ON THE NATURAL VENTILATION EFFECT OF A SIMULTANEOUS TYPE VENTILATOR AND ITS APPLICATIONS

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INTRODUCTION

In Japan, houses are progressively industrialized and low-priced houses are widely spreading, which has caused some environmental problems. One of the problems is caused by the improvement of air-tightening. Air-tightening should be welcomed but securing enough ventilation, which is the primal aim of air-tightening, is sometimes ignored. The lack of ventilation makes indoor climate highly humid, and results in vapor condensation or mold in houses. As a political solution, housing makers have been obligated to install ventilation systems by mechanical force in newly built houses. The common ventilation systems in houses now are divided into two types: an exhaust and supply ventilation type and an only exhaust ventilation type. The former enables heat to be recovered and is used worldwide especially in cold regions. Furthermore, electric energy can also be recovered in that system, so it is an ideal ventilation system. As for the latter system, the polluted air in rooms is directly exhausted, so its energy efficiency is bad. However, because of its simple structure, it is the most widely used. It is used mainly in winter, but here is a problem of extra electric energy consumption by electric exhaust fan, even though there is a possibility that the temperature difference between indoors and outdoors brings about natural ventilation by stack effect. Natural ventilation should be more taken into consideration. The electric consumption by ventilation in a general house is about 150kwh in a year, but LCCO$_2$ exhausted in all the houses in Japan are estimated to be about 800 million ton a year. The authors have suggested a ventilator mainly operated by natural ventilation instead of electric energy, and in this study they will discuss its dehumidification effect when it is used in highly humid indoor environment.

A Common System for Natural Ventilation

Most of the ventilators sold as building materials are supposed to be used as materials either for supplying fresh outdoor air or for exhausting polluted indoor air, so they are one-way ventilation. They work efficiently when ventilation route is definite but such cases are often observed as residents dislike noise coming in through openings on the wall and close the vents, or the undercuts of doors are stuffed with a thick-piled carpet. The countermeasures against inefficient ventilation are necessary especially in highly airtight buildings.

Basic Efficiency of a Simultaneous Type Ventilator

Figure 1 shows the outline of a common type ventilator and the basic efficiency of a simultaneous type ventilator. A normal ventilator below the neutral height, which depends on the stack effect of the building, works as a vent which supplies outdoor air and above the neutral height, works as a vent which exhausts indoor air. And if these ventilation routes are closed for some reason, the vent itself comes to supply and exhaust air simultaneously. This is a kind of a fail-safe system in ventilation. **Figure 2** shows the basic measurement results of a simultaneous type ventilator A (height: 150), a simultaneous type ventilator B (height: 300), and a traditional type ventilator C. In the experiment ventilation times of A was 0.73 times/h, that of B was 1.32 times/h and that of C was 0.16 times/h under the 10℃ temperature difference and there was a great difference in their ventilation effects.

The Measurement Results in Houses

Ventilation volume was measured in a house on the 4th floor of a four-storied apartment. CO_2 was used as a tracer gas and the multi-sampling method was used to calculate the average concentration in a space. The decay rate of CO_2 concentration was used to calculate ventilation times. In the measurement results, ventilation volume per ventilator was 7 to 8 m^3/h. That volume was small but the actual ventilation volume in the whole house is expected to be larger and sufficient because ventilation by stack effect by temperature difference is added and the number of ventilators increases with the number of rooms. The result of the simultaneous type ventilator in a general house was almost satisfactory. Popular ventilators are one-way type as mentioned before and their ventilation efficiency is very poor. Especially in airtight houses the fail-safe design of ventilators is extremely important.

The simultaneous type ventilator in this study has openings in upper and lower part outside, so it can be set away from the neutral height and once air flow begins, with a kind of s siphon effect, the flow is thought to become steady.

In general two-or-more-storied houses, it is inevitable that ventilators tend to supply outdoor air below the neutral height and above it they tend to exhaust indoor air, but the results have proved that under the system which keeps indoor air pressure lower than outdoor air pressure the ventilators becomes vents which supply outdoor air and furthermore simultaneous ventilators work when there is something wrong in ventilation routes.

The Dehumidification Effect by the Simultaneous Type Ventilator

The authors set simultaneous type ventilators in a building space with a problem of high humidity and measured temperature and humidity before and after the setting and inspected their dehumidification effect.

