# Research on the Optimal Selection of Exhaust Range-hood in Chinese Kitchen

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**Abstract**: In this paper, the types and performance of exhaust range-hoods commonly used in China are collected. In order to keep indoor harmful gases（CO and $CO_2$ as representatives） indexes meeting Indoor Air Quality Standard after removing them, authors develop an optimal selection software of exhaust rang-hood which based on the programming technology of ADO on the VC++6.0 platform.

**Keywords**: exhaust range-hood; harmful gas; kitchen; VC++; optimal selection

## 1 Introduction

Exhaust hood is a main component part in gas exhaust system in a kitchen, the primary function of which is to capture cooking fumes, steam, and other exhaust-gas during cooking process. For people's health, many researchers at home and abroad have already studied various types of exhaust hoods, especially the exhaust hoods which are applied to the field of industrial ventilation were studied early [1]. There are few researches on the domestic exhaust range-hood at present. In addition, the system theory of how to choose a type of an exhaust range-hood and the convenient professional optimal selection software are lacked in China. Consider the problem, authors have developed an optimal selection software of how to choose an exhaust range-hood, which has a friendly interface and simple operation way to help people selecting an exhaust range-hood reasonably and professionally by analyzing the pollution diffusion laws of exhaust gas from cooking and burning liquefied-gas with an exhaust range-hood working in a closed kitchen [2-3].

## 2 Physical Model of The Experimental Kitchen

The study is based on a Chinese kitchen established in the Artificial Environment and Energy Saving Laboratory in Shenyang Jianzhu University. The kitchen structure is shown in figure 1, the length of the kitchen is 4.3m, the width is 2.8m, and the height is 2.8m, the door and the window are closed. The main component of liquefied-gas is the propane, 90% purity, the initial temperature of the kitchen is 20℃, and the atmospheric pressure is 101325Pa, the average jet speed at the flame nozzle is about 0.8 m/s and the combustion temperature there is about 863K[4]. The location of the stove is shown in the figure 1, an exhaust range hood, "DULONG" LQ-H, is used, and the center distance between the range hood and the stove is 0.7m.

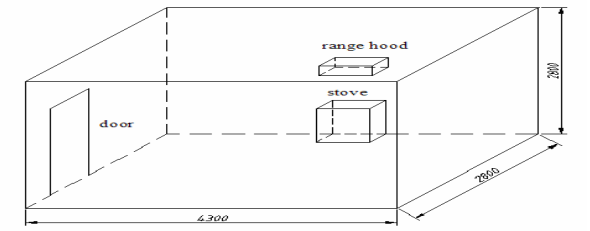


**Figure 1. The experimental kitchen structure**

## 3 Types and Selection Criteria of Range Hoods

### 3.1 Type Statistics of Chinese Exhaust Range-hood

According to < QB / T1816-93 Exhaust Range-Hood > standard in China, exhaust range-hoods are only divided into three types: discharge-type（CXW）, circulation type（CXX）and dual-duty type（CXL）. Most of the range-hood types in the Chinese market today are collected in this research. Authors found that although there is not a unified classification criterion of the range-hood, the major style of current marketplace is the discharge-type, which can also be divided into Chinese style, European style and Side-suction style.

### 3.2 Current Selection Criteria and Guidelines

The survey shows that a consumer prefers to choose the range-hood with suction-fan taking in large amount of air and making great pressure difference between inlet and outlet of the fan; and then selects it according to his aesthetic.

The value of pressure difference provided by manufacturers is total pressure [5], which is the sum of

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static pressure and dynamic pressure of the range-hood, and can not be used as the efficiency assessment index of the range-hood for engineering application. Authors found that selecting a range hood is based on overall considering the minimum air volume and static pressure, which is reasonable through the research, rather than, the greater the air volume and the pressure difference are, the better the efficiency of the range-hood is. If you want to select the most appropriate range hood for a specific kitchen, this study suggests: First of all, you calculate the minimum air volume and static pressure of the gas exhaust system, then choose a range-hood whose air volume and static pressure meet the requirement, and quality is eligible, and then select a range-hood whose motor power is minimum, noise level is the lowest and filter design is reasonable.

The current formula to calculate the minimum air volume of a range hood is:

$$L=1000P \cdot H \quad (m^3/h) \quad (1)$$

Where:

P, circumference of an exhaust hood excluding the side length next to the wall, m;

H, distance between the exhaust hood and the stove, m.

The minimum air volume from equation (1) should be checked by inlet velocity of the exhaust hood, and the velocity commonly could not be smaller than 0.5m/s. But the equation (1) is only appropriate to large or public kitchen [6], and few computing methods are appropriate to private or home kitchen. If the formula above is used to calculate the minimum air volume of range hood for a home kitchen, the result will be relatively large compared with the actual situation and result in waste of energy.

