A STUDY ON THE IMPROVEMENT OF EXHAUST RANGE HOOD AND FAN-ASSISTED VENTILATION SYSTEMS FOR COOKING

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Ventilation rate is regulated by a building code so that indoor air may not be polluted by combustion products from cooking appliances in Japan, which caused unexpected problems such as large noise,troubles brought about by reduced indoor air pressure, and higher heat load of air-conditioning.

In order to solve these problems, we have developopped a efficient exaust range hood which can reduce 2/5 of usual flow rate without any size-up.

We compared it with conventional range hoods and tested it using various cooking appliances. And we also conducted somewhat dynamic experiments such as when really cooked and when fresh air was directly supplied through a duct. Finally, we compared the efficiency when cooked by gas appliances with when by elctric ones.

From these experiments, we found that the performance of the hood and characteristics inherited by the cooking energy were made clear.

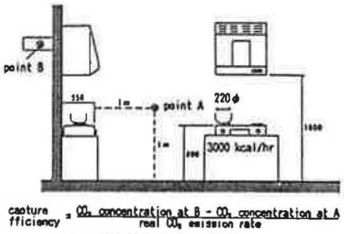
INTRODUCTION

With recent increase in airtightness of residences, kitchen ventilation problems have been attracting people's attention. Japanese building code requires fan assisted ventilation so as to keep O_2 concentration down to 21.5%, which requires higher flow rate of about 0.14m^3/s(500m^3/h).

But unexpected problems have occured by plentiful ventilation. For expample, large noise is generated, doors and windows are hard to open by reduced indoor air pressure, heat load of air-conditioning is increased and so on.

In order to solve these problems, we have developed a efficient exhaust range food and we compared it with conventional range food using various cooking appliances. And we also made somewhat dynamic experiments such as when really cooked and when outdoor air was supplied directly through a duct in a air tight model kitchen, the results ware excellent and interesting as follows.

TESTING METHOD



capture efficiency = (CO_2 concentration at B − CO_2 concentration at A) / real CO_2 emission rate × ventilating rate × 100 (%)

Fig.1 BL Testing Method

The exhaust capture efficiency of a range exaust hood was measured in conformity to the BL testing method (Fig.1). In the case of using electric hot plates, the capture efficiency was measured by spouting out CO_2 as tracer gas through holes on a ring shape tube surroundig outer surface of a pan bottom in comformity to the BL method.

The CO_2 concentration was measured by an infrared spectrophotometer (Honeywell KNG 14) and the air flow rate by an ultrasonic flow meter (Kaijo Denki GF-150).

DEVELOPMENT OF RANGE EXAUST HOOD

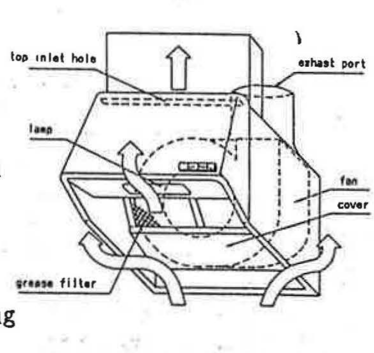


Fig.2 Overflow from Exhaust Range Hood

When flow lines around a conventional hood of typical construction are investigated visually, the overflows as shown in Fig.2 can be observed. The conventinal hood has defects of having interfering components such as the fan bottom cover and the lighting cover and letting exaust air pass through the top inlet hole at low ventilation rate.

After some preliminary experiments and repeated trials and errors, a range exaust hood of construction shown in Fig.3 has been developed. Even though the hood has usual size(600mmH×600mmD×400mmH),100% capture efficiency has been achieved at the ventilation rate of 300m³/h which are about 60% of usual hoods. The constractive features are enumerated as follows:

- Arranging the fan and the lighting cover not to prevent suction.
- Providing greater distnace between the end of hood bottom and the fan inlet port.
- Increasing suction speed around the hood-end using double hood constraction.