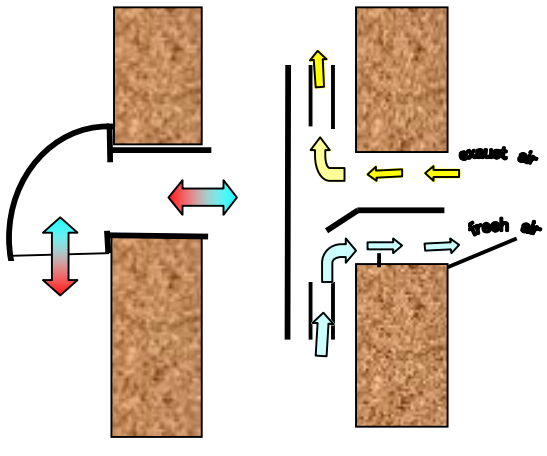


Fig.1 A common system ventilator (left) and simultaneous ventilator (right)

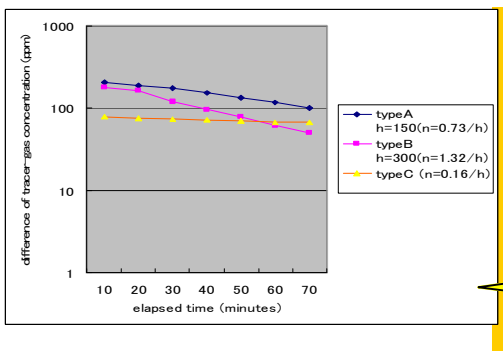


Fig.2 Basic measurement results of simultaneous ventilator and common ventilator

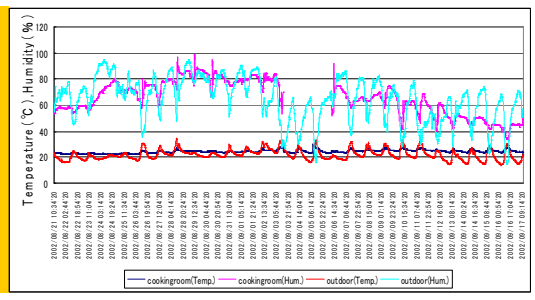


Fig.3 the change of the temperature and humidity in the lunch room

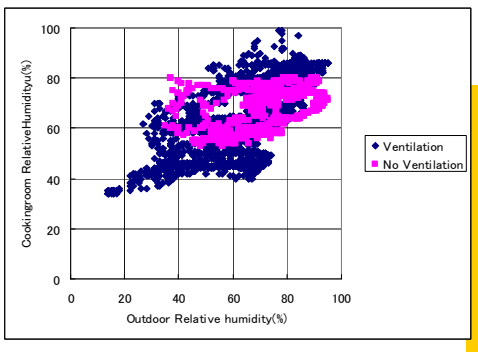


Fig.6 temperature and humidity change before and after simultaneous type ventilators

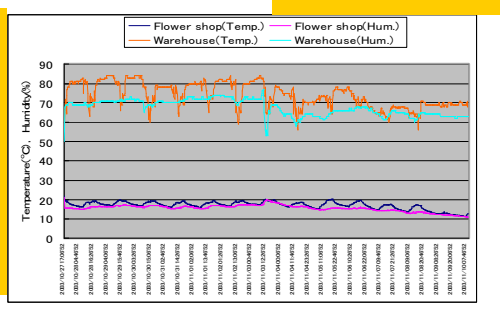
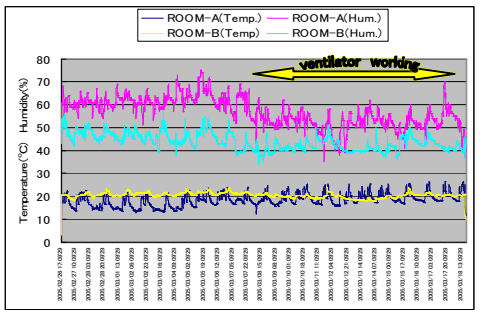


