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A Survey on Improvements of Range Hood in Apartment

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ABSTRACT

Purpose: Residential cooking(gas or electricity) emits many air pollutants. For Removal of these contaminants, range hood is play an important role in the cooking activities. However, deterioration about performance of range hood can be occur in used range hood which is not verified on performance by testing balancing and adjusting in apartment. So, purpose of this study is to improve the range hood against cooking-generated contaminations. **Method:** To improve hood, survey of range hood which mounted in apartment have to conduct at first. In this study, the survey was conducted for 3 steps. First, Visual inspection for conditions of range hood. Second, questionnaire of operating and maintenance method. Third, interview with user about need for improvement, complainant. Finally, we integrated the survey for range hood and introduced the probable cause of deterioration through this comprehensive survey. **Result:** Result of measurement for air volume for range hood, A measured air volume has reduced by 41.4, 38.0, 32.0% each step from rated air volume. There are lots of reasons of this phenomenon including to maintenance, air path of duct, lower-cost devices, exhaust ports. For solve this problem, guideline about operating hood, user in apartment will have to supply with maintenance information at first.

KEYWORD

레인지후드
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Residential Indoor air quality

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1. Introduction

As the outdoor air environment has deteriorated due to outdoor fine dust and yellow dust in recent years, interest in indoor air quality and ventilation has increased significantly in Korea. Ventilation is an important issue that is closely related to the health of the people. In apartment, it is obligatory to ventilate at least 0.5ACH(air change per hour), requiring natural ventilation or mechanical ventilation equipment in accordance with「Ventilation equipment standards for apartment and multi-use facilities」. In addition,「Health-friendly housing construction standards」request the verifications of performance for ventilation equipment according to「 Technical standards for apartment ventilation equipment TAB(test balancing, adjusting) of the Society of Air-conditioning and Refrigerating Engineers of Korea」.

The range hood is installed in most apartment houses. However, unlike the ventilation equipment, TAB is not carried out after installation of the range hood. As a result, the performance of the installed range hood is not verified and it is judged to be the time when a survey is needed.

In Korea, a number of studies have been carried out on improving the performance of the range hood and a study on the improvement of the performance (efficiency) of the range hood has been carried out[1~4]. Min, Lee measured the concentration of various pollutants (PM_{10}, CO, CO_2, HCHO) according to the operation of the range hood and estimated the performance of the range hood[1]. Sohn et al[2] improved performance over conventional hood by over 20% by combining an existing range hood with an induction air curtain unit both with CFD and actual measurement. Sung has shown that it is possible to improve the efficiency of the range hood by simple equipment improvement through application of the air curtain type range hood and CFD analysis[3,4]. As shown above, studies on the performance improvement of the domestic range hood has been carried out in detail, but there are few studies on the range hood for apartment until now.

In foreign countries, studies on the actual condition of existing range hood were carried out[5~7]. Fugler, D.W.[5] measured the airflow of a Canadian existing housing range hood and it was found that only three households out of 17 account for more than 50% of the rated flow and measured both noise and power to provide the performance of the range hood comprehensively. In addition, Singer et al [6] measured the air flow rate of 15 range hoods for household. According to the result of the measurement, it was

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(a) Experimental apparatus of measurement for air flow rate

(b) Range hood with filter

Fig. 1 Testing of range hood

found that 10 of the target devices had the air flow rate, which is less than 70% of the rated flow.

As shown above, the research on the existing range hood has not been conducted in Korea, and phenomenon can be seen that the actual air flow of the range hood is different from the rated flow through the results of the study abroad. Therefore, the purpose of this study is to identify the actual status of the range hood installed in the apartment through the actual condition survey of the range hood installed in the existing apartment and to use it as basic data for improvement.

