Design Support for Electric Kitchens

Background and Objective

Electric kitchens have recently become widespread not only in homes but also for business use, as they can contribute to energy savings and the reduction of environmental impact because of their low emission of radiant heat, high efficiency of instruments in the system, and no emission of combustion gases. However, since the amount of ventilation in electric kitchens for business use is determined based on the standards for gas kitchens, an advantage of electric kitchens in energy savings in air conditioning (reduced amount of ventilation) has not yet been satisfactorily attained.

In this project, we developed a support tool for designing electric kitchens that can simultaneously achieve high energy saving and high thermal comfort, focusing on the ventilation and air conditioning in electric kitchens for business use. Also, we developed a technique for analyzing the exhaustion of oil smoke during cooking, which is indispensable for the measurement of ventilation efficiency in electric kitchens.

Main results

1. Development of prototype design support tool

A calculation function for ventilation circuits was developed to calculate the amount of ventilation in electric kitchens considering temporal variation in the amount of ventilation between an electric kitchen and an adjoining room. This function was integrated into CADIEE, which is a tool developed by CRIEPI for designing the indoor thermal environment of homes (Fig. 1). Also, a function to incorporate the factors such as the amount of heat generated by kitchen instruments, the specifications of air supply and exhaust fans, and the area of the ventilation hood into the calculation of the amount of ventilation was added. Due to these improvements, it is now possible to calculate the air conditioning load of each room using CADIEE while considering heat transfer due to room-to-room ventilation [R09008].

2. Development of technique for analyzing exhaustion of oil smoke during cooking

a) Development of technique for analyzing oil smoke

We developed a method for chemical measurement of organic compounds such as fatty acids in oil smoke, a principal component of the exhaust gas during cooking. This method comprises the following three procedures (Fig.2): oil smoke is sampled through a glass fiber filter placed on the exhaust hood (sampling); the components of the sample are separated via a solid-phase column using a silica adsorbent (pretreatment); and the components are identified and quantified using a gas chromatography mass spectrometer (analysis). Our method was applied to a reference sample of simulated oil smoke, and its measurement accuracy was verified to be satisfactory [V09019].

b) Application of developed analytical technique in actual kitchens

Oil smoke generated from cooking instruments for sautéing and deep-frying food in an actual kitchen (area 72m^2; 300 meals/day), where gas cooking appliances are mainly used, was sampled for 18 days. Fatty acids in the sample were analyzed by the method explained in a). The results revealed that oleic acid, linoleic acid, palmitic acid, and stearic acid are the principal components accounting for 89% of the oil smoke, and that there was no marked change in the percentages of these components even when different types of dish were cooked (Fig.3). It was confirmed that these four types of fatty acid are suitable analysis targets in calculating ventilation efficiency [V09012].

