Residential Use Air-Conditioner with anti-Allergy Function

KENICHI MIYAZAWA*1
HIROSHI KANBARA*1
YASUHIRO NAITO*1
DAISUKE TANAKA*2
TAKAYUKI SUZUKI*2
YUJI NAKAJIMA*3

Improvement of the basic performance of air-conditioners remains an important task demanded by the revised Energy Conservation Law of Japan. Recently, improvement of indoor air quality (IAQ) is another requirement, together with differentiation from competitors. Mitsubishi Heavy Industries, Ltd. (MHI) has developed a filter for decomposing and suppressing allergens causative factors of allergy, and has manufactured an air-conditioner incorporating this filter.

1. Introduction

Against the background of recent mounting concern about the environment and health, air-conditioners are required to have various extra functions aside from the basic performance of air conditioning.

As the basic performance of wall mounted separate type of 4.0 kW or less, upgrading of performance is required by the Energy Conservation Law that becomes effective in 2004. According to this law, performance is defined by the average COP (coefficient of performance: the capacity divided by the power consumption) of cooling and heating, and products exceeding the limit values (for example, in the case of 2.8 kW class, COP 4.90) cannot be sold.

As extra functions, improvements of IAQ are being proposed by manufacturers as a means of differentiation. Filters having functions such as ventilating functions are considered, including the "Negative ion" boom of recent years.

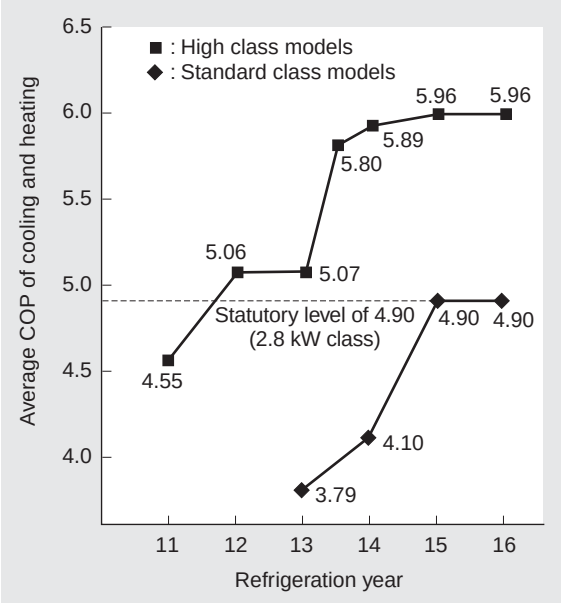

Fig. 1 History of COP
High class models have already satisfied the statutory levels.

2. MHI's policy

2.1 Basic performance

Fig. 1 shows the history of development of COP in the 2.8 kW class (high and standard class) of MHI. In the case of high class models, the COP is already above the limits, and equal to the high end of other manufacturers. Further enhancement is an immediate goal.

2.2 Extra functions

Extra functions of the high class models to differentiate them from competitors' models include (1) the world's first filter for decomposing allergens by the power of enzyme (called allergen clear filter), (2) ventilation function for expelling indoor air to the outside, (3) internal cleaning function, and (4) remote control by using the Internet ("e-@ir").

3. Development of allergen clear filter

3.1 Concept

Indoor air contaminants include gaseous matter causing the "sick house syndrome" and malodor, particulate matter such as cigarette smoke and house dust, microorganisms such as floating bacteria and mold spores, and many others. To eliminate all such contaminants, individual properties must be studied, and appropriate technologies must be selected or developed. Biologic airborne allergens, which are present in the living environment and possibly cause serious diseases, are studied, and technologies for eliminating them are being developed. Such biologic airborne allergens include mite allergens, pollen, pet allergens, and insect allergens (cockroaches, mosquitoes, etc.). They are inhaled

*1 Air-Conditioning & Refrigeration Systems Headquarters
*2 Nagoya Research & Development Center, Technical Headquarters
*3 Advanced Technology Research Center, Technical Headquarters