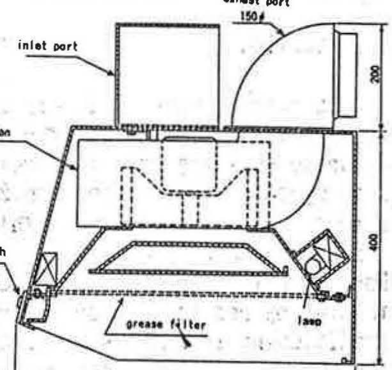


Fig.3 Structure of Developed Hood

RESULTS AND FINDINGS

1) Static Results

The exhaust capture efficiency of the developed range hood using various gas hot plates is shown in Fig.4. Though the efficiency is 100% in the case of the BL method(3.5kW burner), shifting the burner center forward or increasing of the combustion rate lowers the efficiency. However, when multiple burners are fired, buoyant plume interferes with one another and tends to collect at the center, and the capacity does not lower as much as the increase of combustion rate. Even when 4 burners are fired, the developed range hood still holds 90% efficiency at 300m³/h.

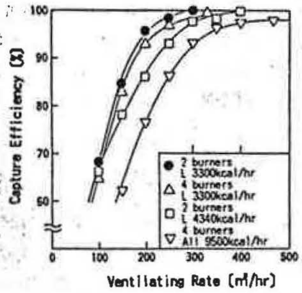


Fig.4 Performance on Various Hot plates

Fig.5 compares capture capacity of various range hoods generally used. Fig.6 shows outlines of the hoods used in the comparison. The capacity of the developed hood and the typical one is contrasted in Fig.7, when gas or electric hot plates are used. The reason why the difference in efficiency appears between electric and gas hot plates in the case of a typical hood may be explained by the difference of buoyant plume speed. As shown in Fig 8, a gas burner generates higher exhaust gas speed, and therefore plume tends to be scattered at the fan and lighting cover.

The performance when installation position was lowered is shown in Fig 9,

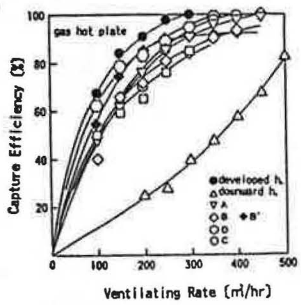


Fig.5 Performance of Various Hoods

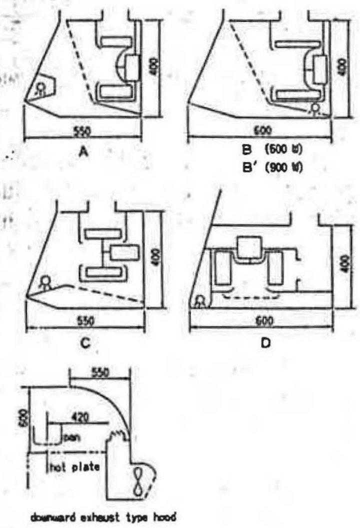


Fig.6 Hoods Used in Experiments

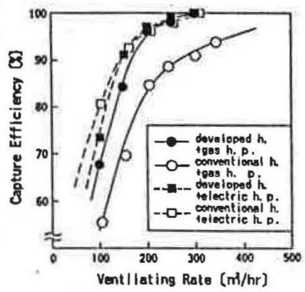


Fig.7 Performance on Gas and Electric Hot Plates

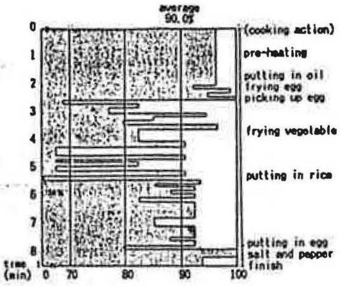


Fig.12 Capture Efficiency with Cooking (electric hot plate fried rice)

