

Summertime Thermal Comfort Predictive Method for Commuter Train Coaches

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1. Introduction

Although almost every commuter train in urban areas of Japan is equipped with an air-conditioning system, particularly in the hot and humid summer season quite a few comments about comfort dissatisfaction, such as feeling “hot” or “cold” are raised by passengers. To make the air-conditioned ambience in train coaches comfortable, it is essential to properly predict the thermal comfort of passengers to determine the thermally uncomfortable situations. The PMV/PPD method employed in ISO 7730 Standard for the thermal comfort prediction method (PMV: Predicted Mean Vote, PPD: Predicted Percentage of Dissatisfied) was originally developed for application to the interior ambience in buildings. The PMV is an index that predicts the mean value of the votes of a large group of persons on a thermal sensation scale varying from +3 (hot) to -3 (cold) with zero indicating a neutral vote. But individual votes are scattered around the mean values and the PPD establishes a quantitative prediction of the number of thermally dissatisfied people.

In this study, human subjects were invited to participate in series of tests to determine the precision of the prediction when the PMV/PPD method is applied to commuter train coaches. Further, the error causes were examined to develop a new, novel approach with higher precision.

2. Subjective Experiment on a Commuter Train Coach

The tests were conducted in a coach of a commuter train standing still during a summer season. A total of about 100 examinees participated and performed a subjective evaluation on the thermal comfort in an ambience simulating the thermal environment inside an operating train coach. Fig.1 indicates the relationship between PMV/PPD and also shows the measured percentage of dissatisfaction from our examinee evaluations. Comparison of the PPD with measured values showed mainly two types of errors: (1) While the PPD is specified one value for a PMV, the measured values of dissatisfaction during a temperature rise period differ from those during a temperature fall period.

(2) While the minimum value of PPD occurs when $PMV = 0$ (corresponding to “thermal neutral”), the

minimum value of our measured values occurs around $PMV = -1$ (corresponding to “slightly cool”) or thereabouts.

Error type (1) is considered to have occurred because the effect of the variation characteristic of thermal comfort was not taken into consideration in the PMV/PPD method, while error (2)

is considered to have occurred because the effect of seasonal characteristics (“slightly cool” is preferred in summer) was not taken into consideration in the method.



3. Development of Thermal Comfort Prediction Method

In this study, a prediction method taking into consideration the above-mentioned two influential characteristic has been developed. As shown in Fig.2, this new method consists of a physiological response calculating section based on a human body thermal model having body temperature regulating functions and a psychological response calculating section based on a regression model obtained from examinee evaluations. As demonstrated in Fig.3, the two trends of errors observed in the PMV/PPD method were substantially improved by the new method. The new method can be utilized in developing more appropriate air-conditioning designs to provide improved passenger comfort. Further, it is expected to be utilized in other countries with hot and humid climates.

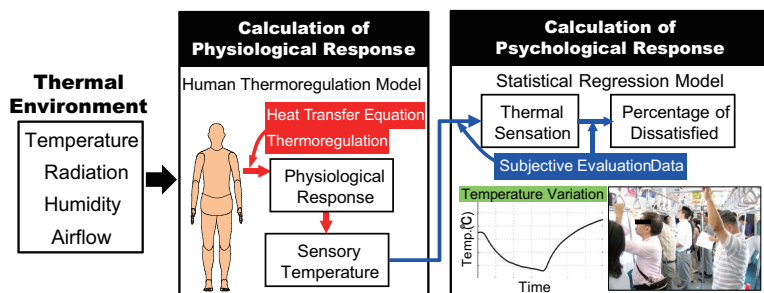


Fig. 2 The schematic representation of the proposed prediction method

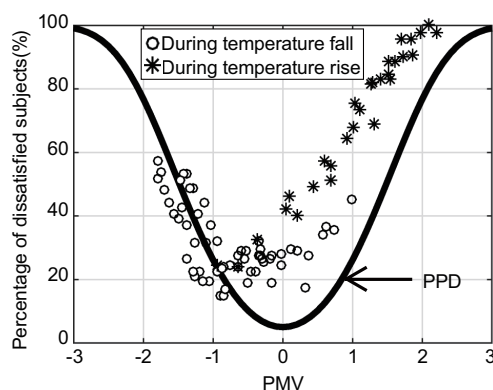


Fig.1 Comparison between results of subjective evaluation and PMV/PPD method

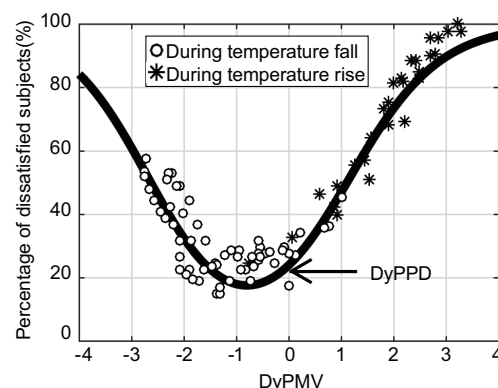


Fig.3 Comparison between results of subjective evaluation and the new (proposed) method