Performance Testing of Air Curtains in Residential Range Hoods
Bruno Claeys\textsuperscript{1}, Jelle Laverge\textsuperscript{1,*}, Ivan Pollet\textsuperscript{1,2} and Giel Bryuneel\textsuperscript{2}
\textsuperscript{1}Building Physics, construction and services research group, Ghent University, Ghent, Belgium
\textsuperscript{2}Renson Ventilation, Renson NV, Waregem, Belgium

Abstract

Air curtain assisted range hoods are very customary in large industrial kitchens. They allow to increase the capture efficiency of the range hood while lowering the net exhaust flow rate. For applications in residential settings, there is a lack of data on the performance of air curtain assisted range hoods, as well as a lack of information on the required settings and boundary conditions to come to the successful application of air curtain assisted range hoods. In this paper we present the results from an experimental test campaign in which we investigated the capture efficiency of a residential air curtain assisted range hood in comparison with a regular range hood, as well as the sensitivity of the capture efficiency to boundary conditions such as net exhaust flow rate, height above the range, enclosure etc. The results show that air curtain assisted range hoods are more efficient at lower flow rates, especially in non-enclosed settings, confirming the performance known from industrial kitchens, but are sensitive to higher mounting and on-going cooking activities.

\textsuperscript{*} Corresponding author. Tel.: +32 9 264 37 49.
E-mail address: jelle.laverge@ugent.be

1. Introduction

The acoustic and airflow performance of range hoods has been captured by ISO standards 5167-1 \cite{1} and 10140-1 \cite{2}, while the IEC 61791 standard \cite{3}, discusses fat absorption and odor extraction performance. These aspects are also treated in the EN 13141-3 \cite{4} standard. There is, however, no mention of capture efficiency, the efficiency of
the range hood to capture and exhaust the pollutants emitted by the cooking activities. Proposals for test methods for this measure have been proposed and tested on residential range hoods available on the US market by Delp [5] and Lunden [6]. In this paper, we build on this work and compare the performance of air curtain assisted range hoods with that of normal direct extraction range hoods.

## Nomenclature

<table>
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<th>Symbol</th>
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<tr>
<td>CE</td>
<td>Capture efficiency</td>
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<td>C</td>
<td>Concentration</td>
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Subscripts:
- fp: first pass
- hood: in the hood
- room: in the room
- inlet: at the inlet

## 2. Methods

### 2.1. Experimental Setup

An test range was constructed within the hotbox of a hot/cold/hot box suite. The space measures 5 by 5 by 2,7 meters, dimensions that are fairly representative for a kitchen in Belgium. The height of the test range is adjustable, the height of the range hood is fixed. The enclosure of the range hood can be adapted from free hanging to enclosed in kitchen cupboards by adding or removing wooden paneling.

![Fig. 1. The experimental setup with adjustable range height, electric range and air curtain assisted range hood in wall mounted non-enclosed mode.](image)

### 2.2. Capture efficiency calculation

To process the measurements and calculate the capture efficiency, we use the ‘indirect approach’ put forward by Delp (2012) and Lunden (2014). Lab grade carbon dioxide is released at a constant rate above a boiling pot of water
Capture efficiency is then defined as:

\[
CE_{FP} = \frac{C_{\text{hood}} - C_{\text{room}}}{C_{\text{hood}} - C_{\text{inlet}}}
\]

where \(CE_{FP}\) is the first pass capture efficiency, \(C_{\text{hood}}\) is the carbon dioxide concentration measured in the exhaust of the range hood, \(C_{\text{room}}\) is the carbon dioxide concentration measured in the test room and \(C_{\text{inlet}}\) is the carbon dioxide concentration measured in the inlet of the room. All measured concentrations are reported in parts per million (ppm).

3. Results

The concentrations measured during a 3 minute cooking event with the air curtain assisted range hood mounted at 0.8 meter above the range are shown in figure 2. The exhaust flow rate of the range hood during the test is 150 m³/h.

Room and exhaust concentrations coincide in the pre-cooking phase of the test (minute 1-6), when no carbon dioxide is released. The concentration in the exhaust of the range hood rapidly climbs during the cooking event (minute 6-9, marked with the 2 vertical black lines in figure 2) while that in the rooms remains relatively low. This is, of course, the desired effect of the range hood and constitutes the effectiveness of the range hood. At the end of the cooking event, the momentary first pass capture efficiency is 77%.

23% of the emitted carbon dioxide, however, still escapes to the room. After the cooking event is stopped, the test is continued until all emitted carbon dioxide is exhausted and room as well as hood concentrations are back at inlet level (minute 9-25). When the cooking event is stopped, the thermal plume created by the pot of boiling water disappears and the efficiency of the range hood quickly worsens. The carbon dioxide concentration within the cooking zone decreases rapidly and becomes equal to the room concentration. The overall capture efficiency integrated over the total length of the test is only 30%.

Fig. 2. Measured carbon dioxide concentrations during a 3 minute cooking event with the air curtain assisted range hood.
4. Discussion

The results clearly demonstrate that the ‘post cooking event’ period is characterized by reduced capture efficiency. In short cooking events, typical for example in frying events or re-heating, this dominates the total capture efficiency. In this test, no alternative room exhaust is used. This is rapidly becoming standard practice in kitchen ventilation in western Europe. The range hood is connected to the central exhaust ventilation unit and serves as both the ventilation vent hole and, when activated, as range hood. This configuration is a worst case scenario for the capture efficiency if the post cooking event period is taken into account.

5. Conclusions

Good capture efficiencies can be obtained with relatively small exhaust flow rates during cooking, but the post cooking event period has a large impact on overall capture efficiency in short cooking events.

References