## 4 Researches on and Analysis of Minimum Air Volume of a Range-Hood

Home range-hood can do work normally when certain air volume is provided by fan. Design principle of the range-hood is to reduce the air volume mostly, if the exhaust-gas can be discharged effectively. There are two reasons: one is that larger air volume will lead to great initial investment and running costs; the other is that it increases the heat and cold loads, the initial investment and running costs of makeup air system. So we must take some measures not only to make the system air volume small, but also make the system efficient in the design of ventilation system.

Based on the law of mass conservation, the mass of pollutants entering the kitchen is equal to the sum of the pollutants mass retained in the kitchen and discharged by mechanical equipment. Authors propose a formula to calculate the minimum air volume of a range-hood, which is appropriate to all kinds of kitchens including home kitchen:

$$L_c = \frac{L_r t_r - \alpha_z V}{\alpha_c t_c} \quad (m^3/min) \quad (2)$$

Where:

$L_r$, Flow rate of the pollutant entering the kitchen, $m^3/min$;

$t_r$, generating time of the pollutant, min;

V, the kitchen volume, $m^3$;

$a_z$, maximum value of the pollutant increment, $m^3/m^3$;

$a_c$, volume ratio of the pollutant to the indoor air discharged, $m^3/m^3$;

$t_c$, working time of the range-hood, min;

when $a_z=0$ $m^3/m^3$ and $t_r=t_c$, The formula (2) is simplified as:

$$L_c = \frac{L_r}{\alpha_c} \quad (m^3/min) \quad (3)$$

The larger the value of $a_z$ is, the stronger the range-hood is able to capture the pollutant. It is related to the location of the stove and the range-hood, air volume and style of the range-hood, and other factors. The experimental data show that $a_c$ increases with air volume of the range-hood, and we found that $a_c$ changes a little after the air volume of the range-hood increases to a certain value. The data are shown in Table 1.

**Table 1. Experimental data**

| 点 | CO | | $CO_2$ | |
|---|---|---|---|---|
| | $L_c(m^3/min)$ | $a_c$（ppm） | $L_c(m^3/min)$ | $a_c$（ppm） |
| A | 7.41825 | 0.3 | 7.41825 | 1432 |
| B | 9.53775 | 1.3 | 9.53775 | 1560 |

According to the experiments and calculations flow rate of CO from flame nozzle in the kitchen is 2.44558E-05 $m^3/min$, and the $CO_2$ is 0.025727469 $m^3/min$. In figure 2 and figure 3, the straight line $L_1$ shows the relationship between air volume of the range-hood and $a_c$ under the experimental conditions; and the curve $L_2$ shows the relationship between required minimum air volume of the kitchen and $a_c$ for discharging CO and $CO_2$, separately. The intersection point of the two lines is minimum air volume of the range-hood to exhaust the pollutants in the kitchen. Comparing the minimum air volume of the range-hood to discharge CO and $CO_2$, separately, the larger one should be choose as the minimum air volume of the range-hood. The above mentioned method calculating the range-hood minimum air volume is applied to developed optimal selection software.

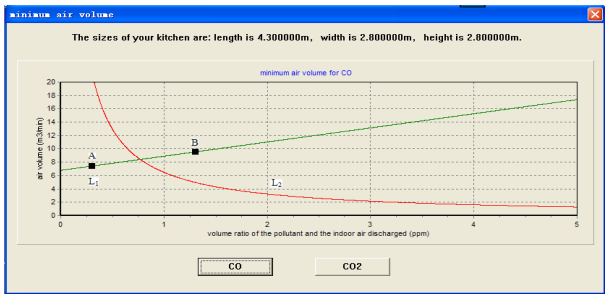


**Figure 2. minimum air volume to discharge CO**

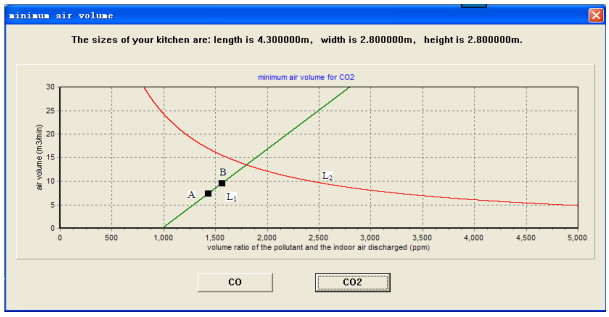


**Figure 3. minimum air volume to discharge $CO_2$**

# 5 Introduction of the Optimal Selection Software of Exhaust Range Hood

## 5.1 The Purpose of the Software

The required minimum air volume of a specific kitchen and the static pressure of the range-hood are able be calculated by this software which provides a professional, effective, shortcut and energy saving method of selecting a suitable exhaust range-hood.

