Research for the Exhaust Gas at Natural Gas Combustion Hobs

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Abstract

The present research was conducted in order to investigate the accuracy of the measurements carried out in the combustion hobs with natural gas fuel. An important conclusion about the exhaust gas in the combustion hobs with natural gas, independently harmonized or not with the Greek legislation, is that the wall-mounted boilers are given to the atmosphere more CO per KW than the classic floor-standing boilers. Another conclusion about the technicians, is that 26.3% of them do not have the necessary license, 19.3 % of them do not have an exhaust gas analyzer at all, but the 70.2 % of them use an exhaust gas analyzer on the first start and on the maintenance this percent drops down to 52.7 %.The conclusions show us that we have to take action about the exhaust gas limits of the wall-mounted boilers and also about the technical people.

Keywords

Natural gas, measurements, exhaust gas, combustion hobs

1. Introduction

Based on Greek legislation, the choice of combustion hobs with natural gas was made because they must issue an official exhaust gas control sheet during the first start. This obligation to issue an exhaust gas control sheet at the beginning is not required for combustion hobs that work with other fuels in the Greek market. From the data collected for the research, it was found that the measurements of the exhaust gases written on the control sheets are not always correct and accurate. This is mainly due to the fact that some wall-mounted boilers circulating in the Greek market, in their manufacturer's technical manual, have delimited some of the measurement values in the exhaust gases, higher than the Greek legislation. Also, during the collection of data for the research, it was found that measurement technicians used analyzers that did not perform all the required measurements.

2. Methodology and Data

The research is based on data from official exhaust gas control sheets and a public poll via google docs, which had been promoted throe social media. The data from the sheets were collected from the office of technical services belonging to the municipality of Larissa and finally from technicians with the necessary natural gas licenses. Those data have been collected, categorized, and analyzed properly. The conclusions were very interesting about the way that technicians work and the specifications of wall-mounted boilers circulating in the Greek market. Natural gas boilers were categorized into three big categories. The first category is wall-mounted boilers, the second category is floor boilers, and the third category is instantaneous water heaters. The total number of boilers encompassing those three categories was 351. More precisely, we have 135 wall-mounted boilers, 211-floor boilers, and 5 instantaneous water heaters. In a public poll, take part and answer the questions of 57 people. All of them were technicians who provided maintenance services for natural gas boilers. The public poll was promoted via social media to take part technicians from all over Greece.

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2.1. Conclusions for the Technicians

From the data collected through the public poll, we can see that most technicians in Greece have the necessary license with 73.7 % (Figure 1).

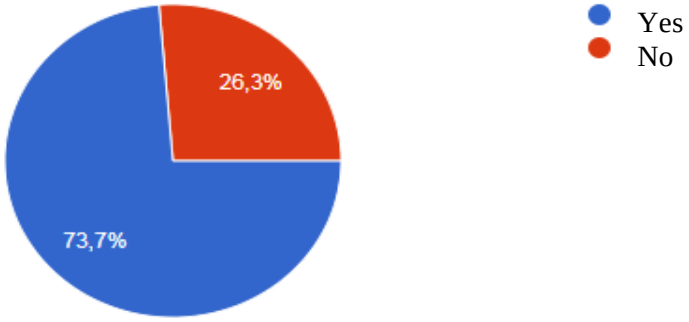

Figure 1: Licensed technicians.

But this number does not agree with the question about the profession of the participants. In the question about the profession 52.6 % answered that they are combustion technicians and 40.4 % are mechanics (Figure 2). The Greek laws give the mechanics the license to provide maintenance services for natural gas boilers when they finish university. Still, the combustion technicians give the license after some years of proven experience in their occupation and after examinations. If all those technicians had the license with the mechanics together would be 93.0 % of participants with the license. But according to the previous question, only 73.7 % have a license. So, 19.3 % of technicians in Greece provide maintenance services for natural gas boilers without the necessary license.

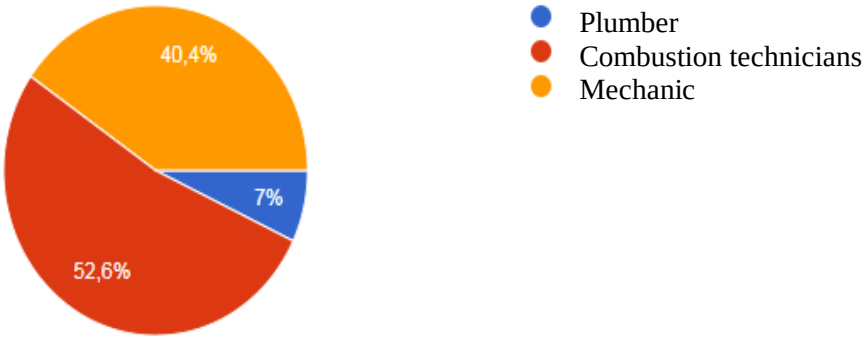

Figure 2: Technicians' occupation.