Table 1. Test allergens

Allergen	Origin	Description
Der f 1	*Dermatophagoides farinae*	Dirt-derived cysteine protease
Der f 2	*Dermatophagoides farinae*	Insect-derived epididymis-related protein
Der p 1	*Dermatophagoides pteronyssinus*	Dirt-derived cysteine protease
Cry j 1	*Cryptomeria japonica*	Pollen surface particulate
Fel d 1	*Felis domesticus*	Epithelial protein

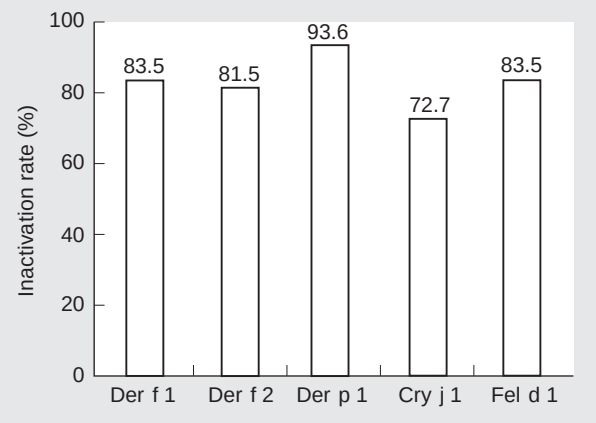

Fig. 2 Inactivation rate of allergens
The inactivation rate varies with allergens, but various allergens are inactivated.

into the respiratory system of the body and cause sneezing, inflammation, and diseases. Unlike microorganisms, they are not metabolized by the activity of living cells, but their molecular structure itself disturbs the immunity of the respiratory system, and inactivation requires advanced reaction. The principal components of allergens are proteins, and they are stable chemically by higher order structure. It has been difficult to inactivate them without using high heat or strong chemicals. MHI has selected an enzyme as a means of inactivating the allergens, establishing the conditions for functioning in the air-conditioner, and finally developing a filter. The history of the development is given below.

3.2 Selection of filter material

The selected enzyme has the property of promoting hydrolysis. Therefore, moisture is required for promoting the reaction of the enzyme and allergen (to inactivate the allergen). To supply moisture for activating the enzyme on the filter, two methods may be considered.

(1) Supplying water from a tank into filter fibers.
(2) Moistening the filter with moisture contained in the air (moisture absorption).

Considering simplification of structure, ease of maintenance by users, and versatility, the second method is selected. For higher moisture absorbing capacity of the filter, special fibers that absorb moisture more readily than cotton or wool are used. These fibers have hydroxyl group on the surface, and their use makes it easy to immobilize the enzyme.

3.3 Performance

Enzyme and urea were carried on a nonwoven fabric of special fibers, and a filter was prepared and presented for the allergen inactivation test. Allergens shown in **Table 1** were used in the test. These are air-borne allergens commonly found in Japan. They (dust allergens) were made to adhere to the allergen clear filter, and the inactivation capability was evaluated.

Fig. 2 shows the inactivation rate of mite allergens and other allergens. The inactivation rate varies with allergens. This is because the properties of allergens are different and also because this enzyme is effective with a wide variety of allergens, and inactivates various allergens present in the indoor environment. In addition, since this enzyme is designed to act on proteins, it is effective not only for allergens but also for viruses, bacteria and mold. For example, influenzae can be inactivated by 99.9% in one hour, and staphylococcus aureus can be sterilized (not only is growth suppressed, but the number of cells is also decreased).

3.4 Unit operation control

For obtaining the maximum capacity of the filter performance, the temperature and humidity of the filter environment are important. The ideal environment is realized in the developed model by using the basic function of the air-conditioner. That is, moisture in the indoor atmosphere is captured in the heat exchanger by cooling operation, and the condensed water is evaporated again in heating operation. In this way, the optimum environment is always realized around the filter. These operations are realized by the control system for changing the operation cycles depending on the environmental conditions by using sensors incorporated in the unit.

3.5 Unit system configuration

Fig. 3 shows the configuration of the allergen clear system in the developed model. The filter is installed in the unit before the heat exchanger. Allergens floating in the environment are sucked in together with the indoor air from the air-inlet grille during operation, and they are captured on the filter. The allergens captured on the filter are inactivated (decomposed) by the enzyme. As a result, even if the substance captured on the filter is released again from the unit, allergy is no longer caused.

