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M.P. Andriyishyn, PhD, K.I. Kapitanchuk., PhD, N.M. Andriyishyn,
(National Aviation University, Ukraine)

Energy efficient usage of natural gas criterias

Authors suggest to provide certain set of actions to process natural gas into so called clean "pipeline quality dry gas" at wells or gas-processing plants to improve gas parameters to be closer to European Union standards

EU has implemented special systems to effectively use of natural gas and adjust pricing according to gas properties. Standart EN 437:2012 and EN 437:2012 IDT was implemented in Ukraine as "ДСТУ EN 437: 2014 Випробувальні гази. Випробувальний тиск. Категорії приладів (EN 437: 2012,IDT, EN 437: 2012, IDT)" [1].

EN 437:2018 serves as a reference document in the specific standards for appliances that fall within the scope of the Council Directive on the approximation of the laws of Member States concerning gas appliances 2009/142/EC. It specifies the test gases, test pressures and categories of appliances relative to the use of gaseous fuels of the first, second and third families for different Wobbe index (sheet 1).

Sheet 1

Classification of gases of different families for different Wobbe indexes

Gas family	Wobbe index at 15°C and 1013,25 Mbar			
	min		min	
	MJ/Nm³	MJ/Nm³	MJ/Nm³	MJ/Nm³
First family - Group A	22,4	6,27	24,8	6,94
Second family - Group H - Group L - Group E	39,1 45,7 39,1 40,9	10,95 12,80 10,95 11,45	54,7 54,7 44,8 54,7	15,32 15,32 12,54 15,32
Third Family - Group B/P - Group P - Group	72,9 72,9 72,9 81,8	20,41 20,41 20,41 22,90	87,3 87,3 76,8 87,3	24,44 24,44 21,50 24,44

To determine proper range of natural gas groups usage term "TEST GAS" used on gas-using machinery. Test gases are gases used for measurement of technological parameters of devices that are using natural gas. Test gases are divided as standard (etalon) gases and calibration gases [1].

Comparison of properties for natural gases that are subjected to ДСТУ ISO 13686:2015 a presented in sheet 2 and sheet 3.

Test gases for gaseous fuels of second family

Gas type	type	composition %	*Ws*, MJ/Nm³	*Hs*, MJ/Nm³	*d*	Pressure, *P* Mbar
Main gas, effective burning	G20	CH_4= 100	50,72	37,78	0,555	*P*n = 20 *P*min=17 *P*max =25
Partial burn, soot	G21	CH_4= 87 C_3H_8= 13	54,76	45,28	0,684	
Flame separation point	G222	CH_4= 77 H_2= 23	47,87	31,86	0,443	
Flame lift-off	G23	CH_4= 92,5 N_2=7,5	45,66	34,95	0,586	

According to GTS codex [3] minimal methane number for gas proportions is MN=77. Thus demands for quality of natural gas that is used in GTS and delivered to consumers are higher then EN 16726:2015 and are compared to ДСТУ ISO 13686: 2015 requirements.

According to GTS codex, transport operator provides data of all chemical and physical properties of gas being transported for other operators of connected systems or connected consumer subjects with. Physical-chemical data passport. Natural gas PCD from such passports and deviations from GTS codex numbers of ДСТУ ISO:13686:2016 and EN 16726:2015 are presented in sheet 4.

Apparently natural gas PCD and highest burn heat temperature for most chosen routes are in range of boundaries set by GTS codex except of route M1204. In case of route M1204 deviation of natural gas burn heat temperature from test gas G20 increases from 0.4% to 4.2%.

This means that PCD of natural gas delivered by route M1204 is in range of allowed but the statement that M1204 gas effective is false. Wobbe index differs from test gas G20 numbers by 0.6% to 4.6% from optimal for different routes but in case of M1204 Wobbe index is 8.8% higher than optimal.

Methane number (as in EN 16726:2015) influence on gas burn efficiency is researched in [5]. According to [3] methodology minimal methane number MNk for natural gas that is used in GTS is calculated to fit GTS codex parameters. These calculations show minimal methane number of Mnk=75 for natural gas mixture of: methane – 90%, ethane – 2.5%, propane – 2%, butane – 1%, pentane – 0.5%, nitrogen – 2.98%, carbon dioxide – 1%, oxygen – 0.02%.

Suggests that Wobbe Index is one of the main criteria when determining quality of natural gas for natural gas Interchangeability from different sources ДСТУ ISO:13686:2016. For effective natural gas combustion the Wobbe Index Ws gas of should not differ form Ws of gas G20 by more than 2 percent.

Especially in cases where equipment designed precisely to work with G20 gas. In that case it is necessary to adjust gas pressure or substitute machine design for different gas usage. Methane number that is corrected by Wobbe Index could be another criteria of quality of gas determination.

