ELSEVIER

Catalysis Today 47 (1999) 415–420

CATALYSIS TODAY

Catalytic combustion in a domestic natural gas burner

Seonhi Ro Vaillant[1,a], Anton Scholten Gastec[b,*]

[a]Berghauser Straße 40, abt. ZEFV, PO Box 101061, 5630 Remscheid, Germany
[b]PO Box 137, 7300 AC, Apeldoorn, Netherlands

Abstract

Gastec and Vaillant developed a boiler in which the combustion is catalytically stabilised as well as a completely catalytic boiler. The catalytically stabilised boiler emitted about 5 ppm NO_x and 0 ppm CO. In this boiler the burner is replaced by a metal honeycomb. The honeycomb is partly coated with a catalyst washcoat. The coated part is at the flame side of the honeycomb. The coated length of the channels is an important parameter. A too long coating results in CO emissions, a too short coating in higher NO_x emissions.

The catalytic boiler emitted 0 ppm NO_x, 0 ppm CO and 0 ppm CH_4. The gas is combusted catalytically in two metal honeycombs. Most gas is converted in the first few millimetres from the entrance of the monolith. The heat that is produced is radiated to a heat exchanger. The remaining honeycomb and the secondary honeycomb convert the rest of the methane.

Comparing these boilers, the completely catalytic boiler shows lower emissions and a lower sensitivity to the gas quality. The partly catalytic burner is more reliable and can use a conventional security system. Production and development costs are thus smaller.

Keywords: Catalytic combustion; Natural gas; Domestic burner; Metallic honeycombs

1. Catalytically stabilised burner

In Fig. 1 the principle of the catalytically stabilised boiler is represented. The gas and air are premixed and distributed over the honeycomb. At the bottom end of the honeycomb the mixture is ignited. The honeycomb operates as a radiation burner. The catalyst is only applied at the bottom side (about 1 mm) of the honeycomb. The catalyst is heated by the flame and converts roughly 50% of the methane catalytically. The feed of the flame thus becomes leaner. The concentration of radicals decreases and the NO_x emission decreases.

The length of the honeycomb that is coated with catalyst and the diameter of the cells are very important. These parameters determine the conversion of the methane. In case the catalyst is too active, the emission of CO increases. When the catalyst is not active enough, the reduction of NO_x is too low. The results obtained with an optimised catalyst are presented below.

2. Results of the catalytically stabilised boiler

In Fig. 2 the CO and the NO_x emission are represented as a function of the specific capacity.

*Corresponding author. Tel.: +31-555-393-394; fax: +31-555-393-223; e-mail: slt@gastec.nl
[1]Tel.: +49-2191-182036; fax: +49-2191-1872036; e-mail: seonhi.ro@vaillant.de