Fig.5 Temperature and humidity change in the flower shop and the warehouse



An Example of a School Lunch Room

School lunch rooms are lacking of ventilation during

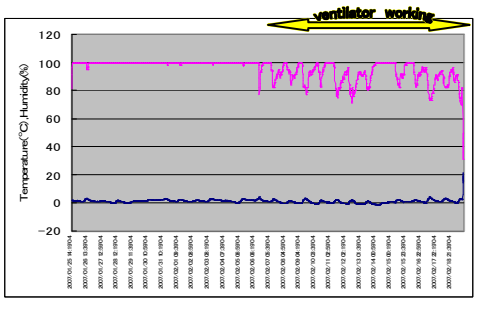


Fig.7 Change of temperature and humidity of a water purification plant

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necessary for sanitary reasons but insufficient ventilation at night keeps the floor wet, so in hot and humid summer, a problem of mold occurs. The authors set a simultaneous type ventilator with upper and lower openings in a school lunch room in an elementary school in Sapporo and measured its efficiency. The temperature and humidity in the lunch room and outside were measured and recorded successively with a small data logger. **Figure 3** shows the change of the temperature and humidity in the lunch room during the measurement period. The relative humidity was around 60% during the summer vacation, and when the vacation was over and the room began to be used, it reached almost 80%. After the ventilator was set, it gradually decreased and at the end of the measurement it was below 50%. Since the temperature difference between inside and outside hardly exists in summer, ventilation volume itself became small, but this might not be a problem in a lunch rooms where drying is intended. In addition, though the effect of the decrease of outdoor humidity is seen, drying effect by ventilation is more eminent.

The authors could not use tracer gases when measuring ventilation volume for sanitary reasons, so they estimate its ventilation times using the decay part of the absolute humidity difference between inside and outside of the room, for the change of absolute humidity is close to that of a tracer gas. The decay part of the absolute humidity difference was calculated with the absolute humidity difference between indoor air and outdoor air during the night (from 0:00 am to 7:00 am), when no one was in and vapor generation from the washed floor stopped. Without ventilators, ventilation times vary a lot and are difficult to estimate, but with ventilators they are about 0.07 times/h. Furthermore, as **figure 4** shows a correlation between the relative humidity of the lunch room and that of outdoor air during the night (0:00 to 7:00), the relative humidity came to follow the outdoor air after setting the ventilator. Therefore its ventilation effect is proved to be clear. A dietitian working in the lunch room said that the floor which had been wet until the next morning became dry after setting the ventilator. Her words support the measurement results.

An Example of a Flower Shop and a Apartment house

There are a lot of fresh flowers in the shop, so the humidity was normally high and the shop keeper was worried about vapor condensation on the walls and windows of the shop and warehouse. The humidity change was measured in winter before and after a natural ventilator was set. At least one ventilator was set on each south and each north side, considering the seasonal wind. Two ventilators were set on the openings above windows in the shop and five ventilators on the windows in the third and fourth floor. the warehouse on temperature and humidity **Figure 5** shows shop and the warehouse change in the flower recognized both in the shop fall of humidity was immediately after the setting and the warehouse The relative humidity fell of the ventilators. indicates the dehumidification about 10%, which ventilator. The staff of the effect of the shop says that vapor condensation which was seen on the wall of the shop is gradually vanishing and that they can feel the shop is getting dry. Traditional ventilators are already set in the apartment, but their ventilation efficiency is so poor that the residents are always complaining about the vapor condensation and mold in the apartment house. **Figure 6** shows temperature and humidity change before and after simultaneous type ventilators were set in two apartment houses in Asahikawa. The humidity of the two apartment houses fell 8 to 10% after the setting of the ventilators. In addition the residents say vapor condensation and mold have disappeared. The dehumidification effect of the ventilator was confirmed.

Fig.4 A correlation between the relative humidity of the lunch room and outdoor air

An Example of a Water Purification Plant

In a water purification plant in Sapporo, vapor condensation could not be prevented by the use of traditional ventilators, but the simultaneous type ventilators were effective in dehumidification. In **figure 7**, the relative humidity which had been almost 100% fell to below 90% in average after the setting of the simultaneous ventilators. The staff says that there is no more vapor condensation. In this plant, the windows are closed and electric fans are shut down at night to save energy, which caused vapor condensation. Therefore the simultaneous ventilators, which need no electricity, were very effective. In this way, a ventilator with a small volume of ventilation proved to produce a good result.

CONCLUSION

In this paper, the dehumidification effect of a simultaneous ventilator in some kinds of buildings was investigated. The results of the measurements confirm that the ventilator comes to supply and exhaust air simultaneously in case the ventilation routes are closed and works as a fail-safe system for ventilation. Its ventilation volume is small, but its successive use has a good effect on dehumidification. In Japan ventilation by mechanical fans has become compulsory for new houses. However, the methods of natural ventilation should be established in order to save electricity because Japanese Prime Minister has declared that Japan aims to reduce the exhaust of CO2, one of the greenhouse gases, by 25%, which is much higher rate than that in Kyoto Protocol. In this sense, the simultaneous type ventilator in this study is an effective item.