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Analysis of thermal comfort on planes

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Background

Thermal comfort is related to the feeling of well – being; of not feeling cold or hot. According to the standard ISO 7730, it can be expressed in terms of [1]:

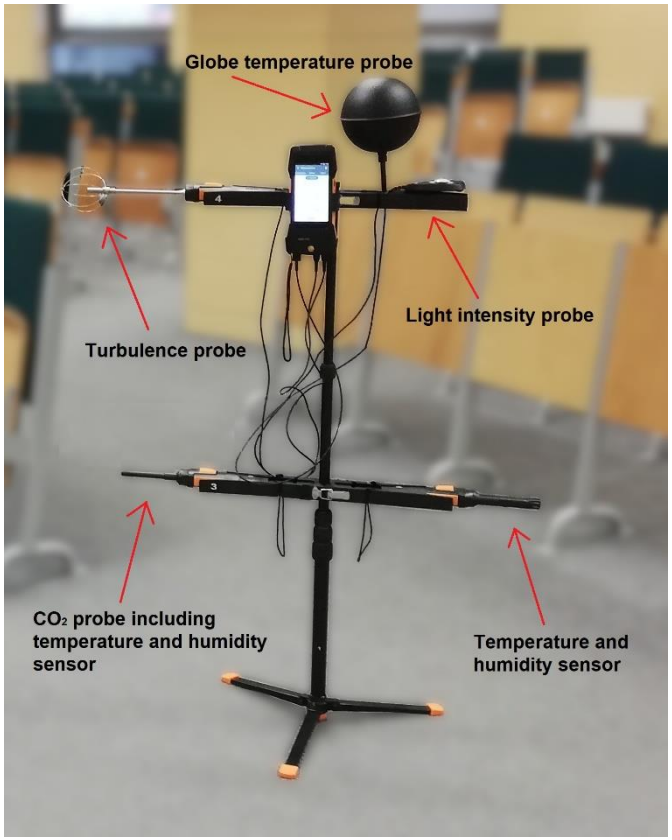
- predicted mean vote (PMV)
- predicted percentage of dissatisfied people (PPD)

PMV – average rating of a group of people on a seven-grade scale, with values from -3 (too cold) to +3 (too hot). Thermal comfort area usually lies between +0.5 and -0.5.

PPD – depends on the type of room; to 10% (for thermal comfort)

Experimental method

Position of a temperature/humidity sensor in the cabin (Giaconia C. et al. (2015), *A correlation linking the predicted mean vote and the mean thermal vote based on an investigation on the human thermal comfort in short-haul domestic flights*, Applied Ergonomics 48, pp. 202-213 [3])



Photograph of the measuring station

Temperature and humidity sensors were placed in the middle of the ceiling and in the upper part of the plane walls

Experimental method

The PMV and PPD is presented below according to [1]:

$$\begin{aligned} PMV = {} & \left[0{,}303 \cdot \exp\left(-0{,}036 \cdot M\right) + 0{,}028\right] \cdot \\ & \left\{ \begin{array}{l} \left(M - W\right) - 3{,}05 \cdot 10^{-3} \cdot \left[5733 - 6{,}99 \cdot \left(M - W\right) - p_a\right] - 0{,}42 \cdot \left[\left(M - W\right) - 58{,}15\right] + \\ - 1{,}7 \cdot 10^{-5} \cdot M \cdot \left(5867 - p_a\right) - 0{,}0014 \cdot M \cdot \left(34 - t_{air}\right) + \\ - 3{,}96 \cdot 10^{-8} \cdot f_{cl} \cdot \left[\left(t_{cl} + 273\right)^4 - \left(\bar{t}_r + 273\right)^4\right] - f_{cl} \cdot h_c \cdot \left(t_{cl} - t_{air}\right) \end{array} \right\} \end{aligned} \quad (1)$$

The formula considers: indoor air temperature (tair), mean radiant temperature (tr), partial pressure of water vapour (pa), metabolic rate (M), effective mechanical power (W), surface area factor of clothing (fcl), temperature of the outer surface of the clothes (tcl), heat transfer coefficient (hc)