2. How to Investigate the Actual Condition of the Range Hood

2.1. Overview of actual condition survey

Table 1. Overview of survey

Item	Contents	Detailed contents
Area	Nationwide survey	Seoul, Gyeonggi-do, Daejeon, Chungcheongnam-do
Target	Apartment resident	Main target : Housewife (main user)
Step	1. Visual inspection: Conditions of range hood 2. Questionnaire: Operating method 3. Interview: Need for improvement, complainant	
Sample size	80 person	Use range hood: 77 No use range hood: 3

Recently, studies on the pollutants generated during kitchen cooking in Korea [8~9] have reported that kitchen cooking accounts for a large proportion of indoor pollutants and emphasized the solution through ventilation. However, there are few studies on the performance verification of the range hood which should be operated during kitchen cooking and the performance is expected to deteriorate through consideration of previous studies. Thus, this actual condition survey measured the airflow of the hood installed in the home and compared the performance of the hood with the rated flow of the hood. In addition, we were to diagnose the range hood installed in the existing apartment rather than the simple survey, and then, following the survey, we interviewed the individuals in detail to identify occupants' perception of the range hood.

The survey was conducted by randomly selecting 80 households in Seoul, Gyeonggi, Daejeon, and Chungcheong. The survey has of a total of 8 questions, consisting of basic questionnaires on residents and range hoods.

If there are many occupants, the survey and interviews were conducted for housewives who mainly use the range hood. The survey for each step was conducted in the order of Table 1, and the details of each step are as follows:

(1) Visual inspection

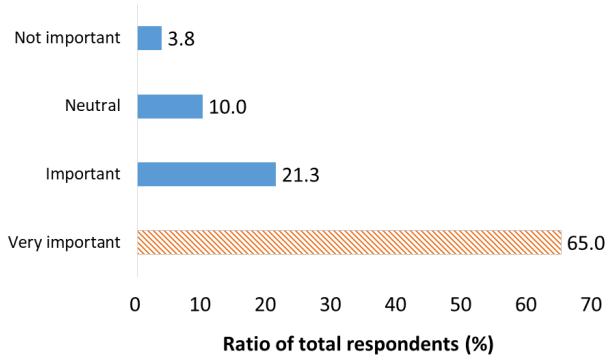
The simplest basic survey such as range hood and cap grill type, basic specification, condition (filter, duct, noise) etc.

(2) Survey

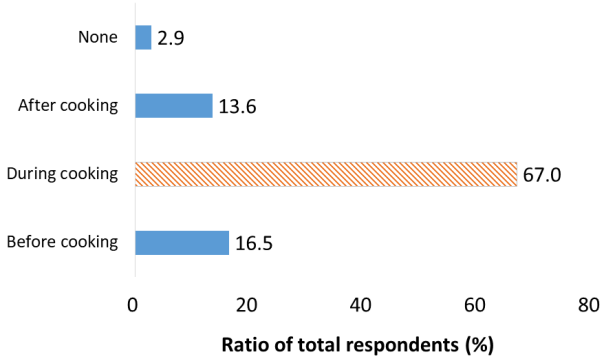
General information on how to operate the range hood (daily cooking/hood operation frequency), operation time, maintenance, improvement etc.

Table 2. Measuring instruments

Measuring target	Instrument	Specification
Air velocity	TESTO 480 profession climate instrument	Meas. Range : 0 to 5m/s Accuracy : ±0.03 +4 of mv



(a) Importance awareness rate of range hood (N=80)



(b) Timing of range hood (N=103, Duplicating answer)

Fig. 2 Survey result of operation, awareness

(3) Interview

Detailed survey such as complaints when using the hood, improvement points, reasons for not using the hood, awareness of the range hood, awareness of the pollutants related to cooking

2.2. How to measure range hood performance

Fig. 3 Maintenance problem for Range hood

Table 3. Sample characteristics

Age	Survey sample(%)	Period of residence	Survey sample(%)
20-30	7.5	Under 1 years	6.3
30-40	5.0	1-2 years	15.0
40-50	18.7	2-3 years	7.5
50-60	56.3	3-5 years	11.2
Over 60	12.5	5-7 years	11.2
The number of samples=80		7-10 years	6.3
		Over 10 years	42.5

In Korea, KS C 9304 is used to measure the air flow rate to find out the performance of the range hood. Foreign countries also do not define the criteria for the unique performance measurement of a separate range hood. ASHRAE[10] presents 100cfm (50L/s) as the minimum standard of range hood air flow and in the case of an enclosed kitchen, the minimum air flow for the normal function of the range hood was suggested by presenting more than 5ACH in consideration of the kitchen volume.

