

Many speak about “ideal living space.” However, such a space cannot be realized easily.

It is often said that noise control or air conditioning seldom develops into good business. People feel momentary comfort when they move from a noisy place to a quiet one, or from a humid place to a cool one. In time, however, they get accustomed to the new place that is relatively good in terms of noise control or air conditioning, and begin to long for an even more comfortable environment. This is the reason why efforts to create a comfortable environment don’t make money.

The same is true for the air conditioning of a train car. Among the factors relevant to air conditioning are temperature, humidity and wind velocity. The desirable air condition varies even with regard to the same person, or according to the type of train (e.g. express or commuting).

In an express train, passengers stay in the same compartment for a long time in the same posture, without making much movement. In such a situation, passengers desire a calm air condition under which they hardly perceive any drafts. By contrast, in a commuter train for suburbanites, passengers want to feel drafts e.g. when they enter a car during rush hours in a hot day. If there are no perceptible drafts, they may ask, “Is the air conditioner all right?” or voice similar complaints.

What is a Comfortable Air Condition?

Now the question is: How can comfort be represented by numerical values? Table 1 shows a definition, according to JIS E 6603, of standard temperature and humidity conditions for train cars. This definition is based on considerations of comfort and economic factors. Also, a general assumption is that people perceive drafts as comfortable if their velocity is about between 0.1 and 0.2 m/s.

But there is a further question: Do people really get satisfied if they are in an environment whose conditions meet the criteria in Table 1? The fact may be that this table presents only a point of reference, while desired comfort-related conditions vary according to train use.

Table 1 Comfortable Air Condition

	Temperature (°C)	Relative humidity (%)	Wind velocity (m/s)
Cooling	26	55	About between 0.1 and 0.2
Heating	20	52	

Characteristics of Comfort Required for Express Train Cars

The Shinkansen (bullet trains) and other express train cars have entrances that separate compartments from the external space. Compartments are subjected to relatively small changes in temperature, because the number of passengers who move in or out at stops is small compared to commuter trains. Also, passengers in a compartment generally keep the same posture for a long time, without making much movement.

[Absence of Perceivable Drafts]

In such an environment, passengers are sensitive to drafts from the air conditioning system. They surely feel discomfort when there are strong drafts. Even in case of drafts whose velocities don’t exceed the recommended range, passengers may come to feel bad in time if they sense drafts blowing in the same direction.

From the viewpoint of drafts, a desirable air conditioning system therefore must be able not only to adjust the wind velocity to the agreeable range, but to change the wind direction from time to time.

[Ensuring a Uniform Compartment Temperature]

Compared to commuter trains, express train cars, as a whole, are subjected to relatively small changes in temperature. However, a look at different areas in a car reveals that areas at both ends of the car, located close to the entrances, are more subject to temperature changes than the central area due to the opening and shutting of compartment sliding doors. If block-type air conditioning equipment is installed on the ceiling or under the floor, the equipment is usually placed in the central part of a car. Accordingly, it may be impossible, due to duct loss or other factors, to adjust the air condition as planned at border areas in a car, which are distant from the equipment.

An uneven temperature distribution in a compartment therefore results in the deterioration of service quality. Accordingly, the train air conditioning system should be designed to ensure a uniform air condition.

Characteristics of Comfort Required for Commuter Trains

Compared to an express train, side sliding doors of a commuter train car are opened and shut more often. As air movement between the inside and outside of a car is more direct, the compartment is subjected to greater changes in temperature, especially in areas near side sliding doors.

[Refreshing Drafts]

After sweltering on a platform in a hot summer,

passengers want to get cool upon boarding a train. A measure to meet their expectations is to give strong drafts that make passengers feel a sharp decrease in perceived temperature.

Currently, some commuter trains are equipped with cross flow fans etc. that provide refreshing drafts.

[Changing the Air Condition from Place to Place]

While an area near a side door is subject to great temperature changes, temperature in the seats area between side doors, in which there are less passenger movements, is assumed to be more stable.

Accordingly, it may be necessary to change the air condition from place to place. In summer, for instance, a lower temperature may have to be set in the area close to a side door than in the seats area.

Current Air Conditioning System

Next, we will look at air flow in a car. Table 2 shows typical air conditioning systems for train cars. The systems are broadly classified according to the position at which air conditioning equipment is mounted. In conventional train cars, the equipment is generally mounted on the ceiling. On the other hand, it is mounted under the floor in a Shinkansen car, or other cars that need a low center of gravity.

All these systems have some disadvantages related to the center of gravity, duct loss, equipment space etc.

For most train cars in Japan, the air conditioning equipment is designed to give drafts downward from near the ceiling, or obliquely upward from near the rack. This means that drafts flow basically from top to bottom, if seen from the perspective of a compartment as a whole.

Air Flows from Bottom to Top

As shown in Fig. 1, air in a train car, as well as in a living space, mostly flows from bottom to top due to the effect of heat from human bodies, equipment, sunlight etc. (though this is not necessarily true, depending on such factors as the movement of people, the opening of windows and the operation of air conditioning equipment).

As mentioned above, a train air conditioning system sends drafts from the upper part of a compartment (a position near the ceiling, the rack etc.), which is distant from passengers. Accordingly, the system tends to give strong drafts of high velocities.

A conclusion from the discussion so far is that the direction of air flow in a general living space is opposite to that of drafts from air conditioning equipment. This means that, for instance, rising cigarette smoke collides with drafts blowing downward. Smoke, with its odor, is therefore perturbed and diffused over the entire compartment (Fig. 2).

If drafts can be sent from the lower part of a compartment (i.e. from a position nearer to passengers), to accord with the basic air flow from bottom to top in a living

space, it will become feasible to give softer drafts of lower velocities. Also, providing an air exit or a ventilating opening in the upper part will make air flow one-directional, from bottom to top. This will prevent cigarette smoke etc. from being diffused over the entire compartment, and help create an ideal air condition (Fig. 2).

This design for a comfortable air condition, if realized, will feature air conditioning equipment and supply ducts installed under the floor. Barring problems with installation space, the design will also contribute to developing a system with a low center of gravity and limited duct loss.

My proposal for ideal comfort in air conditioning involves various tasks that need to be fulfilled to turn the ideal into a reality. We must continue to make steady efforts to offer passengers a comfortable in-vehicle environment.