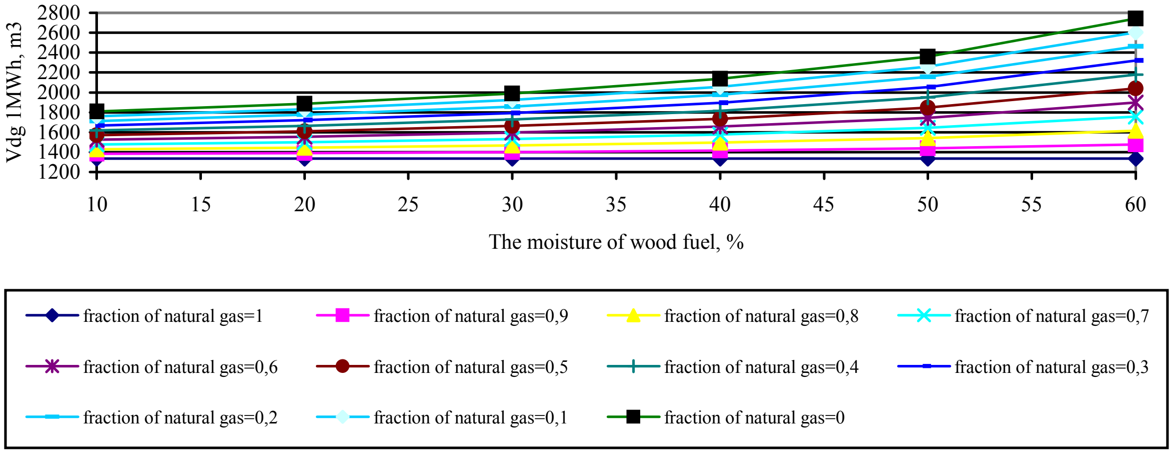

Figure. 4. The changes of flue gas volumes function of natural gas fraction and wood fuel moisture

The changes of combustion air and flue gas volumes depending on different natural gas fractions and wood fuel moisture are presented in figures 3 and 4. As it results from figure 3, the decrease of natural gas fraction in cofiring leads to growing of combustion air necessary for complete combustion. The supply of combustion air must be increased also if the moisture of wood fuel is growing.

The natural gas can be replaced by propane-butane mix. It is supposed that the mix of propane-butane consists of 50% propane and 50% butane.

In this case theoretically necessary combustion air, the theoretical volumes of flue gas components and total theoretical volume of flue gas are following - V^o=27,37 m^3/m^3, V_{CO_2}=3,5 m^3/m^3, $V^o_{N_2}$=21,6 m^3/m^3, $V^o_{H_2O}$=25,1 m^3/m^3, $V^o_{d.g.}$=29,6 m^3/m^3.

Like in case of natural gas the total volume of flue gas is depending on air excess α. If the air excess α=1,05, then the actual volume of flue gas $V_{d.g.}$=31,0 m^3/m^3.

The consumption of propane-butane mix to produce 1 MWh of heat is depending on boiler efficiency and composition of the propane-butane mix. The consumption of propane-butane mix if to consider that it consists of 50% propane and 50% butane is presented in Table 5.

Table 5.

The consumption of propane-butane mix

Boiler efficiency η_k	0,88	0,90	0,92
B, m^3/MWh (50% propane+50% butane)	37,7	36,9	36,1

The volumes of emissions generated during the process of propane (50%) and butane (50%) combustion (Q=1 MWh) are varying depending on boiler efficiency and air excess α (Table 6).

Table 6.

The volumes of emissions generated (propane 50% + butane 50%)

Air excess α=1,05			
Boiler efficiency η_k	0,88	0,90	0,92
$V_{CO_2\,1MWh}$	132,0	129,1	126,3
$V_{N_2\,1MWh}$	856,3	837,3	819,1

The maximal possible temperature in the combustion process depends on air excess (Table 5).

Table 7.

The maximal temperature in the combustion process of the propane-butane mix

	Air excess α=1,00	Air excess α=1,05	Air excess α=1,10
50% propane+50% butane	2201,4	2117,1	2040,0

The obtained data enables one to estimate the applicability of fuels from the various points of view like prices, the amounts of flue gas, level of environmental taxes, temperatures to be achieved and so on.