Singer et al[7] measured airflow compared to the rated flow of a range hood certified under the same conditions as the Home Ventilating Institute (HVI) and demonstrated the capture efficiency of the range hood using tracer gas, and demonstrated the performance deterioration of the existing range hood using. However, there is currently no established definition of an internationally recognized range hood efficiency rating. This study measured the air flow rate of the range hood by using equation of KS C 9304 (1) and measuring instrument (Table 2).

$$Q_m = A\,\overline{V} \tag{1}$$

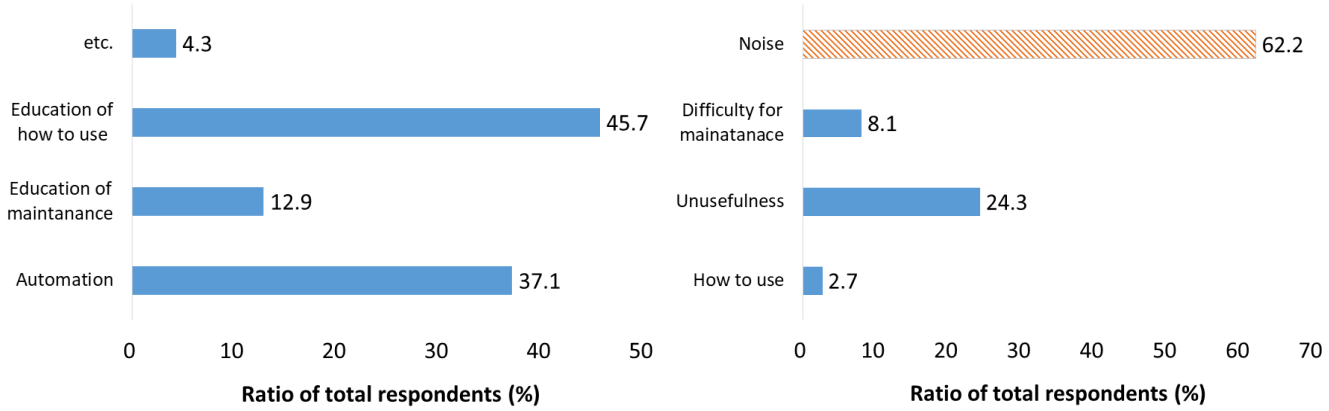
Where Q_m : Measured air flow of the range hood (m^3/s)

$\overline{V}$: Measured air flow (m/s)

A : Range hood exhaust area (m^2)

Table 4. Frequency of actions (N=80)

Index	How often cooking per day?	How often operate range hood per day?
	Survey sample(%)	Survey sample(%)
One time	17.5	19.5
Two times	35.0	37.7
Three times	43.8	32.5
Four times	2.5	0.0
Five times (or more)	0.0	6.5
None	1.3	3.9



(a) Improvement of range hood (N=70, Duplicating answer)

(b) Reason not to use range hood (N=37, Duplicating answer)

Fig. 4 Survey result of operation, awareness

Table 5. Air flow rates of range hood. Sample of hood represent the entire range of measurement

Set up	Number of hood	Air volume of range hood(m^3/h)				
		Sample range	Rated flow		Measured flow	
			Mean	SD	Mean	SD
1	20	300±30	308	21.1	140.4	53.6
2	23	400±30	399.8	13.7	160.5	58.2
3	21	600±20	608.1	12.0	189.9	49.1

As shown in Fig. 1(a), this study measured air flow in exhaust filter of the range hood. The wind speed can be adjusted depending on the type and the specification of the range hood and the shape of the exhaust vent is also very diverse. Therefore, this actual measurement measured the air flow rate by differentiating the measurement points according to the number of the exhaust filters divided. Fig. 1 (b) is an island-type large range hood with an exhaust port divided into four filters and the average wind speed was calculated by measuring 9 places and 36 places by filter compartment.

For the accuracy of the measurement, the hood began to be measured at least 5 minutes after start-up and the wind speed was measured in the order of the highest wind speed to the lowest wind speed. When the number of steps of the range hood is changed, the process of stabilizing the air flow of the hood should be preceded. Therefore, it was measured after changing the exhaust airflow due to the regulation of the number of steps of the range hood and after operating for more than 5 minutes and wind speed was measured for more than 1 minute at each measurement point.