The next questions are about the use of an exhaust gas analyzer. The first question was about if the technicians had an exhaust gas analyzer, a critical tool for natural gas boilers that give technicians all the necessary measurements to adjust the burner efficient. Using the exhaust gas analyzer from the technicians is also critical in the first start or yearly maintenance to eliminate the risk of producing harmful to the health exhaust gas. In this question 80.7 % answer that they have exhaust gas analyzer and the rest of them dose not (Figure 3).

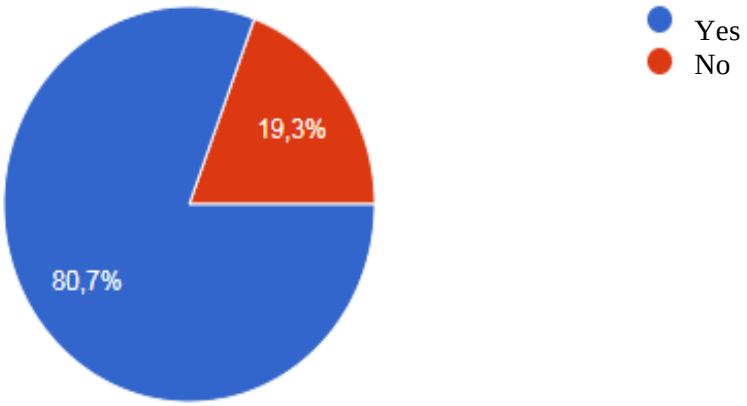

Figure 3: Position of exhaust gas analyzer.

The next two questions try to figure out the technician's use of the exhaust gas analyzer. One question was whether they use an exhaust gas analyzer at first start of a natural gas boiler, and the second about whether they use it in the yearly maintenance of the natural gas boiler. The answer is yes for the first start of a boiler pick up 70.2 % (Figure 4) and for the yearly maintenance pick up 52.7 % (Figure 5). The answers show that technicians do not use the exhaust gas analyzer as they have to do to ensure the efficiency of the boiler and the quality of the exhaust gas.

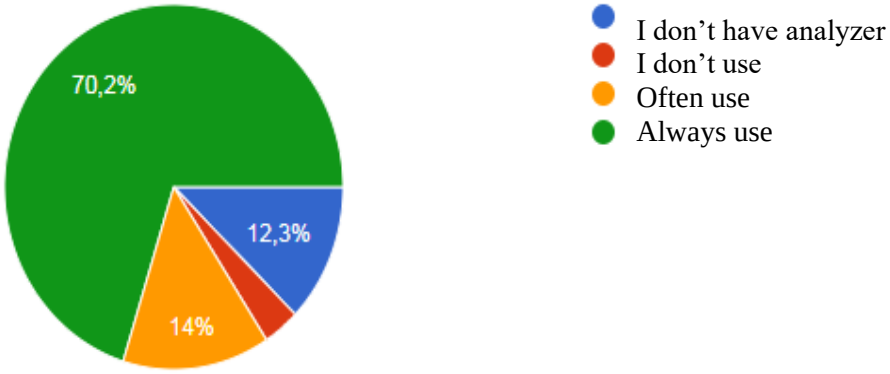

Figure 4: Frequency of exhaust gas analyzer usage at first start of natural gas boiler.

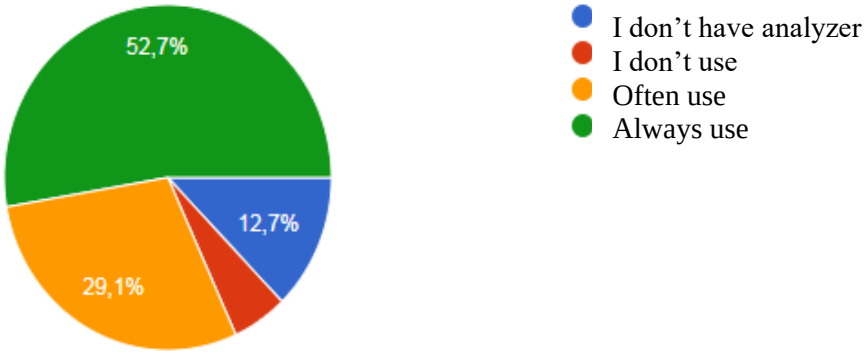

Figure 5: Frequency of exhaust gas analyzer usage (yearly maintenance).