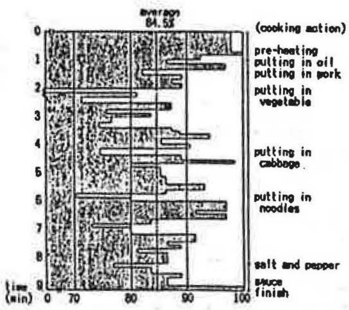


Fig.14 Capture Efficiency with Cooking (electric hot plate chow mien)

according to dishes and heat sources together with cooking motions. Figures indicate that motions to move a frying pan and to mix ingredients cause buoyant plume to overflow, thus lowering the efficiency. From the view point of difference in menus, chow mien which requires bigger motion loses greater efficiency. The electric appliances lower the efficiency more greatly when hands are moved than the gas ones, resulting poorer mean effficiency.

In the high air tight rooms, fresh air must be fed forcibly when a range hood is operated in order to restrict the depressure in the room. In this experiment, the capture capacity was measured when the air was supplied into a model kitchen of 3.6m×3.6m floor. The air was blown off from a external fan through a inlet port at the top of the developed hood. On the inlet port, louvers are installed horizontally, allowing the air direction to vary vertically. The area equivalent to clearance per unit floor area ($\alpha A/A$) was about 0.4cm²/m². The capture capacity was compared with the blowing off directions with 80% of exaust flow rate. Fig.15 shows the results of a gas hot plate. The capacity was found to be lowered only when the air was fed downward. It was surmised that the negative pressure was generated at the hood front end due to the supply air flow, and buoyant plume overflowed from the hood front by being sucked to the negative pressure portion, which lower the capture efficiency.

Then, the capture capacity was compared when the ratio ofthe feed air from a duct was changed. Fig.16 shows the results obtained with a gas hot plate. When the air feed rate was set at 0, that is, the air was supplied only from the cracks, the capture capacity was influenced. This indicates that the supply air flow rate has an optimum range which does not affect the efficiency.

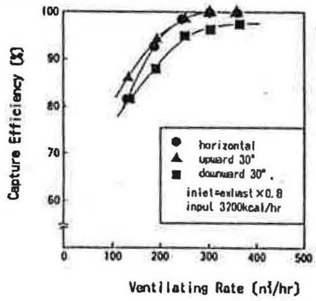


Fig.15 Performance on Blowing Direction of Inlet (gas hot plate)

Finally, the capacity of buoyant plume from a electic hot plate was examined. From Fig.17, the effect of direction and air feed rate on the capture efficiency seems to have nearly the same tendency. However, in either case, the lowering rate of efficiecy is greater than that of the gas one.

As shown during these dynamic experiments, the characteristics of slow exaust ascending speed generated by electric appliances can be thought to work negatively.

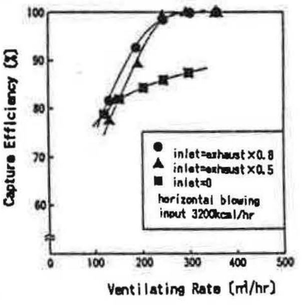


Fig.16 Performance on Various Inlet Rate (gas hot plate)

CONCLUSION

This research and development has made it clear that the ventilation rate can be reduced to 300m³/h while maintaining 100% efficiency. It was also confirmed that lowering the installation hight can provide higher efficiency.

Finally, the results of the dynamic tests show that the efficiency are greatly affected by feeble horizontal air current.

With these researches and contrivances, the kitchen ventilation should be brought into a system, and cleaner and more comfortable kitchen and living spaces could be created.

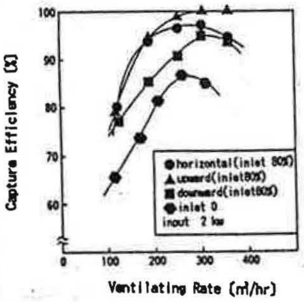


Fig.17 Performance on Various Inlet (electric hot plate)

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