The conclusions which can be made from these calculations are:

- the cofiring process has some advantages compared with only wood fuel combustion;
- the cofiring process reduces combustion air volume reducing in such a way electricity consumption for ventilators;
- the volumes of carbon dioxide and nitrogen are reduced in cofiring process thereby the consumption of electricity for flue gas ventilators can be reduced;
- the addition of natural gas when burning wood fuel allows to intensify drying, ignition and combustion processes in such a way utilizing more efficiently wood fuel resources and stabilizing the combustion process.

The results can be used for designing of cofiring furnaces.

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Gedrovičs M. Kurināmās koksnes, dabasgāzes un propāna-butāna maisījuma kombinētās degšanas procesu raksturojošie lielumi.

Kurināmā koksne, dabasgāze un propāna-butāna maisījums ir ļoti izplatīti kurināmie apkures un karstā ūdens apgādes nodrošināšanai. Darbā aplūkotas kurināmās koksnes un dabasgāzes patēriņa, kopējā oglekļa dioksīda un slāpekļa reālā tilpuma un arī degšanai nepieciešamā gaisa un dūmgāzu kopējā tilpuma izmaiņas atkarībā no dabasgāzes daļas un koksnes mitruma, sadedzinot kombinēto kurināmo, lai saražotu 1 MWh siltumenerģijas. Daži aprēķini veikti propāna-butāna maisījumam, kas var aizstāt dabasgāzi. Parādīts, ka kombinētai kurināmo sadedzināšanai ir dažas priekšrocības, salīdzinot ar vienas pašas kurināmās koksnes sadedzināšanu – samazinās degšanai nepieciešamā gaisa un dūmgāzu tilpumi, kas, savukārt, samazina gaisa ventilatoru un dūmu sūkņu elektroenerģijas patēriņu. Dabasgāzes piejaukšana, sadedzinot kurināmo koksni, ļauj intensificēt koksnes žūšanas, uzliesmošanas un degšanas procesus, tādējādi ļaujot efektīvāk izmantot kurināmās koksnes resursus un stabilizēt degšanas procesu. Iegūtie dati ļauj novērtēt kurināmo piemērotību kombinētai sadedzināšanai no dažādiem aspektiem, ņemot vērā cenas, dūmgāzu daudzumu, dabas resursu nodokļus, sasniedzamās temperatūras utt. Rezultātus var izmantot kombinētās sadedzināšanas kurtuvju projektēšanai.

Gedrovičs M., The characteristic values of wood fuel, natural gas and propane-butane mix cofiring.

Wood fuel, natural gas and mix of propane-butane are very common fuels to provide heating and hot water supply. Some figures like the consumption of wood fuel and natural gas, the total volumes of carbon dioxide, the actual total volumes of nitrogen, the changes of combustion air and flue gas volumes as function of natural gas fraction and wood fuel moisture are presented for natural gas and wood fuel cofiring process to produce 1 MWh of heat. Some calculations are done for the propane-butane mix which can replace the natural gas. It is shown that the cofiring process has some advantages comparing with only wood fuel combustion - reduced volumes of combustion air, carbon dioxide and nitrogen reducing in such a way electricity consumption for air ventilators and flue gas ventilators. The addition of natural gas when burning wood fuel allows to intensify drying, ignition and combustion

processes accordingly utilizing more efficiently wood fuel resources and stabilizing the combustion process. The obtained data allows estimating the applicability of fuels for cofiring from the various points of view like prices, the amounts of flue gas, level of environmental taxes, temperatures to be achieved and so on. The results can be used for designing of cofiring furnaces.

Гедрович М., Некоторые характеристики совместного сжигания топливной древесины, природного газа и пропанобутановой смеси.

Топливная древесина, природный газ и пропанобутановая смесь являются распространенными видами топлива для обеспечения отопления и горячего водоснабжения. В работе представлены расчеты расхода древесины и природного газа, общего объема CO_2 и фактического объема азота, а также изменения объема воздуха и дымовых газов в зависимости от доли природного газа и влажности топливной древесины при совместном сжигании для производства 1 МВтч тепловой энергии. Некоторые расчеты проведены для пропанобутановой смеси. Показано, что комбинированное сжигание имеет некоторые преимущества по сравнению с сжиганием одной только древесины – уменьшаются объемы необходимого воздуха и дымовых газов, что уменьшает расход электроэнергии для привода вентиляторов и дымососов. Подмешивание природного газа при сжигании топливной древесины позволяет интенсифицировать процессы сушки, воспламенения и горения древесины, стабилизируя при этом процесс горения. Полученные результаты позволяют оценить совместное сжигание, учитывая разные факторы. Результаты могут быть использованы для проектирования топок совместного сжигания.