## 5.2 The Structure of the Software

The structure and processes of the software are shown in figure 4 and figure 5.

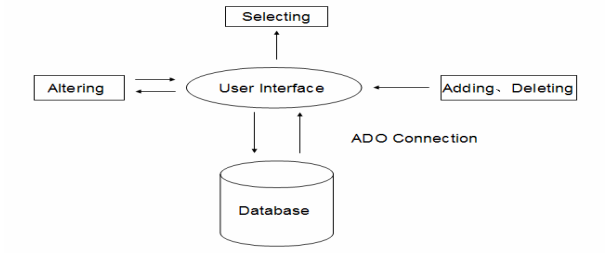


**Figure 4. structure diagram of the optimal selection software of range-hood**

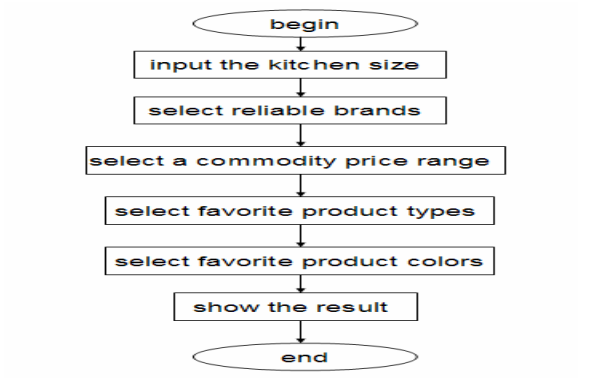


**Figure 5. process diagram of the optimal selection software of range-hood**

## 5.3 Application Example of The Software

We use the software to select a range-hood for the specific kitchen established in the Artificial Environment and Energy Saving Laboratory in Shenyang Jianzhu University.

In main interface of the software, a customer could click the button “select”, then input 3-D sizes of the kitchen, and select the reliable brands, a commodity price range, the favorite product types and colors following the wizard prompts. The result shows that the required minimum air volume of the kitchen and the models, parameters and pictures of the range-hoods which are optional, it helps user to easily select a range-hood. The result is shown as follows.

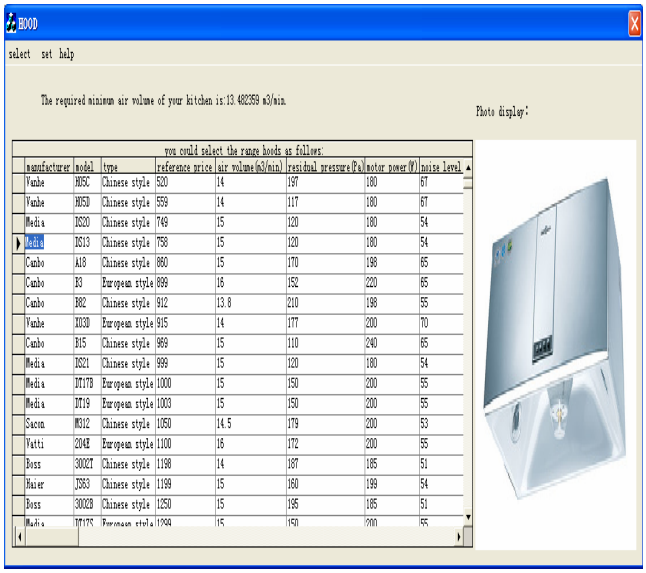


**Figure 6. The result of optimal selection of range-hood**

# 6 Conclusions

(1) There are models, parameters and photos of range-hoods commonly used in China in the database of the software, which provides sufficient data resources for customers choosing range-hoods. And the software includes adding, deleting and altering function to increase the flexibility of database update.

(2) A formula of the minimum air volume of range-hood for home kitchen, which can also be used for other kitchens, is presented. The software calculates the required minimum air volume of a specific kitchen, and shows the result in the interface to help user selecting a suitable range-hood.

(3) The pressure data provided by manufacturers is total pressure, which is the sum of static pressure and dynamic pressure. However the static pressure can be

used as design basis for engineering application rather than the total pressure. The software could calculate the static pressures of the range-hoods and show the result in the interface.

(4) The software can help user selecting a range hood reasonably according to a specific kitchen circumstances, and it is intuitive, friendly, and simple.

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