Strategies for efficient kitchen ventilation

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1 HEALTH RISKS

Cooking devices are a major source of contaminants in dwellings. They cause exposure to combustion products and vapors. The type and production rate of contaminants depend on the heating type (gas vs. electric cooking) and cooking process (frying vs. boiling).
Major health risks appear to be fine dust particles (which may contain carcinogenic PAH), NOx, CO, CO2, VOC like acrolein and micro-biological contaminants due to excess moisture.
Apart from this, odors from the cooking appliances may be annoying as well as excessive heat, which (especially in combination with a high humidity) even may be a physiological burden.

2 MINIMIZE DISPERSION FLOW AND CHARACTERIZE IT

To control the cooking contaminants, it is important first to restrict their dispersion and to know their characteristics. This depends on:

- Type of heat source, e.g. gas burning, electric hot plate, electric induction plate;
- Pan type (casserole, saucepan, frying pan, griddle, pressure cooker), pan height, lid type;
- Status of the cooking or frying process (warming, cooking or frying stage) and typical temperature (depending on the major substance, e.g. water, oil, sugar);
- Free flow space (height to cooker hood, closed back or corner or island arrangement), flow conduction (Coanda effect) and local flow disturbance (nearby windows, doors and pathways);
- Cook behavior (stirring, temperature control, lid use, moving along).

The first step to control contamination is to try and minimize the production rate and dispersion forces by altering said factors (processes and geometry).
For the design of an effective cooker hood, the flow characteristics (flow velocities, flow directions and flow field geometry) needs to be measured in critical situations.

3 LOCAL CAPTURE IS PREFERRED OVER DILUTION

Local capture is by far the most effective way to control the dispersion of cooking contaminants. Once dispersed into the room a larger air volume becomes contaminated and needs to be replaced by a much larger ventilation air volume during a longer period. In the meantime people present in the kitchen are still exposed to the resulting concentrations. Hence, local capture potentially is much more efficient, concerning both exposure and energy use.

In airtight, energy efficient buildings with minimized ventilation due to demand control, the low background ventilation level leads to long lasting, high concentrations of (cooking) contaminants. Therefore, in general the need for a high capture efficiency rises with increasing energy efficiency of dwellings.

4 MAJOR SPECIFICATIONS FOR USER-FRIENDLY COOKER HOODS

For users two major drawbacks prevent an unrestricted use of the cooker hood:

1. It does not sufficiently reduce odor spread;
2. There is a high noise nuisance.

Odor sensation has a logarithmic relation with pollutant concentration (e.g. 90% reduction of odor concentration will reduce odor complaints by maximal half). So, only a nearly perfect capture efficiency will meet the requirements for odor control. Since the design of an 80 or 90% effective hood only slightly alters from a 100% efficient one, the latter should be the design goal.

For the cooker hoods noise production a threshold value of 40 dB is proposed.

Apart from this, important demands are an attractive design and no adverse effect on the usability of the cooking appliances.

5 IMPROVE LOCAL CAPTURE EFFICIENCY

For common cooker hoods the capture efficiency is poor. Recommended steps to improve this are:

- Redesign the cooker hood, i.e. minimize the capture distance (hood height), maximize the overhang, move the suction slots to the critical contaminant escape spots at the perimeter, avoid large internal pressure drops;
- Enclose the contaminant flow by conducting plates and/or direct it to the hood by support flows. Automatically close down openings when no activities (like stirring) are ongoing;
- Derive the correct capture (and support) flow rates from the flow characteristics and the new hood geometry, using known design rules. Evaluate and tune this with tests;
- Control the flows and the distribution over the hood depending on production spots and intensity, favorably automated control using sensors.

There are interesting examples of improving capture efficiency in professional kitchens.

6 RECIRCULATION OR EXHAUST?

If captured contaminated air is exhausted from the kitchen area the flow equilibrium means that provisions for comparable supply flows are necessary, especially in airtight dwellings. Some imbalance (overflow from surrounding rooms) may be useful to prevent dispersion of poor quality kitchen air to surrounding rooms. In general this (temporary applied) supply flow is quiet large compared to normal ventilation system flows. Therefore, a special kitchen supply provision is recommended.

This kitchen supply needs special attention concerning draught risk. Furthermore a temporary high energy loss may occur due to the temperature deviation of the incoming outside air. Heat recovery, favorably including latent heat exchange to maximize the re-gain, enables the re-use of the heat of the exhaust air.

Another option is to recirculate contaminated air after filtration. However, filter demands will be high due to the complex mixture of (fine) particles, aerosols, gaseous components and odors. To filter the water vapor, condensation on an additional cold heat pump element may be required. Also this element may extract excess heat to control the kitchen temperature. Finally, necessary periodic filter replacement will have its drawback on user-friendliness and filter inefficiency will still require (possibly extra) background ventilation to reduce rest exposure.

7 BACKGROUND VENTILATION

Some rest contamination into the kitchen may be unavoidable, e.g. because of incidentally escaping flares of cooking air or due to exhalation of food that is further processed after it is taken of the stove. Therefore some background ventilation is considered to be necessary. Also after preparing food some low level elongation of exhaust fan operation time is recommended.