0920-5861/99/$ – see front matter
PII: S0920-5861(98)00324-1

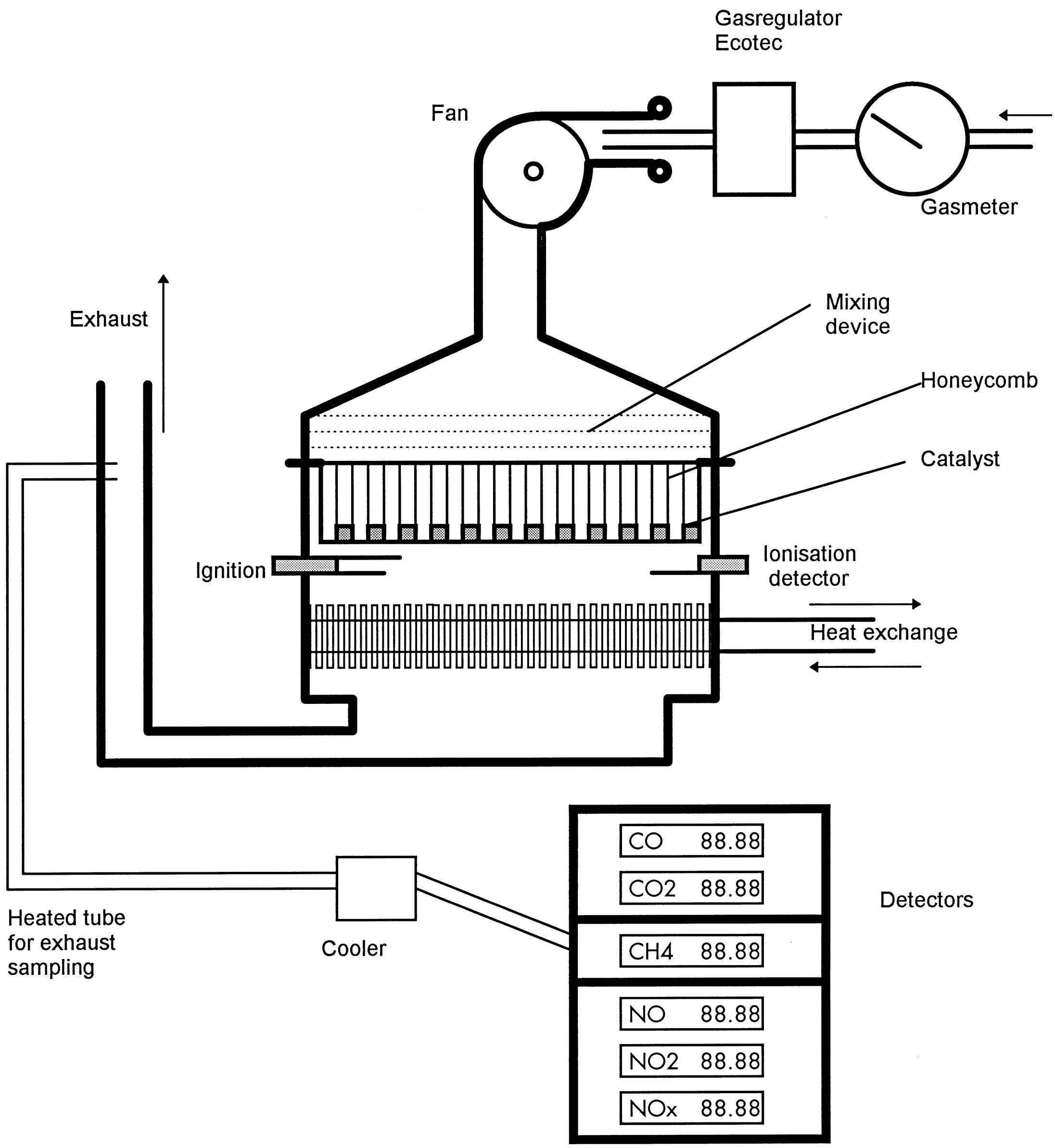

Fig. 1. The catalytically supported boiler.

CO is only detected at low specific capacity. As is mentioned above, this is caused by a too high catalytic conversion. Fig. 3 shows the emissions of CO and NO_x as a function of the air-to-fuel ratio. A high air-to-fuel ratio (>1.5) resulted in small CO emissions. The NO_x emission was very low, about 5 ppm, in the complete measurement series.

3. The completely catalytic boiler

The completely catalytic boiler is schematically represented in Fig. 4. The premixed gas air mixture is distributed over the first heat exchanger.

During the start up phase, the premixed gas air mixture is ignited between the first and the second monolith. The first honeycomb starts as a conventional

