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Experimental Study on the Combustion System Optimization in the Case of a 36 kW Condensing Boiler

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Abstract

The Energy-related Products Directive that came into force in all EU countries on September 25, 2015 is focusing attention on the condensing boilers more than ever before since they currently represent the most advanced and environmental friendly heating technology based on fossil fuels. In this context, an experimental study referring to the combustion system of a condensing system of 36 kW nominal heat output - defined in central heating mode and condensing regime - was developed. The analyzed condensing system is of premixed type, consisting of an air blower, a gas valve, a fuel gas-air mixer and a cylindrical multihole burner. Beside nominal heat output, another important requirement is a wide heat output range, for flexibility relative to the load. Consequently, the minimum heat output of the boiler should be as low as possible. This problem of maximum and minimum heat output of the boiler is, in fact, a question of maximum and minimum air flow that enters in the combustion system, which is decided by minimum aria of nozzle of the fuel gas-air mixer. In order to establish the optimum solution for the analyzed combustion system, four fuel gas-air mixers, Siemens type, had been experimented. The paper presents the results of this study.

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Keywords: condensing boiler; experimental study; combustion system; fuel gas-air mixer; central heating; heat output; blower rotation speed.

1. Introduction

The interest for condensing boilers is now higher than ever before since the Energy-related Products Directive was implemented in September 2015 as a part of the EU commitment to reduce carbon emissions. These boilers are the most efficient and least pollutant heating devices (there are the only boilers complying with the NOx class 5,

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according to EN 483:1999) based on fossil fuel as primary energy source [1, 2]. Consequently, condensing boilers are considered the most advanced technology in boilers field. Compared with conventional boilers, condensing boilers can reduce the annual gas consumption with even more than 20% [3]. In the current approach on environmental protection and reductions of the fossil fuels use, these boilers are taken into consideration as additional backup heating solution in hybrid systems with air source heat pump [4], solar thermal system or wood pellet boiler [5].

The performance of any condensing boiler is mainly decided by its combustion system. Therefore, several studies refer to this subject. They are mainly focused on the improvement of the combustion characteristics, which means increasing of the thermal efficiency and emissions reduction (NOx and CO). Thus, results of an experimental study on the emissions of a cylindrical multihole premixed burner are presented in [6] while combustion characteristics of three types of porous media burners (metal fiber, ceramic and stainless steel fin) are presented in [7]. There were also performed theoretical and experimental studies referring to the gas interchangeability [8], enhancement of the fan performance in order to provide optimized performance parameters (flow rate, inlet/outlet pressure, torque of impeller) [9] and to modulating ratio [10]. These studies prove that configuration and optimization of the combustion system is one of the most important stages in the development process of any boiler. The current study refers to this matter in the case of a project referring to the development of a condensing system with 36 kW nominal heat output – defined in condensing operating regime, Central Heating (CH) mode. The combustion system of the boiler is premix type, with cylindrical multihole burner. The aim of the study was to establish the optimum fuel gas-air mixer under two main restrictive conditions: maximum accepted percentage deviation of nominal heat output is 3%; minimum heat output of the boiler is 25% of nominal heat output (or less). These restrictions refer to the width of the condensing boiler heat output range, which decides the flexibility of the boiler relative to the load.

2. Presentation of the experimental facility

The analyzed condensing boiler has an annular heat exchanger with seven coils (see Fig. 1b), placed inside a cylindrical case. Water flows inside the coils and combustion gases flow outside the coils. There are two passes on the water side as well as on the combustion gases side. The first water pass consists of three coil elements while the second pass has four coil elements. Connection of coils is ensured by collectors. Referring to the combustion gases side, the first five coils delimitate the cylindrical combustion chamber wherein the cylindrically burner is placed, axially with the chamber; this is the first pass. The other two coil elements constitute the second pass for combustion gases. The two passes are separated by a wall. Combustion gases flow radially in both passes: from the burner to the inner surface of the cylindrical case (first pass, combustion chamber), by passing the five coil elements of the annular heat exchanger from their inner to their outer surface; from the cylindrical case to the flue gases collector (second pass), by passing the last two coil elements of the annular heat exchanger from the outer to the inner surface. From the flue gases collector, the flue gases are removed into the atmosphere.

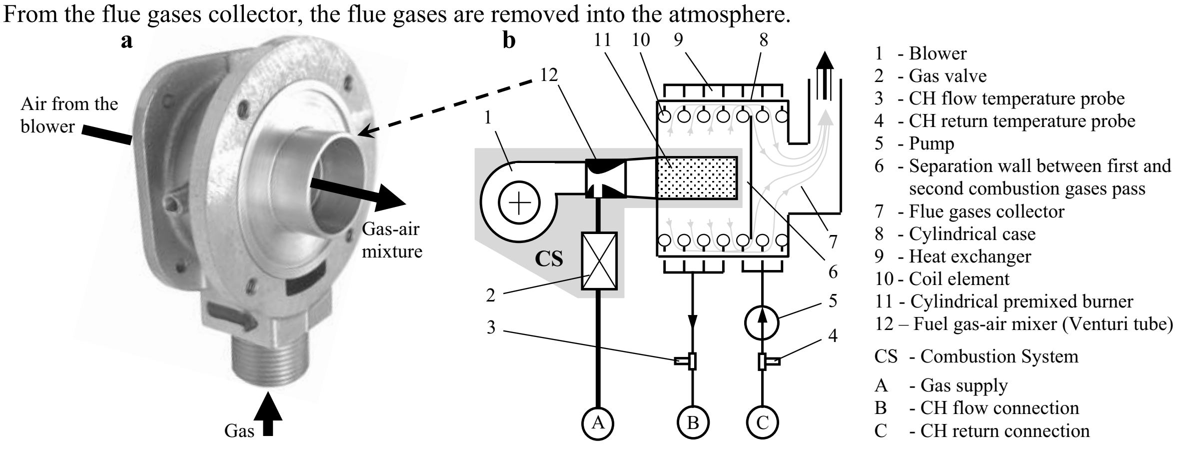

Fig. 1. (a) Siemens fuel gas-air mixer; (b) Schematic of the condensing boiler.