The developed model has a mechanism for control-

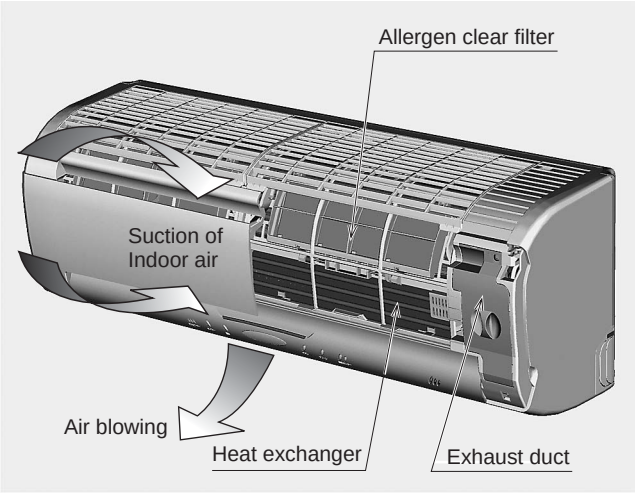

Fig. 3 Concept of unit system
Filter is installed in front of heat exchanger. Sucked-in allergens are captured on filter (right half: air-inlet grille detached).

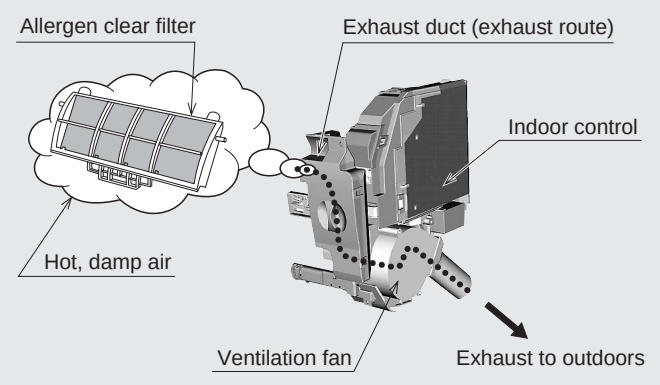

Fig. 4 Exhaust mechanism
Hot, damp air is discharged outdoors through an exhaust duct installed next to the filter.

ling the capacity of the enzyme to the correct degree. For the allergen clear filter, atmosphere of high temperature and high humidity is desired, whereas for the unit such atmosphere is not desired from the viewpoints of air conditioned comfort, contamination and mold growth. Accordingly, a duct for releasing the unit air to the outside is installed next to the filter, the air is released outside after optimum condition operation by the fan for ventilation, and stagnation of hot, damp air in the unit is prevented (**Fig. 4**).

4. Other functions

When an air-conditioner is purchased, the price and performance are vital, but extra functions such as air purifying and ease of cleaning are also important. The new air-conditioner is distinguished from others by various features as well as the allergen clear filter, including (1) ventilation function, (2) unit internal cleaning functions, and (3) remote control function by use of the Internet.

4.1 Ventilation function

Usually, the filter of an air-conditioner cannot remove carbon dioxide, formaldehyde or other gases present in the room. The new air-conditioner has a fan for ventilation, which operates together with the sensor to detect concentration of gases for discharging the contaminated indoor air to the outside. The ventilation function has been attracting attention as a means of enhancing IAQ recently, and other manufacturers are also attempting to develop it.

In this model, the ventilation function does not work alone, but is combined with unit drying operation and others, and has been developed as part of compound functions.

4.2 Internal cleaning function

After long operation of the air-conditioner, dust and stains are collected inside, and moisture and mold also accumulate in the unit. Such deposits not only lower the operating capacity of the air-conditioner, but also cause malodor. Accordingly, to remove moisture in the unit, unit drying operation is combined with the ventilation function, and a fan using antimold agent is also operated to remove dirt and mold.

In addition, to remove the collected dirt and mold, the air-outlet grille is designed as a detachable unit to be cleaned directly, and various needs of users are satisfied (**Fig. 5**).