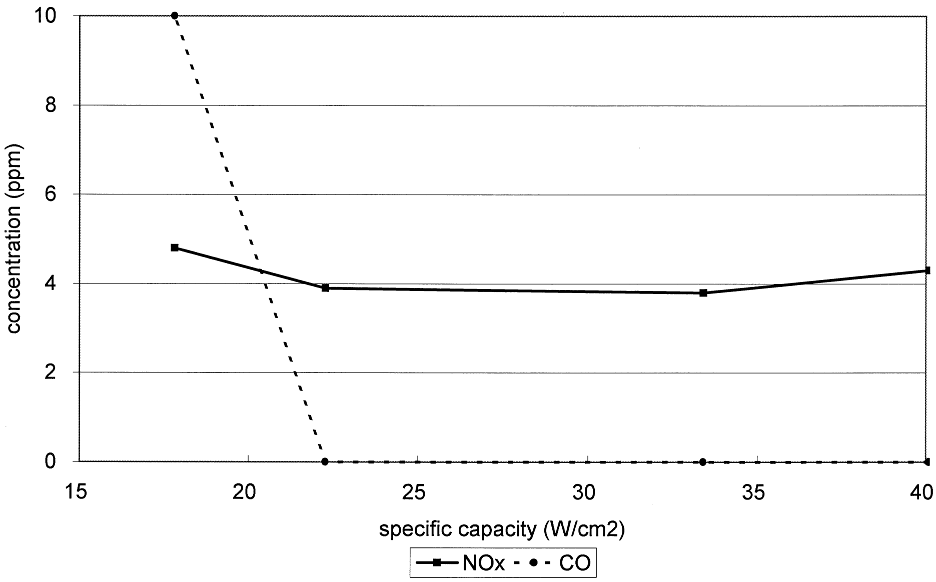

Fig. 2. The catalytically stabilised boiler; variation of capacity.

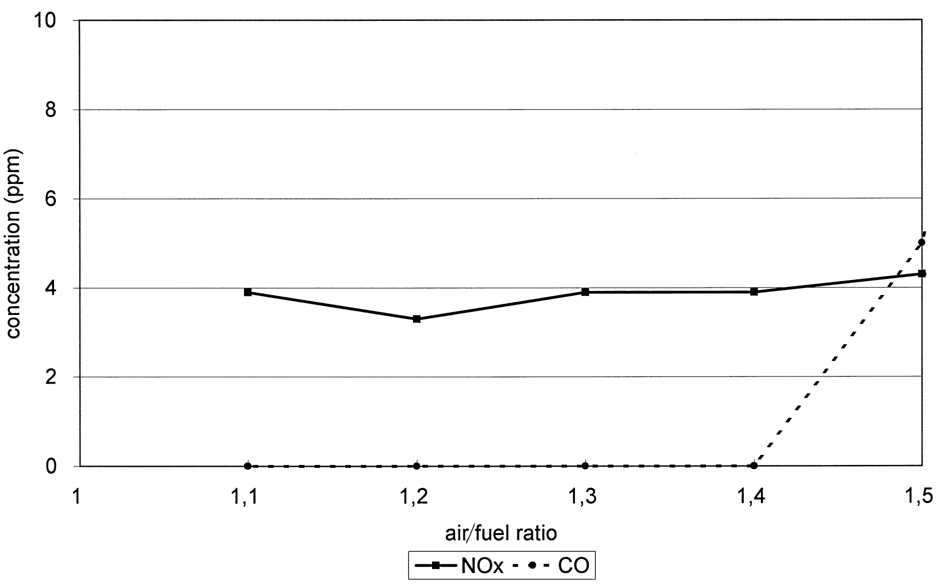

Fig. 3. The catalytically stabilised boiler; variation of air-to-fuel ratio.

radiation burner. In this phase, the second honeycomb is heated up. As the temperature of the first honeycomb at the side of the flame increases, the catalyst on the first honeycomb starts to convert the methane. The catalyst heats up the honeycomb further. The catalytic reaction zone moves to the inlet side of the first honeycomb and at the same time the conversion of the first honeycomb increases. After some time the