The rated flow of the existing range hood presents the maximum number of steps as a representative value in general, but this study measured the number of all steps. Based on this, the rated flow and the measured air flow for each step were compared to evaluate the performance deterioration of the range hood installed in the apartment.

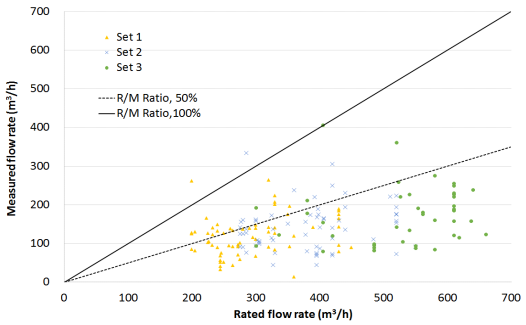


Fig. 5 Result of measurement for air flow rate. M/R ratio: Measured flow per rated flow

3. Survey Results

3.1. Survey and interview results

3.1.1 General characteristics of respondents

The general characteristics of respondents are shown in Table 3. As indicated in 2.1, respondents consisted mainly of housewives who use the range hood the most frequently, with 56.3% in their 50s, 18.8% in their 40s, and 12.5% in their 60s or older. In the residence period of respondents, the respondents who have lived longer than 10 years were found to be the highest, 42.5% and the frequency of the residence period is 6.3~15.0%, showing relatively uniform distribution.

3.1.2 Operation frequency of cooking and range hood

Table 4 shows the frequency of respondents' cooking and range hood operations. In respondents' cooking frequency a day, three times (43.8%) were the most, 2 times were 35.0% and 1 time was 17.5%, showing that it was 2.9 times per day. The interview results showed that the number of cooking in the questionnaire does not match with the number of meals. In other words, many respondents were found to cook from one to three times per meal.

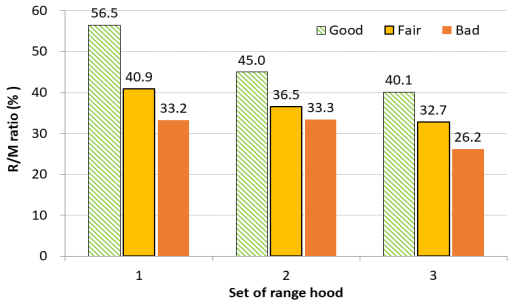


Fig. 6 Maintenance problem for Range hood. Measured flow per rated flow

The number of hood operation was found to be twice (37.7%), three times (32.5%) and one time (19.5%). Respondents who do not operate the hood were surveyed to be 3.9% (n=3) and respondents were found to operate the range hood on average 2.9 times a day.

The households where the number of cooking times is greater than the number of cooking times were found to be respondents with low frequency of operating the hood during cooking because they do not feel the necessity of operating the hood during cooking.

3.1.3 Awareness and operation point of range hood

Fig. 2 (a) shows the awareness of the importance of and the operation of the range hood. 10% of respondents responded as neutral and 3.8% of them perceived it as unimportant. On the other hand, 65% of the respondents said that the use of the range hood was very important during cooking and 21.3% were found to recognize the hood as important. The interview results showed that the majority of respondents who answered, “very important” and “important” said they recognized the problems of fine dust and kitchen cooking highlighted recently and considered the range hood more important than in the past. Based on the results of the survey, it seems that most households regard the use of the range hood as important. At the operation time of the range hood, the highest rate (67%) was during cooking, followed by 13.6% after cooking and 16.5% before cooking.

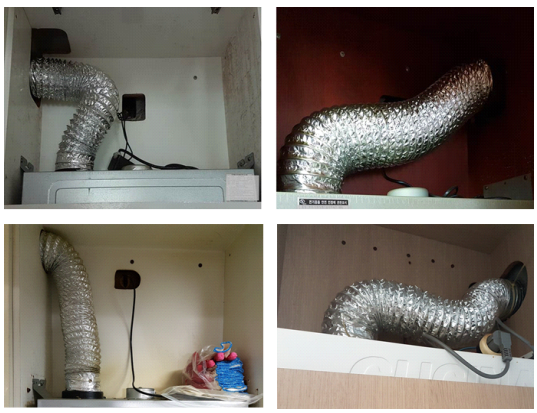


Fig. 7 Problem of exhaust duct

3.1.4 Maintenance and improvements of range hood

During the inspection of the range hood, the visual inspection showed that there was a problem with maintenance of the range hood installed at home (Fig. 3). On the other hand, when the range hood was operated, the respondents said that recognition of the problem of the range hood was recognized through the following three phenomena (n=52).