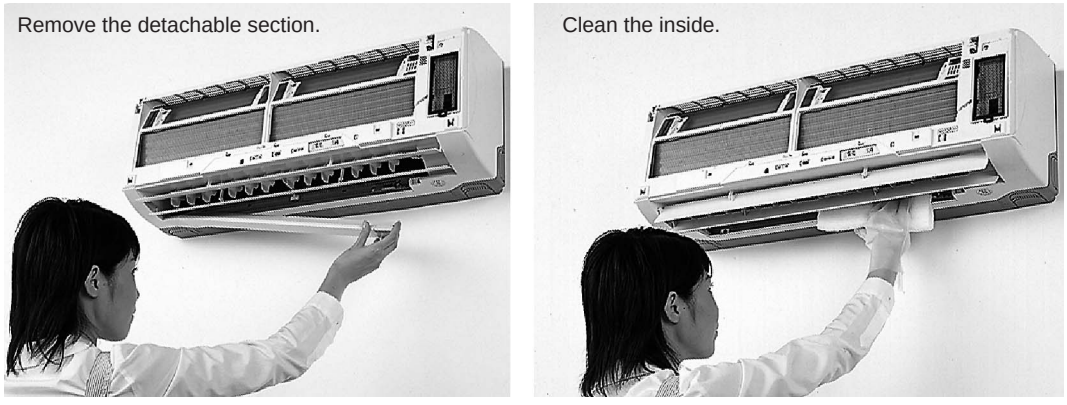

Fig. 5 Detachable cleaning mechanism
Air-outlet grille is detachable to facilitate direct cleaning of the inside of the unit.

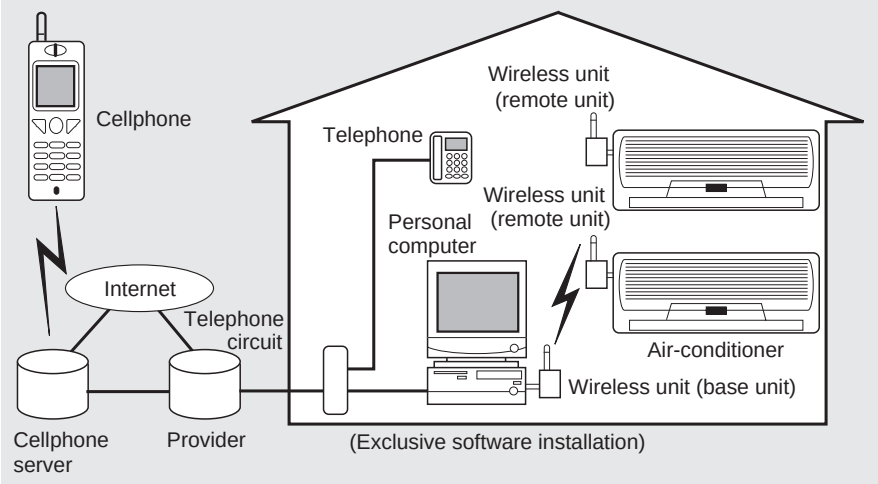

Fig. 6 Concept of "e-@ir"
Wireless communication of air-conditioner and personal computer simplifies the installation.

4.3 Internet communication function

The concept of this system is shown in Fig. 6. By communication between the air-conditioner and a personal computer, two-way communication is realized from outside by use of cellphone or e-mail, and the air-conditioner can be operated and monitored from a remote location.

By combining with the ventilation function (especially in summer), hot air in the room can be discharged beforehand from the outside by operating the ventilation function, and the cooling operation can be started efficiently when the user returns home. In this way, power consumption is saved, and the time required to reach a desired temperature is reduced by 20 percent as compared with the existing model.

5. Conclusion

The new air-conditioner has achieved the average COP of 5.96 (122% of the specified level) as compared with the new statutory level of 4.90 in class 28, and this performance is the highest in the industry. In addition, the IAQ improving functions include the allergen clear filter and ventilation function.

Henceforth, MHI will continue to develop new products with higher basic function and new functions suited to the needs of users.

References

(1) Miyazawa, K. et al., High-Efficiency Residential-Use Air-Conditioner, Mitsubishi Juko Giho Vol. 39 No. 2 (2002) p. 60


Kenichi Miyazawa


Hiroshi Kanbara


Yasuhiro Naito


Daisuke Tanaka


Takayuki Suzuki


Yuji Nakajima