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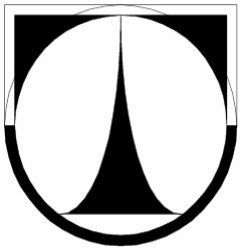

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INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

QUALITY OF FUEL GASES IN SPECIFIC PERIODS

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Abstract: *At the Slovak University of Agriculture in Nitra it is realised research of drying in agriculture and research of thermodynamics of combustion of natural gas for heating of drying medium, uninterrupted from 1968. Purveyor of natural gas, SPP in Bratislava, publishes every month on Internet composition of delivered natural gas. Authors present their work in which they present arithmetical average values for every year of composition of natural gas and of thermodynamical parameters of this gas and its stechiometric combustion gases in the years 1977 and 2006 to 2010. They note that the delivered natural gas is extraordinary pure and his composition is without changes constant.*

1. Introduction

At our Slovak University of Agriculture in Nitra is realised continuously from the year 1968 research of drying in agriculture and research of thermodynamics of combustion gases from natural gas used for heating of the drying medium. In drying plants in agriculture it was used natural gas from Russia as heat source for heating the drying medium. It is the cleanest fuel gas with constant characteristics. Authors therefore studied thermodynamics of the process of drying and also thermodynamics of combustion of natural gas which was used for heating of the hot drying medium.

Authors present in their paper parameters of natural gas in the period of research and present a method for calculations of stechiometrical thermodynamical parameters.

2. Supply of natural gas

Authors present as first information composition of natural gas which was supplied in the year 1977 from former ZEZ n.p. in Bratislava. Contemporary natural gas supplier, SPP a.s. in Bratislava, presents on his web sides regularly every month detailed in laboratory appointed composition of delivered natural gas.

Authors took from Internet this characteristics for supplies in years 2006 to 2010 [6].

From these monthly values they calculated annual arithmetical average values of natural gas composition, which are inserted in the table No 1.

3. Natural gas parameters

Authors realised calculations of thermo-dynamical parameters of natural gas with method of thermodynamics of gas mixtures in their manuals HAVELKA [1] and VITÁZEK [3] and in their common work VITÁZEK-HAVELKA [4].

All calculations were realised in SI system for a mass unit of the gas 1 kg. Converting to other volumetric units, fixed with temperature and pressure, is very simple. Also it were realised calculations of stechiometrical thermodynamical parameters in volumetric dependence for temperature 15°C, pressure 101.325 kPa and relative humidity equal to zero, prescribed with Ministry of Economy SR [6] in intimation No. 559/2007.

Stechiometrical thermodynamical parameters of combustion gases are calculated as process of combustion which occurs exactly in mass concentrations relevant to chemical relation.

In this calculations authors used exact values of enthalpy of individual gases in the mixtures , input natural gas with atmospheric air and output combustion gases, from thermal tables

RAŽNJEVIČ [2]. Following to this knowledge's authors prepared a computer program in Q-Basic for calculations of parameters of pure natural gas and its combustion gases as accessory in the work VITÁZEK-HAVELKA [4].

Authors demonstrated with analysis of composition of natural gas that it is supplied from several sources (bores): 1.source, supplied in the year 1977, 2.source, supplied in the years 2006 to 2008, 3. source, supplied in the years 2009 and 2010. Authors compiled of information's from suppliers the table No.2 in which are arithmetical average values of composition of natural gas in relevant periods and present calculated stechiometrical thermodynamical parameters.

These calculations are realised with computer program from the work VITÁZEK-HAVELKA [5]. Composition of this natural gas create only hydrocarbons, the greatest part is methane CH_4 in quantity 91.68 to 97.173% of volumetric concentration. The whole quantity of hydrocarbons is from 97.50 to 98.99% of volumetric concentration.

4. Price relations

Account for delivered natural gas from ZEZ n.p. in Bratislava in the year 1978 was 0.83 Kčs per one normal cubic meter with temperature 20°C and pressure 101.325 kPa. In this time 1 Kčs was equal to 1 Sk.

Invoice for natural gas delivered with SPP a.s. in Bratislava in the season 2010/11 for one normal cubic meter of natural gas, with temperature 15°C and pressure 101.325 kPa was 0.4697 € which is equal to 14.15 Sk .

Increase of the price of natural gas evoked sensible reduction of drying of forages in agriculture and leads to ever growing effort of better utilisation of energy in the natural gas.

5. Conclusion

Natural gas which is in this time delivered is extraordinary pure. Combustible hydrocarbons create in the whole mass volume of this natural gas. Greatest part is methane CH_4. Composition of delivered natural gas is in the whole time practically without changes, constant. Therefore the calculated thermo-dynamical parameters are the same for all appreciated time sections. Differences are very slight, insignificant. In practice is therefore possible to use above mentioned average values from the period 2006 to 2010 for all calculations of thermodynamical parameters.