(1) Control of number of steps: Even if the number of steps of the hood is adjusted, there is not enough change in performance felt (25.0%)
(2) Diffusion of odor and contaminants : Despite operating the range hood, diffusion of odor and contaminant to the entire indoors (59.6%)
(3) Noise : When the use period of the hood is high, awareness of the problem (15.4%) due to the increase in the noise of the hood (15.4%)

The result of the survey based on this showed that many respondents said the range hood needs improvement (Fig 4(a)). Among them, the use of the range hood (45.7%) was the highest. During the interview process, respondents perceived the use of the range hood as the correct method of use. It would be necessary to provide guidelines for operating the range hood. As an improvement on the range hood, 37.1% answered that if the indoor air quality deteriorates due to cooking, etc., the automation function that the range hood can automatically cope with is required.

In addition, 12.9% of respondents presented the need for education on correct maintenance of the range hood. Maintenance of the range hood includes some methods such as filter replacement and cleaning, but consumers were found not to be aware of this information, and it is considered that basic information about maintenance should be accompanied.

As a reason for the reluctance to use the range hood (Fig. 4 (b)), most respondents pointed out the noise problem in the range hood (62.2%). Especially the interview result showed that most respondents do not use the range hood before and after cooking because of noise, and use only intermittently during cooking, showing that they consider the noise problem as an important factor in using the range hood.

3.2. Results of range hood performance measurement

This study measured the flow rate of the range hood and evaluated the performance of the range hood installed in the existing apartment and compared it with the rated flow (Fig. 5).

Although the rated flow of the basic range hood is based on the maximum air flow rate, this study measured and investigated the number of all steps to evaluate the performance.

Of the 80 households to be measured, five households that do not use the range hood at all or have range hood that is so aged as to be impossible to measure were excluded from the measurement and this study was based on the results of 75 households.

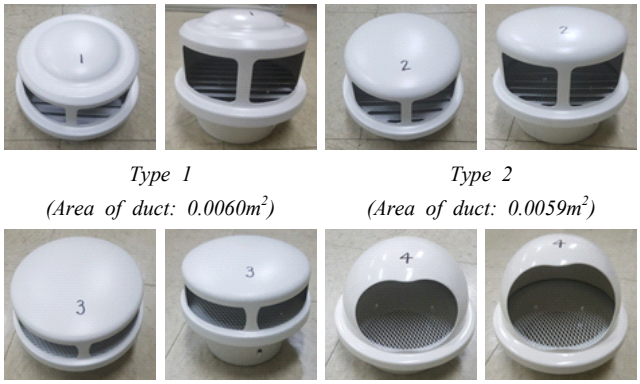
The rated flow of the range hood was 299.9, 386.4, and 530.2 m^3/ h, respectively, for each number of steps. On the other hand, the air flow rate was measured as 121.2, 138.2, and 167.9 m^3/h on average, respectively, by the number of steps. This is 41.4, 38.0 and 32.0% compared to the rated flow of the product and the decrease in the measured flow rate compared to the rated flow was noticeable, and especially, the decrease rate was found to be higher in the hood with higher rated flow. In addition, even if a product with the same range hood or similar rated flow is installed at home, the performance was found to be very different.

As shown in the introduction, the specifications of the range hood are very diverse, so this study specifies a range approximate to the sample value and sample value within a certain range by the number of steps as shown in Table 5.

First, the sample value of the three-step rated flow is 608.1±12.0m^3/h, whereas that of the measured air flow is 189.9±49.1m^3/h and the standard deviations was found to be relatively great with distinct air volume reduction. In addition, sample values(with standard deviations) were measured as 140.4±53.6m^3/h, 160.5±58.2m^3/h in the other steps, showing that even with the range hoods with the similar rated flow. The performance variation is remarkable.