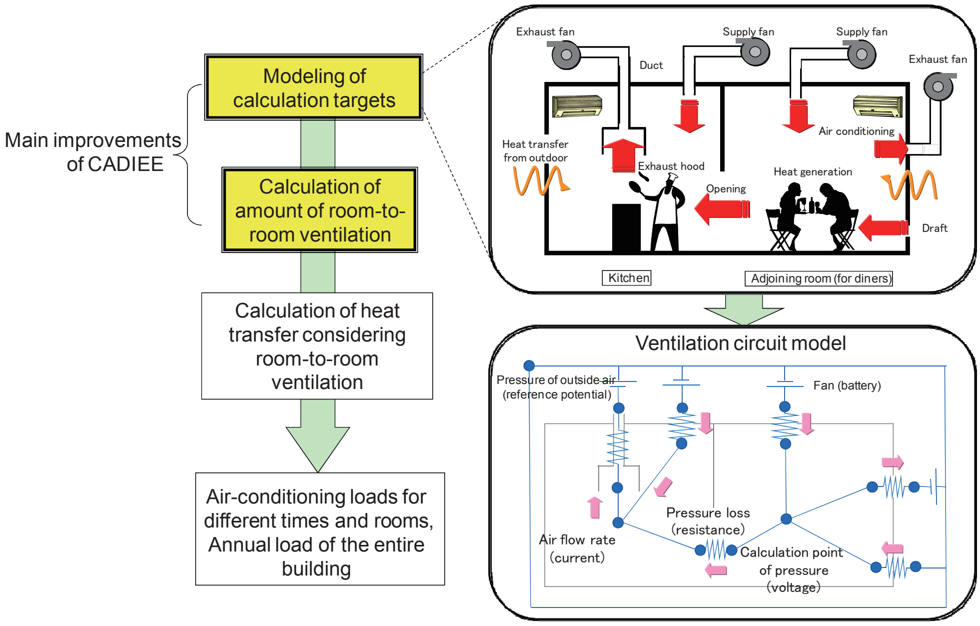

Fig. 1　Calculation flowchart of developed prototype design support tool

The flow rate of all air is obtained by calculating the balance of the flow rate and pressure of air at each node of a ventilation circuit, similar to an electric circuit.

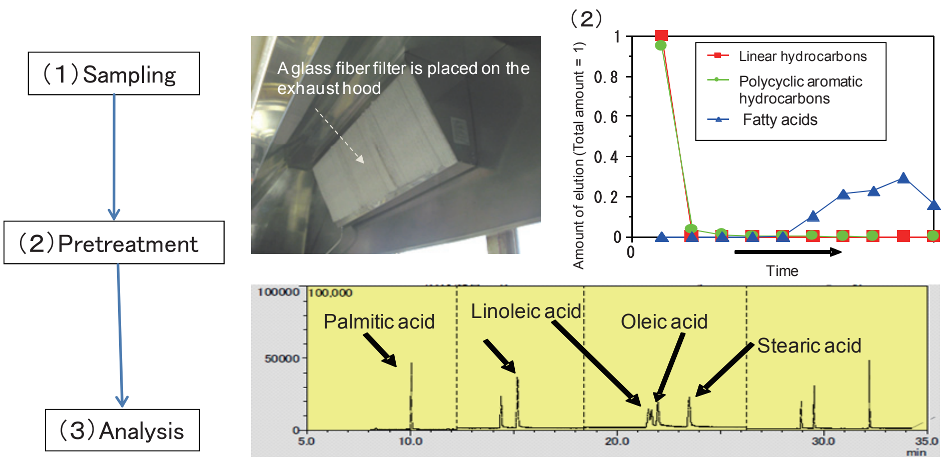

Fig. 2　Flowchart of oil smoke analysis and example of analytical result

(1) A glass fiber filter is placed on the exhaust hood. (2) Each component is separated via a solid-phase column. (3) Chromatograph of fatty acids obtained using a gas chromatography mass spectrometer indicates the clear separation of principal components.

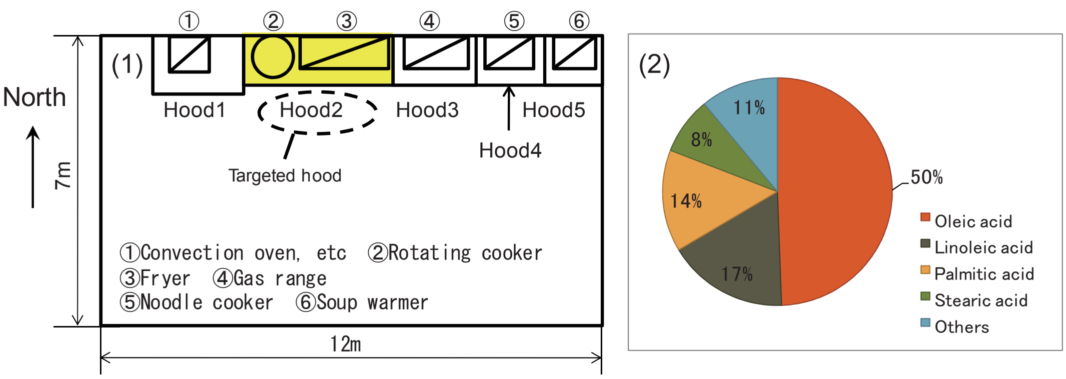

Fig. 3　Layout of kitchen used and analytical result for oil smoke

(1) Layout of kitchen used (Appliances 1-6 all use gas.) (2) Weight percentages of components in oil smoke (over an 18 day period)