Natural gas quality comparison

Burn parameters								
Name		Sign	Units	GTS codex	ДСТУ ISO 13686:2016 (Group H – DVGW G260:2008)	EN 16726: 2015	Poland (gas class E) GAZ - SYSTEM	Slovakia EUSTREAM
Wobbe index	Full range	*Ws*	kW-h/m^3	12,05…15,40	12,8…15,7	–	12,5…15,8	13,4…14,3
			MJ/Nm^3	42,47… 55,42	46,1…56,5	–	45,0…56,9	48,3…51,5
	Nominal		kW-h/m^3	–	15,0	–	–	–
			MJ/Nm^3	–	54,0	–	–	–
	Deviations		kW-h/m^3	–	-1,4…+0,7	–	–	–
Highest burn temperature		$H_{S,n}$	kW-h/m^3	10,8…11,42	9,5…13,1	–	Higher than 10,56	9,96…11,9
			MJ/Nm^3	38,85…41,1	34…47	–	Higher than 38,0	35,86…42,8
Relative density		d_n	–	0,55…0,70	0,55… 0,70	0,55…0,70	–	0,55…0,7
pressure (full range)		*p*	kW-h/m^3	10,8…11,42	9,5…13,1	–	Higher than 10,56	9,96…11,9
Methane number		*MN*	MJ/Nm^3	38,85…41,1	34…47	–	Higher than 38.0	35,86…42,8
Additional partical	Water dew point	–	^{0}C	no higher (-8)	Soil temperature	-8	-5.5 з 1.10 по31.03 3,7 з 1.04 по 30.09	-8
	Hydrocarbon dew point	–	^{0}C	no higher 0	Soil temperature	-2	0	0
	myst, dust, liquid	–	mg/m^3		absent		1,0	
	Oxygen: in dry system in damp systemy	–	%	absent	 3 0,5	 – –	 – –	 – –
	Sulfur	–	mg/m^3	6	30 a	20	40	20
	Mercaptans	–	mg/m^3	20	6	no higher 6	16	5
	hydrocarbons	–	mg/m^3	–	5	5	–	2

PCD of natural gas of different operators and deviations from test gas G20

AT parameters	GTS codex	ДСТУ ISO 13686 G20	EN 16726 :2015	Sumygas	Sumygas Chernigiv gas	Lvivgas	Lvivgas	Ivano-Frankivsk gas	Volyngas	Volyngas
				M 71	M 166	M 246	M 1204	M 404	M 208	Lokachi
Methane, %	min 90	100	-	96,2982	89,7835	94,69	71,476	92,9976	91.3773	93,2261
Ethane, %	max 7	-	-	2,001	4,8953	2,73	14,977	3,456	4.2262	2,4891
Propane,%	max 3	-	-	0,6380	1,1392	0,783	8,28	1,3814	0.9952	0,6669
Butane, %	max 2	-	-	0,197	0,3304	0,2476	2,698	0,6704	0.2771	0,181
Pentane etc., %	max 1	-	-	0,0438	0,2014	0,547	0,6	0,3415	0.1214	0,1217
N, %	max 5	-	-	0,6730	1,6672	0,9413	1,153	0,5672	1.4018	3,1644
C, %	max 2	-	2,5	0,143	1,979	0,5093	0,51	0,5819	1.596	0,1367
O, %	max 0,02	-	0,001	0,006	0,0040	0,0042	0,09	0,004	0.005	0,0141
Methane number	75		65	83.8	76.3	79.0	51.9	76.9	78.1	82
% deviations Code/EN				11,7 28.9	1,7 17.3	5,3 21.6	-30,8 -20.2	2,5 18.3	4,1 20.2	9,3 26.2
Burn temperature kW-h/m^3(MJ/Nm^3)	10.06…10.64 (36.2…38.3)	10.49 (37,78)	-	10,53 (37,92)	10,63 (38,27)	10,57 (38.07)	13,52 (48,7	10,94 (39,38)	10.59 (38.12)	10,346 (37,2469)
% deviation from G20			-	0,37	1,297	0,768	28,9	4,235	0,9	-1,411
Wobbe number kW-h/m^3(MJ/Nm^3)		14,08 (50.72)	-	13,85 (49,85)	13,45 (48,41)	13,77 (49.56)	15,32 (55,2	14,0 (50,41)	13.52 (48.68)	13,4348 (48,3652)
% deviation from G20			-	-1,715	-4,554	-2,287	8,833	-0,611	-4,022	-4,643
Density, kg/m^3	0.55…0.75	0.668	0.55…0.7	0,697	0,7528	0,7106	0,9376	0,7349	0.7383	0,7143
% deviation from G20				4,341	12,695	6,377	40,359	10,015	10,524	6,931
Dew point ^{o}C	-8	-22,9	-8	-13,3	-13,2	-		15,3	-8,6	-7,9

Authors suggest minimal methane number of MN=65 defined by EN 16726:2015 is not sufficient. It is proven that even in case of higher combustion energy output for gas with Wobbe Index significantly lower of G20 gas test values the overall efficiency of using this gas in particular burner system is much lower. Flame flow for natural gas in streams M166 and M208 is closer to wrinkles due to chemical mixture of gas and natural gas in M1204 stream creates "yellow tipping" due to incomplete combustion, sulfur content similar to G21 test gas. With mediocre combustion energy output same burners consume more natural gas to provide same amount of energy.

Natural gas from stream M404 has almost ideal mixture of components. Its Wobbe Index is 50,41 MJ/Nm^3 but hydrocarbon dew point of 15.3°C at P=3.92 MPa. That indicates relative humidity of 100%. Specific humidity of gas in stream is 0.44 grams per cubic meter that is dangerous for creating natural gas hydrates, solid clathrate compounds that may damage machinery or obstruct pipeline flow.

Authors suggest to provide certain set of actions to process natural gas into so called clean “pipeline quality dry gas” at wells or gas-processing plants to improve gas parameters to be closer to European Union standards.

As for government policies they have to be reworked from using “energy saving” term to “energy efficiency” term and start improving on efficient usage of natural gas by approving and applying newest energy efficient technologies and machinery into gas transport\consumer network.

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