In addition to the ventilation of the apartment and building conditions, the variation of the performance is large depending on various conditions of the installed range hood. As indicated in 2.2, the measured air volume of the range hood herein is not the measurement under the same conditions as those of KS C 9304 due to the nature of field survey but even considering this, performance deterioration of the range hood installed in the general house is large. In addition, the ratio of the measured air flow to the rated air flow is 32.0% in the 3-step stage (the maximum air flow mode of a general range hood), showing the greatest performance deterioration. This figure is based on the maximum air flow rate and 64.0% out of the target households were found not to meet minimum air volume standard (100 CFM) of range hood recommended by the ASHRAE.

This study comprehensively conducted a survey, interviews, performance measurements, and found that the performance deteriorations of the hood were caused by the following four problems.



Type 1 (*Area of duct: 0.0060m^2*)

Type 2 (*Area of duct: 0.0059m^2*)

Type 3 (*Area of duct: 0.0046m^2*)

Type 4 (*Area of duct: 0.0070m^2*)

Type 5 (*Area of duct: 0.0126m^2*)

Type 6 (*Area of duct: 0.0063m^2*)

Fig. 8 Types of exhaust port

4. A Comprehensive Analysis of the Survey

To evaluate the performance of the range hood, this study conducted a survey of actual conditions in three steps as shown in Table 1, and confirmed the performance deterioration of the range hood and collected feedback from users. Comprehensively analyzing airflow measurement, surveys of the range hood and interviews, we presented the causes of the deterioration of the range hood as four causes as follows.

4.1. Maintenance of users and aging

The most obvious problems in the survey of the range hood include the maintenance and aging of the hood. The hood in the building that is more than 10 years old was also found to be outdated and not to be used by users and to operate in a state where performance is severely degraded.

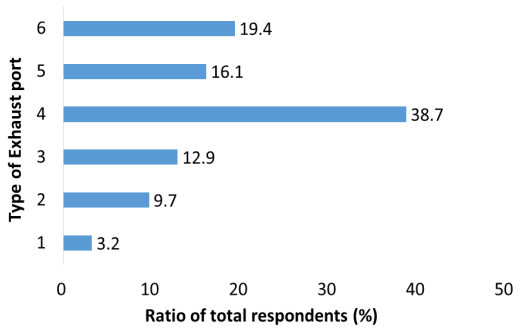


Fig. 9 Frequency of mounted exhaust port

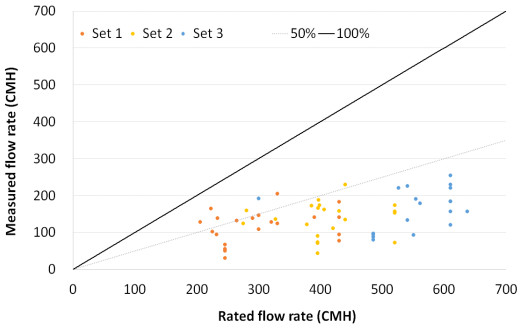


Fig. 10 Air volume of range hood with flat exhaust port

In the range hood, a filter is installed typically at the suction portion to play a primary role in protecting the exhaust fan. As shown in Fig. 4, this filter must be cleaned and in extreme cases, two households without filters were found. As a result, the range hood exhaust motor was broken, loud noise was generated during operation, resulting in a deterioration in performance. In addition to the range hood, just as maintenance issues, including filters, are important in all ventilation installations, the range hood must also be maintained.

Fig. 6 shows the performance of the hood by dividing the maintenance state into 3 steps of Good, Fair and Bad through the inspection of the filter, fan, and internal condition of the target hood. If the hood is in good condition, the performance on step 1(rated flow versus measured flow) is 56.5% whereas if the maintenance state is bad, the performance is found to be lowered to 33.2, so if the maintenance status of the hood is bad, the performance of the hood is found to be reduced to less than 1/3.

Nevertheless, as indicated in the survey improvement section, users said it is necessary to provide education on the basic operation and maintenance of the range hood, showing that their awareness of maintenance and the actual results are very contradictory. Based on this result, it seems that guidelines for maintenance are needed.

4.2. Duct channel

Because of the wide variety of range hoods and building types, it is very difficult to type the ducts of the range hood. As shown in Fig. 7, however, if the duct is over- or under-refracted for no reason, the unintentional performance deterioration of the equipment occurs. In fact, the measured air flow of all hoods in which the duct was placed abnormally was measured to be less than 50% of the rated flow. Especially in the case of KS C 9302, the air flow is measured under the condition that the duct is basically straight, and the loss of pressure is relatively small, so it is considered that the difference between the measured air flow and the rated flow due to the duct is large.