Carbon dioxide which is produced in combustion of natural gas, is considered as harmful greenhouse gas, though even if it is the alone resource of carbon for growing of vegetable kingdom. Authors demonstrated, that quick, detailed and precise calculations were realised with advantage with computer program in Q-Basic.

Authors express their great gratitude to SPP a.s. in Bratislava. Realisation of this work, and also of more others, is possible only thank to SPP which publishes in Internet detailed laboratory values of composition of delivered natural gas.

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Table No 1: Natural gas parameters in specific years

YEAR	1977	2006	2007	2008	2009	2010
COMPOSITION						
Methane CH_4	91,68	97,250	97,46	97,385	96,806	96,97
Ethane C_2H_6	4,09	1,183	1,078	1,123	1,462	1,407
Propane C_3H_8	1,18	0,369	0,342	0,352	0,462	0,437
Iso-Butane C_4H_{10}	0,44	0,0542	0,0517	0,0525	0,0675	0,065
n-Butane C_4H_{10}	0,0625	0,057	0,0583	0,0742	0,0716	0,072
Iso-Pentane C_5H_{12}	0,13	0,0117	0,0108	0,01	0,0158	0,0133
n-Pentane C_5H_{12}	0,0108	0,01	0,01	0,01	0,01	0,01
Hexane et more C_6H_{14}	0,07	0,017	0,01	0,01	0,0233	0,0117
Carbon dioxide CO_2	0,58	0,184	0,15	0,163	0,226	0,179
Nitrogen N_2	1,83	0,854	0,689	0,836	0,856	0,819
Hydrocarbons total	97,59	98,95	99,02	99,00	98,97	98,98
Parameters from supplier						
Relative density		0,5737	0,5704	0,5715	0,5751	0,5737
Density kg/Nm^3		0,7009	0,6990	0,6999	0,7048	0,7031
Heat value kJ/Nm^3	34307	34279	34281	34426		
kWh/Nm^3				9,522	9,563	9,564
Heat of kJ/Nm^3	38044	38005	38018	38188		
combustion kWh/Nm^3				10,561	10,608	10,604
Sulphur content mg/Nm^3		0,308	0,108	0,044	0,034	0,044
Wobbe Index MJ/m^3		50,3	50,32			
from c.h. kWh/m^3				13,96	13,98	13,99
Emissions factor $kgCO_2/GJ$		55,24	55,19	54,98	55,18	55,34

1 Nm^3 standard state: t = 15°C, p = 101.325 kPa, $\varphi = 0$
Volume parts of individual gases are expressed in % of volumetric concentration.

Table No 2: Natural gas stechiometric parameters at various sources

Gas sources **Season**	**1. source 1977**	**2. source 2006-8**	**3. source 2009-10**	**2006-10**
Average composition				
Methane CH_4	91,68	97,37	96,89	97,17
Ethane C_2H_6	4,09	1,128	1,434	1,250
Propane C_3H_8	1,18	0,354	0,449	0,392
Iso-Butane C_4H_{10}	0,44	0,0528	0,0663	0,0581
n-Butane C_4H_{10}		0,0593	0,0663	0,0581
Iso-Pentane C_5H_{12}	0,13	0,0108	0,0146	0,0123
n-Pentane C_5H_{12}		0,0103	0,01	0,0101
Hexane et more C_6H_{14}	0,07	0,0106	0,0175	0,0133
Carbon dioxide CO_2	0,58	0,166	0,202	0,180
Nitrogen N_2	1,83	0,793	0,837	0,811
Hydrocarbons total	97,59	98,99	98,95	98,97
Calculated parameters				
Density kg/Nm^3	0,7441	0,6960	0,7007	0,6079
Relative density	0,6075	0,5683	0,5721	0,5698
Heat value kJ/kg	47390	48945	48837	48902
Heat of combustion kJ/kg	52532	54402	54266	54347
Wobbe Index from c.h. MJ/m^3	45,24	45,19	45,24	45,21
Emissions factor $kgCO_2/GJ$	56,06	55,34	55,41	55,37
Mass of C in 1kg NG kg/kg_g	0,725	0,739	0,739	0,739
Mass of H_2 in 1kg NG kg/kg_g	0,230	0,244	0,243	0,244
Mass of the dry air kg/kg_g	16,238	16,885	16,834	16,863
CO_2 in combustion gas kg/kg_g	2,657	2,709	2,706	2,708
H_2O in combustion gas kg/kg_g	2,057	2,183	2,171	2,178
Temperature of hot gases °C	2025	2013	2014	2013
Enthalpy of comb. gas kJ/kg	2749,8	2737,0	2738,7	2737,7

Volume parts of individual gases are represented in % of volumetric concentration.