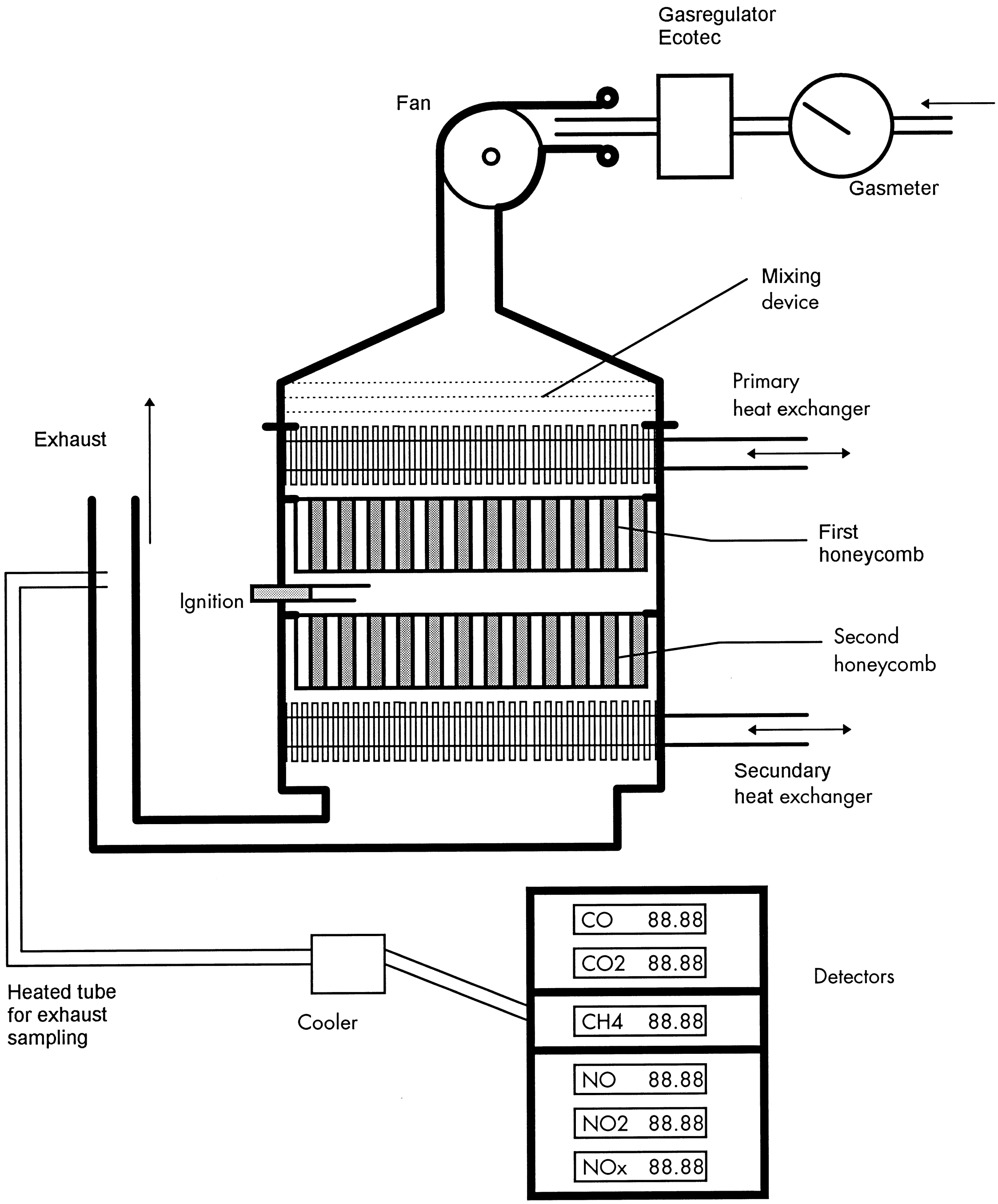

Fig. 4. The catalytic boiler.

methane concentration reaching the flame is too low to sustain the flame. The second honeycomb converts the methane unconverted by the first honeycomb.