Also, in the case of two cases during the survey, it was found that the range hood was not functioning properly because the duct was damaged or the connection with the hood part was incomplete. To improve range hood performance, duct inspection should be preceded.

4.3. Hood design, low-cost range hood

Buildings over 10 years have a high rate of remodeling. In this process, the range hood is mostly replaced as part of remodeling. In this process, the range hood is installed at a low price for cost reductions. As a result, the performance of the range hood was found to deteriorate.

Recently, range hoods which were classified as kitchen appliances has been emphasized and many products with differentiated designs have been released. Some of hood with new designs are superior in terms of aesthetics, high in price and users' preference is relatively high, but performance was measured to be less than ordinary hood.

4.4. Area of exhaust port

The range hood exhausts the contaminants that were sucked through the internal exhaust fan to the outside through the duct and takes a common exhaust duct system or a method of installing an exhaust port (exhaust port, cap grill, hereinafter exhaust port) on the outer wall part and the type is divided into 6 major types (Fig. 8). Depending on the installation type of these various cap grills, the performance of the range hood may be greatly affected.

In the past apartment, type 4 and co-duct type were mostly used as hood duct finishing. Recently, however, when designing facades of apartment, there is a tendency to prefer a flat exhaust port for the sense of unity with the outer wall. As a result, apartment using type 1 ~ 3 when finishing the hood exhaust increased more than in the past. In fact, the results of the field survey showed that the percentage of type4 the most used in the past was the highest, 38.7% but the percentage of apartment using type 1 ~ 3 was high around new households (Fig. 9).

If this type of exhaust port is installed, the exhaust efficiency of the hood may be adversely affected. The use of such a narrow exhaust port may have an impact on efficient kitchen exhaust.

For example, the diameter of the exhaust duct commonly used for household range hood is 125mm($0.0123m^2$), whereas the exhaust port area is reduced by 1/3 of the exhaust duct area, depending on the exhaust port type. In this case, no matter how high the performance of the range hood, the performance deterioration of the hood at the exhaust port portion may inevitably occur. The percentage of the exhaust port installed in the target apartment is as shown in fig.9. Of these, narrow exhaust port (Type 1~3) that 25.8% has an outlet area of less than $0.0060m^2$ is

installed.

Fig. 10 shows the performance of the range hood with flat exhaust ports (Type 1 ~ 3). As a result, the performance of the range hood connected to Type 1, 2, 3 was measured to be less than half compared to the rated flow. Given the relatively low years of use of buildings and range hoods using flat exhaust ports of the type, the area of the exhaust port is considered to affect the range hood performance.

5. Conclusion

To improve the performance of the range hood installed in existing apartment, this study conducted a comprehensive survey. Through the survey, it was found that the range hood is operated 2.9 times a day on average and cooking is performed 2.9 times on average.

As a result, the measured air volume of the range hood was 41.4%, 38.0% and 32.0%, compared to rated flow by the number of steps, and performance deterioration was measured to be very large. Also, even if a range hood with similar air volume, the same product is installed at home, the variation in performance was found to be very large because of various conditions.

This study is to suggest four causes of performance deterioration of the range hood.

(1) The performance of the range hood deteriorated as the maintenance problem of the user and the aging of the range hood progressed.
(2) The channel of the duct from the range hood to the outer wall is damaged as it is used for a long time or if the channel of the duct is unnecessarily bent, the efficiency is greatly lowered. As a result, actual flow of hood relevant to problem for duct channel was found that it is less than 50% compared to the rated flow.
(3) When remodeling an aged building, the range hood is classified as a part of kitchen appliances, and a low-cost range hood is installed typically. In addition, the design of the hood which did not consider performance of hood was found to lead to the performance deterioration.
(4) The efficiency of the hood was found to be very poor with lower area of the exhaust port area. It is considered that the performance of the hood can be changed depending on the choice of exhaust port.

Through the survey, it was found that the users did not have enough information about the maintenance and proper use of the hood despite their awareness of the importance of the range hood. To solve this problem, performance improvement should be preceded by suggesting basic guidelines for hood first.

Acknowledgements

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