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Local and overall thermal comfort in an aircraft cabin and their interrelations

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A B S T R A C T

In this study the interrelation between local and overall thermal comfort of passengers in aircraft cabins was investigated by thirteen simulated flights. For each of the tests forty test persons filled out questionnaires concerning their perceived overall and local thermal comfort at temperatures of 20 °C–25 °C, which were measured at every second seat. With these physical and subjective data PMV (Predicted Mean Vote) and TSMV (Thermal Sensation Mean Vote) of test persons as well as PPD (Predicted Percentage of Dissatisfied) and PD (Percentage of Dissatisfied) were compared. The PMV was consistently similar to the TSMV, while the thermal dissatisfaction in tests was always higher than PPD. The hypothesis at the beginning of this study was that the high ratio of thermal dissatisfaction in the aircraft cabin reported in literature might be caused by local discomfort. Therefore statistical analyses about the interrelations between local and overall thermal comfort were performed and models indicating such interrelations were developed. Some local perceptions are significantly different from overall thermal perception and these body segments alter in dependence of the overall thermal environment. Also body segments rated similarly were detected and these segments were pooled to distinct body regions using principal component analysis. Under the same overall thermal sensation the local thermal perception on a certain body region predominantly influenced the overall thermal comfort. Therefore weighting factors of local body regions on the overall thermal comfort were determined in dependence of the overall thermal sensation by means of multiple linear regression models.

1. Introduction

There are only a few investigations published on thermal comfort in aircraft cabins, while a comfortable environment in aircraft cabins is a major factor in airlines business competition. The existing investigations [1,2] indicate the character of the indoor environment of aircraft cabins as follows: low relative humidity (typically below 15%), vertical temperature difference (typically 3 K), varying air velocity depending on the location in and the type of cabin (from 0.1 m/s to 0.6 m/s). These inhomogeneous thermal environments can lead to an unwanted local cooling or warming and cause thermal dissatisfaction (approx. 25% of occupants). There are internationally established models (DR and PD due to vertical air temperature gradients) for the assessment of these local thermal discomfort phenomena [3], which are valid only for persons in overall thermal neutral status. However, the local thermal comfort may vary depending on the overall thermal situation or the local thermal comfort feeling might influence the overall thermal evaluation. In addition, the models do not consider the body segment differences regarding local cooling or warming.

Extensive local and overall thermal comfort investigations on inhomogeneous environments have been performed since the 1990s focusing mainly on the assessment of the climate in vehicles. There were two approaches; one is the assessment with equivalent temperature using multi-segmented thermal manikins or heated sensors [4,5]. The result of this approach is established in ISO 14505-2 as annex D2: “Interpretation of equivalent temperature in terms of perception of thermal sensation and thermal comfort” [6], which identifies the acceptable equivalent temperature depending on the body segment. A similar study was performed in a simulated aircraft cabin in recent years [7].

Another approach is the multi-segment physiological model combined with computational fluid dynamics CFD, which predicts the local skin temperature of human body in inhomogeneous environments (e.g. [8]). However, this approach evaluates the overall thermal comfort without considering the local thermal sensation but only with regard to the mean skin temperature. According to these results the cooling of the feet and at the same time the heating of the head cause an identical overall thermal comfort as without local stimulation, although the observed

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