2.1.1. Conclusions for the Boilers

Another important conclusion about the exhaust gas in the combustion hobs with natural gas, whether harmonized or not with the Greek legislation, is that the wall-mounted boilers are given to the atmosphere more CO per KW than the classic floor-standing boilers. According to the data, the wall-mounted boilers have exhaust gas of 1.583 CO ppm per 1 KW, and the floor-standing boilers have exhaust gas of 0.147 CO ppm per 1 KW. That means 10.76 times more CO ppm in the atmosphere. Regarding the produced gas of NOx, the wall-mounted boilers have exhaust gas of 0.820 NOx ppm per 1 KW, and the floor-standing boilers have exhaust gas of 0.166 NOx ppm per 1 KW. The difference is that the wall-mounted boilers produce 4,939 times more NOx than the floor-standing boilers. In the following table (Table 1), we can see the total amount of the KW, the CO in ppm, and the NOx in ppm of the two biggest natural gas boilers categories. CO is a highly toxic gas, and it can cause death. The NOx can cause several problems in humans as breathing problems, headaches, chronically reduced lung function, eye irritation, loss of appetite, and corroded teeth. The Greek law [1] about the exhaust gas from natural gas burners limited the higher level of CO to 90 ppm and NOx to 150 ppm per boiler.

Table 1
Total numbers

	Total KW	CO ppm	NOx ppm
Wall-mounted boilers	3739.1	5919.0	3068.6
Floor-standing boilers	43981.3	6468.2	7312.0

2.1.2. Specifications of Burner Manufacturers

The specifications of the burner manufacturers play a key role in the proper operation of the device. Due to this, for the arrangements required for the proper operation of the combustion chamber, the combustion technician takes the manufacturer's instructions first and then the Greek legislation. At the first start of a wall-mounted boiler or in the yearly maintenance, the technician has to take measurements of the exhaust gas and compare them with the specifications of the manufacturer of the boiler. From small research done in the manuals of the manufacturers of wall-mounted boilers, it was found that the manufacturers' requirements for efficient and proper operation of wall-mounted boilers in the exhaust gases are higher than the limit values set by the Greek legislation [1]. For example, the following figures 6 and 7 are easy for someone to see that the manufacturer gives specifications higher than the Greek legislation regarding carbon monoxide.

POWER SPECIFICATIONS	Max/min power output (80°C-60°C) Pn	kW	21,4 / 3,4	27,4 / 3,9	30,2 / 5,2
	Max/min power output (50°C-30°C) Pn	kW	23,6 / 3,9	30 / 4,5	33,5 / 5,8
	Domestic hot water max/min power output Pn	kW	24,9 / 3,5	28,7 / 4,1	36,3 / 5,3
	Combustion efficiency (of flue gas)	%	98,0	98,0	97,9
	Nominal calorific flow rate efficiency (60/80°C) (Hi)	%	97,5 / 87,8	97,9 / 88,2	97,5 / 87,8
	Nominal calorific flow rate efficiency (30/50°C) (Hi)	%	107,3 / 96,7	107,3 / 96,6	108,2 / 97,4
	Efficiency at 30% at 30°C	%	109,8 / 98,9	109,6 / 98,7	109,7 / 98,8
	Minimum calorific flow rate efficiency (60/80°C) (Hi)	%	93,1 / 83,8	91,1 / 82	94,4 / 85,0
	Efficiency rating (dir. 92/42/EEC)	stars		★★★★	
	Sedbuk class		A/90	A/90	A/90
	Loss of burner gas when operating	%	2,0	2,0	2,1
EMISSIONS	Available air pressure	Pa	100	100	100
	NoX class	class		5	
	Flue gas temperature (G20) (80°C-60°C)	°C	61	62	63
	CO2 content (G20) (80°C-60°C) max / min	%		9,2 / 8,9	
	CO content (0%O2) (80°C-60°C)	ppm	141,8	123,8	106
	O2 content (G20) (80°C-60°C)	%	3,9	4,2	4,3
	Maximum flue gas flow (G20) (80°C-60°C)	Kg/h	42,1	48,6	61,3
	Excess air (80°C-60°C)	%	23	25	26
HEATING CIRCUIT	Expansion chamber inflation pressure	bar		1	
	Maximum heating pressure	bar		3	
	Expansion chamber capacity	l		8	
	Min/max heating temperature (high temperature range)	°C		35 / 82	
	Min/max heating temperature (low temperature range)	°C		20 / 45	
DOMESTIC HOT WATER CIRCUIT	Domestic hot water min/max temperature	°C		36 / 60	
	Specific flow rate of domestic hot water (ΔT=30°C)	l/min	12,1	14,5	18,1
	Quantity of hot water ΔT=25°C	l/min	14,5	17,4	21,8
	Quantity of hot water ΔT=35°C	l/min	10,4	12,5	15,5
	Hot water comfort rating (EN13203)	stars		★★★	
	Hot water minimum flow rate	l/min	2,0	2,0	2,0
	Domestic hot water max/min pressure	bar		7 / 0,2	
ELECTRICAL	Power supply frequency/voltage	V/Hz		230 / 50	
	Total electrical power absorbed	W	77	83	84
	Minimum ambient temperature for use	°C		+5	
	Protection level for the electrical appliance	IP		X5D	
	Weight	kg	29,7	32,3	34,6

Figure 6: Exhaust gas analyzer results. Source: Technical installation and maintenance book [2], Ariston Company, CLAS ONE SYSTEM model.

