Self regulate gas condensing boilers able to cope with gas quality variation: State of the art and performances

Phase 1 - Management Summary (Nov. 2017)

The technology of combustion controlled condensing boilers is first introduced in the market in 2001 and meanwhile highly developed and offered by 11 European manufactures in a wide range of load and application in 24 European countries. Reliable market data is hard to get, but data from Germany reveal an already high and growing share in sales since few years already. The technology mainly relies on the technology of ionization signal in combination with a smart control including also the fail-safe function. In contrast to the apparently established market introduction, the knowledge in the technical public (grid operators, installers, members of standardization committees, etc.) and from independent lab- and field investigation seems to be poor. Phase II of the project aims to shorten this lack and bring light on the actual performances

Project goal and approach

With the developing gas markets in Europe – e.g. market liberalization, integration of renewables, European standardization - gas application technologies providing a high flexibility to gases from different natural sources and from renewable production like bio methane and hydrogen become more and more important. Against this background - within GERG five project partners (CETIAT; DGC; ENGIE, EON, GAS.BE) decided to conduct a project on the technology of combustion controlled condensing boilers (CCCB), a technology already introduced in some European markets but still in technical and market development. The first phase of the project was executed as desk research from February to September 2017 and provides results on the technology of CCCB, standardization, market and existing literature about any other aspect. Additionally a proposal of appliance tests protocol was elaborated and those tests should be conducted in a second phase of the project. The second phase will be starting in October 2017. The project costs of the partners are borne by the single partners themselves. Project organization and the compilation of the common report are supported by the project sponsors Gasunie Transport Services B.V. (NL) and National Grid Gas Distribution Limited, UK. Sponsors are having full information of the project work and receive the reports of phase I and II. More sponsors are still invited to participate.

Results of Phase I

Technical background

Although strong efforts have been done to standardize gas qualities in Europe, the Wobbe range is still defined nationally and differs from member country to member country. UK for example specifies a narrower band from 47.2 MJ/m³ to 51.4 MJ/m³, whereas Belgium allows a range from 46.6 MJ/m³ to 53.9 MJ/m³.

Effective gas qualities and its fluctuation at single exit points are rarely documented in Europe. Published measurements from France and Germany document a maximum local variation of the Wobbe number in ranges from 3.4 MJ/m³ to even 6 MJ/m³. As supply in the future might be more diversified and injection of renewable gases will increase, gas quality will probably fluctuate even more.

Standard condensing boilers

Standard condensing boilers are designed to cope either to the group H (45.7 MJ/m³ to 54.7 MJ/m³) or E (40.9 MJ/m³ to 54.7 MJ/m³) respectively or the group L (39.1 MJ/m³ to 44.8 MJ/m³) defined in EN437. Within the gas group they should operate with the defined range of gas quality safely,

reliable and environmentally friendly. Comprehensive lab investigation within the GasQual project on new condensing boilers revealed the following:

- New condensing boilers adjusted to the nominal value of the gas group H cope with the whole bandwidth of gas quality within the group H
- Emissions of CO and NO_x as well as efficiency depend partially strongly on the Wobbe number of the supply gas even within group H.
- Once the nominal adjustment of condensing boiler is changed (which may occur in the field, when gas quality is fluctuating) the appliance does not cope any more to the whole Wobbe range required.
- No experiences are documented for older, long-time installed condensing boilers.

The new developed technology of combustion controlled appliances may overcome these difficulties, as they adjust steadily to the nominal operation point avoiding an increase of emissions and false adjustments due to varying local gas qualities.

Technology of CCCB

Intensive desk research on this technology comprising literature research, technology analysis and market investigation has been conducted by the project partners.

Information on different gas quality sensors on the market is compiled, including direct and indirect measuring methods as well as sensors measuring before, within and after the combustion zone. The easiest method applicable for fully premixed burners used in condensing boilers is the measurement of the ionization current within the combustion zone. The signal responds quickly on gas quality change, so that a fast control is realizable. The form of the ionization curve depends strongly on the air factor, which itself depends on the gas quality. However the absolute value of the ionization signal may depend on the age of the probe and the boiler etc. This problem is solved by smart control software including a recalibration mechanism. Different systems basing on patents from Kromschröder, Siemens and others are realized in different boilers.