During the stationary phase, most of the methane is converted at the top of the first honeycomb. The evolving heat is radiated to the primary heat exchan-

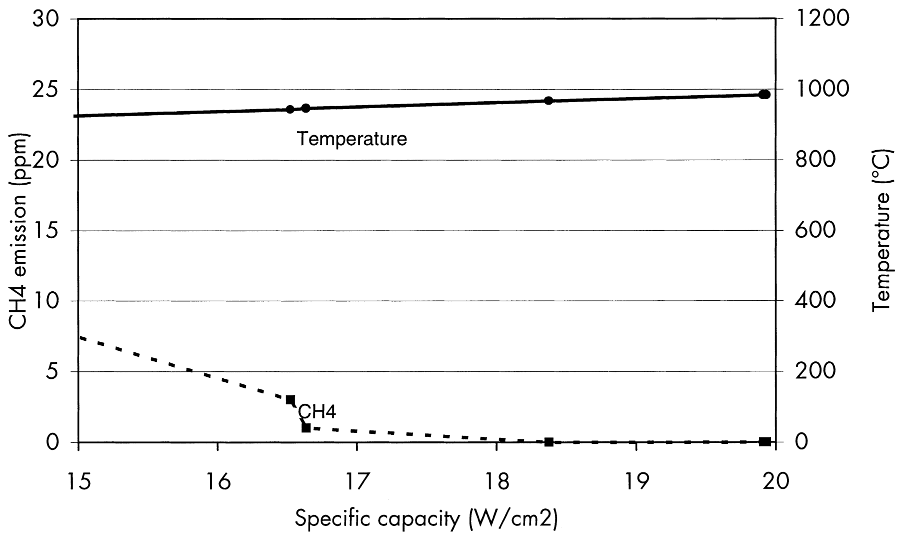

Fig. 5. The catalytically stabilised boiler; variation of capacity.

ger. The second honeycomb converts the methane slip from the first honeycomb.

4. Results of the completely catalytic boiler

No emissions were detected during stationary operation. CO as well as NO_x was 0 ppm under all conditions. Only at low capacity the heat produced by the reaction is not enough to keep the catalyst at operating temperature. The small methane emission resulting from the decreased temperature disappears at higher capacities as is apparent in Fig. 5.

5. Comparing the catalytically stabilised and the completely catalytic boiler

In Table 1 the catalytic boiler is compared with the catalytically stabilised boiler. The catalytically stabilised burner has a lower NO_x emission than a modern radiation burner. The catalytic burner shows zero emission of NO_x. The CO emission of the catalytically stabilised burner is comparable with that of a conventional burner. No CO is emitted in the catalytic boiler.

For the catalytically stabilised boiler, no new security system has to be developed. A conventional ionisation detector can be used. This is not the case for the catalytic boiler. Because no flame is present, a new detection system has been developed to detect incomplete conversion of fuel.

Table 1
Comparison of catalytically stabilised and catalytic combustion

	Catalytically stabilised	Catalytic
NO_x	+	++
CO, CH_4	+	++
Security system	++	+/−
Insensitivity to gas quality	+/−	++
Reliability	++	+
Production cost	+/−	−
Development effort small	+	+/−

The influence of the gas quality of the catalytically stabilised boiler is comparable to that of a modern radiation burner. The catalytic boiler showed stable operation with all the different tested gas qualities.

The catalytically stabilised burner is very reliable. The burner will operate as a radiation burner when the catalyst has for some reason been deactivated.

The extra production costs of the catalytically supported boiler involve the cost to install a catalyst instead of a radiation burner. For the production of the completely catalytic boiler, an extra heat exchanger and two catalysts are needed. This adds to the production costs. On the other hand, no metal substrate is needed. Cheaper ceramic honeycombs can be used. This reduces the production costs.

The development of a catalytically stabilised boiler requires a smaller effort. For the catalytic boiler, more new parts and a new security system need to be developed.

6. Conclusions

The newly developed catalytically stabilised boiler shows a reduced NO_x emission of 5 ppm. The new catalytic boiler shows no emissions of CH_4, NO_x or CO. Comparing these boilers, the completely catalytic boiler shows lower emissions and a lower sensitivity to gas qualities. The partly catalytic burner is more reliable, can use a conventional security system and production as well as development costs are smaller.