In the next figure (Figure 7), we can see also see the limits are out of the Greek legislation.

Technical data

Gas type	U.M.	City Class 25 K		City Class 30 K		City Class 35 K	
		G20	G31	G20	G31	G20	G31
CE certification		0476 CS 1134		0476 CS 1134		0476 CS 1134	
Class		II2HM3P (II2H3P)[2]		II2HM3P (II2H3P)[2]		II2HM3P (II2H3P)[2]	
Type		B23 - B23P - B53 - B53P - C13 - C33 - C43 - C53 - C63 (C13-C33-C53-C83) - C83 - C93					
Working temperature range (min÷max)	°C	0 ÷ +60		0 ÷ +60		0 ÷ +60	
(1) = allowed in Italy only (2) = outside Italy							
Max heat input Qnw	kW	25.0	25.0	30.0	30.0	33.2	33.2
Max heat input Qn	kW	20.0	20.0	24.0	24.0	28.0	28.0
Min heat input Qr	kW	2.5	2.5	3.0	3.0	3.5	3.5
Max heat output 60°/80°C *	kW	19.4	19.4	23.3	23.3	27.4	27.4
Min heat output 60°/80°C *	kW	2.4	2.4	2.8	2.8	3.3	3.3
Max heat output 30°/50°C *	kW	21.0	21.0	25.2	25.2	29.5	29.5
Min heat output 30°/50°C *	kW	2.7	2.7	3.1	3.1	3.7	3.7
NOx Class		5	5	5	5	5	5
CO at 0% O2 (Qn)	ppm	230.1	217.0	203.5	221.6	169.0	205.5
CO2 at nominal input	%	9.00	10.04	9.20	10.20	9.00	10.20
Condense quantity at Qn (30°/50°C *)	l/h	2.5	2.5	2.9	2.9	3.0	3.0
Condense quantity at Qr (30°/50°C *)	l/h	0.3	0.3	0.3	0.3	0.4	0.4
Condense acidity	pH	2.8	2.8	2.8	2.8	2.8	2.8
Flue temperature, Max.	°C	61.5 60/80° Qr	61.5 60/80° Qr	69.0 60/80° Qr	69.0 60/80° Qr	64.0 60/80° Qr	64.0 60/80° Qr
Flue temperature, Min.	°C	41.0 30/50° Qr	41.0 30/50° Qr	47.0 30/50° Qr	47.0 30/50° Qr	38.0 30/50° Qr	38.0 30/50° Qr
Flue mass flow rate at Qnw (60/80°C *)	kg/h	41.11	41.86	48.31	49.32	54.60	54.41
Flue mass flow rate at Qr (60/80°C *)	kg/h	3.94	4.22	4.83	4.89	5.76	5.63
EFFICIENCY							
Efficiency η100% Qn/Qa (NCV) at 60°/80°C *	%	96.1		96.0		96.2	
Efficiency at Qn (NCV) at 30°/50°C *	%	105.1		105.2		106.4	
Efficiency at η30% Qn/Qa (NCV) at 30°/50°C *	%	106.4		106.0		106.7	

* system return / flow water temperature; NCV = Net Calorific Value (=Hi) Remark: data have been measured with horizontal coaxial flue, length = 1 m.

Figure 7: Technical data. Source: Technical installation and maintenance book [3], Italtherm Company, CITY CLASS 25K, 30K, 35K models

3. Conclusions

From the data of the flue gas control sheets we can see that t the wall-mounted natural gas boilers produce 10.76 times more CO than floor-standing boilers. Because of this, the manufacturers of the wall-mounted boilers should correct the combustion parameters, to produce less CO. However, according to the data from the manufacturers' manuals, of wall-mounted gas boilers the values of produced CO are greater than the limit of Greek legislation. The state should intervene and create control mechanisms that will check the wall-mounted boilers with appropriate methods, to see if they are harmonized with the Greek legislation. The state also should give importance to the control of the technicians who work with the boilers. Finally, the technicians should be forced to use analyzer during the ignition and maintenance of a natural gas boiler, so that they can be adjusted correctly for more efficient combustion and environmental protection.

Farther research on combustion boilers, including all fuels, would give us a clearer picture for the harmful gases that included in atmosphere. Also, farther information's for the use of the flue gas analyzer and the professional technical staff will be useful.

4. Acknowledgements

I want to thank the office of technical services in the municipality of Larissa and the technicians for providing me the necessary data from the exhaust gas control sheets to do this research.

5. References

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