Condensing boilers of one single manufacturer type are equipped with a CO-probe to control air factor and gas quality. According the first information this manufacturer will switch to ionization controlled boilers too.

The construction and assembly of the actuator elements, fan and gas valve in the combustion controlled condensing boilers are very similar: The fan with an electronic speed control is the leading element. Gas is introduced in a venturi tube sitting in the inlet of the fan so that the air flow rate determines the pressure on the outlet side of the gas valve. The simple gas valve controls inlet pressure and an orifice often regulated by a step motor. The fail-safe function is given by the smart control.

Within the standard EN437 CCCB are approved due to the category I2N comprising all gas groups within family 2, i.e. (39.1 MJ/m³ to 54.7 MJ/m³).

Market investigation CCCB

First CCCB entered in 2001 the market on a boiler with a maximum load of 15 kW. Up to now 12 manufacturers offer this technology with in a wide load range from 12kW up to even 150 kW. Not only single family houses, but also smaller flats up to multi-family houses and light to medium commercial buildings boilers may be equipped with this technology. The technology is offered on the wide panel of models. The technology is offered in at least 25 European countries. It is interesting to mention, that the technology is even offered in countries, where the respective category due to EN437, I2N, is not yet accepted, for example UK. In these countries CCCB are approved due to I2HL or I2EL and their technical advantage may not be aware for installers, customers and grid operators.

Very few reliable data of the market penetration of this technology are available. An inquiry of the Federation of German Heating Industry for DVGW revealed that nearly one third of the sold heating appliances in 2014 were combustion controlled condensing boilers. Information about the share of installed appliances may be deduced from the inquiry during the L/H-conversion projects in Germany. It seems to depend very much on the region and on the local preferred manufacturers. Share of up to one quarter of all installed condensing boilers have been documented.

Technical Investigation documented

Literature research revealed an immense amount on publication on different sensor technology, gas quality studies and very specific details, but a lack on independent lab tests and field test of CCCB technology. Some few older publications document manufacturer-independent measurements of functionality, emissions and praxis behavior of CCCB. Against the background of gas quality standardization in Europe and the intent of some countries to enlarge their legal Wobbe range it is of great interest to make a new effort to measure and evaluate the technology of combustion controlled condensing boilers in the lab for the praxis.

Evaluation in the lab of existing boilers equipped with combustion control

The goal of the lab tests is to investigate –within the limited time and budget – five selected CCCB under conditions relevant for the current and future praxis. As gases we defined the whole range of test gases due to EN437 with a slight extension at the lower end due to the German group LL (34,3 MJ/m³ - 54,7 MJ/m³) including a bio methane and mixtures up to 30% Hydrogen. Test will be conducted in stationary and unsteady conditions. The calibration process will be investigated too.

We are looking for support

Five project partners (CETIAT; DGC; ENGIE, EON, GAS.BE) have been preparing an extended and detailed report for the phase 1. The work was supported mainly by the partners themselves and by two sponsors. The report includes the following elements:

- Technical Background
- Standard condensing boilers Technology description
- Combustion controlled condensing boilers
    - Components used
    - Realized Systems in combustion controlled condensing boilers
    - Prospects
- Market research and Standards
- Summarizing and conclusions of results from literature
- Proposal for Phase II
    - Measuring program
    - Selection of test appliances
- Summary
- Literature list

For the phase 2 having now started we will test at least 5 boilers with Combustion control and compare those with 10 boilers tested without combustion control.

We are looking for more sponsors. For a fee of 8000 Euros the sponsor will get the full report for phase 1 and the extensive tested results of phase 2.

It is also possible to sponsor the report only for 4000 Euros and the phase 2 at later stage for another 4000 Euros). The final report including the test results will be available early 2018.

Contact for more information:

E.ON Metering GmbH, E.ON Metering GmbH

Dr. Petra Nitschke-Kowsky

petra.nitschke-kowsky@eon.com

Danish Gas technology Center (DGC)

Jean Schweitzer

jsc@dgc.dk

Partners

Sponsors

A project initiated by