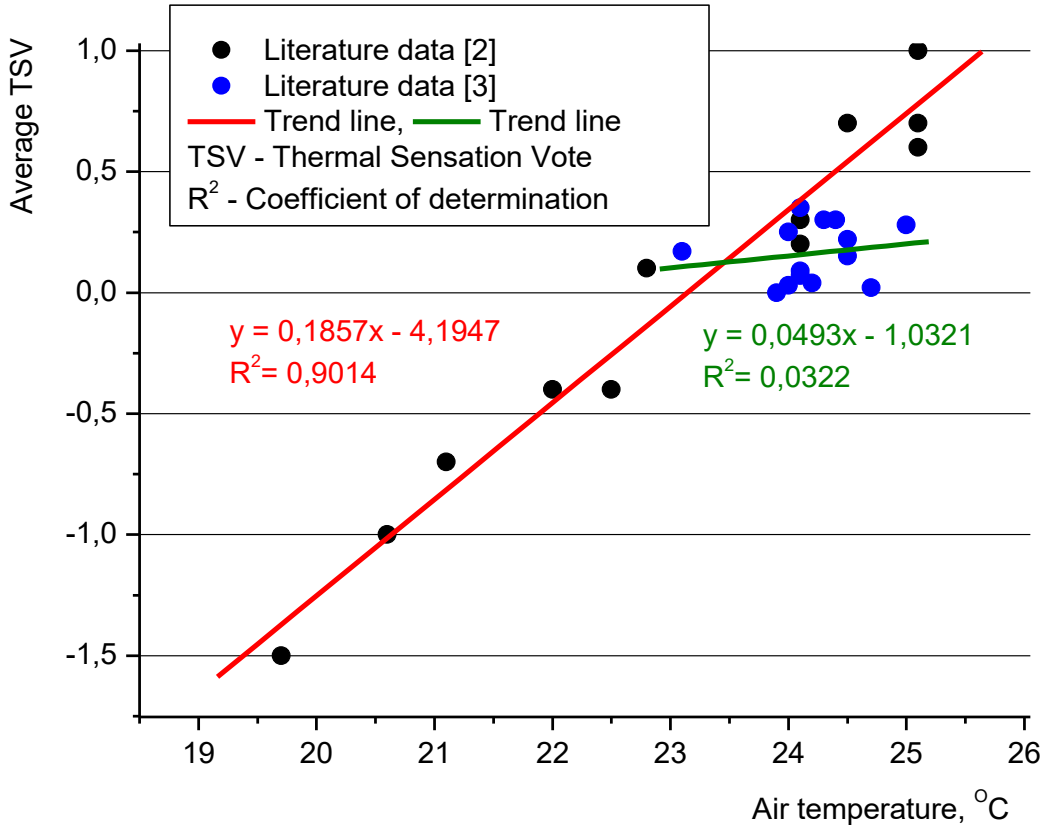
$$PPD = 100 - 95\exp\left(-0{,}03353 \cdot PMV^4 - 0{,}2179 \cdot PMV^2\right) \quad (2)$$

Results and discussion

Thermal comfort test results and their analysis

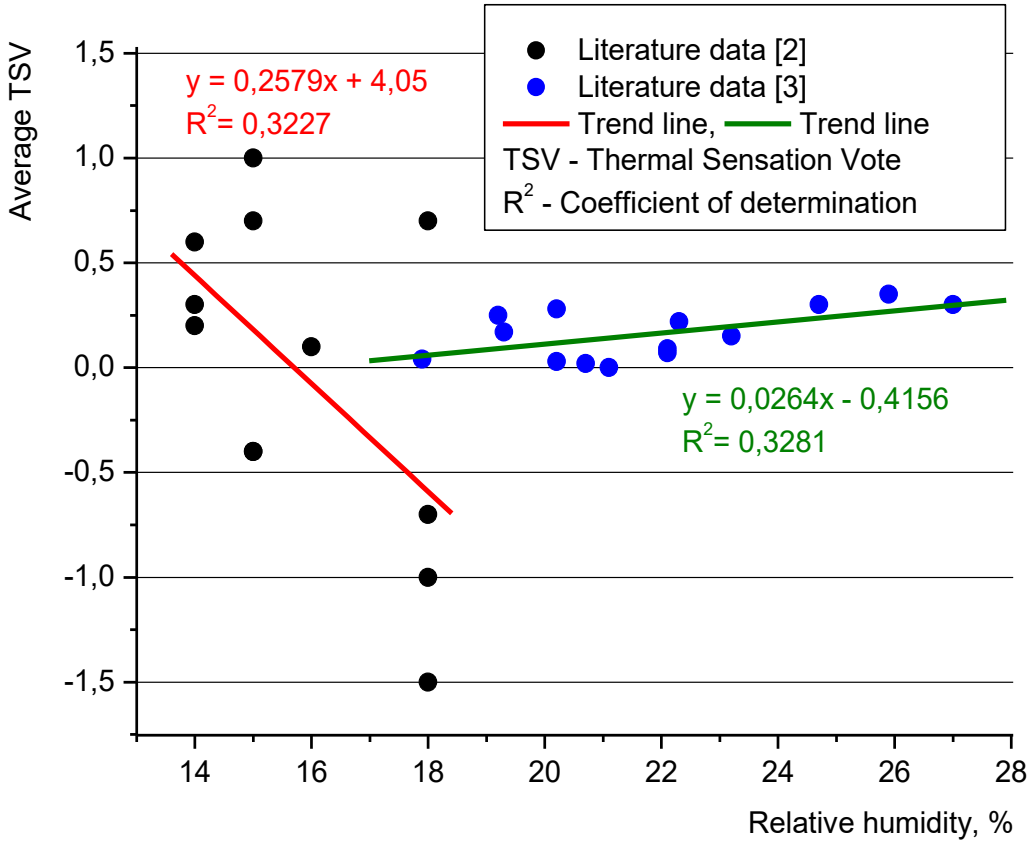
- The analysis was performed on the basis of research available in the literature.
- Internal air parameters and thermal sensations were examined using questionnaires.
- In addition to direct measurements of air parameters, passengers were asked to complete questionnaires in which they indicated subjective assessments of their current impressions and feelings.

Results and discussion



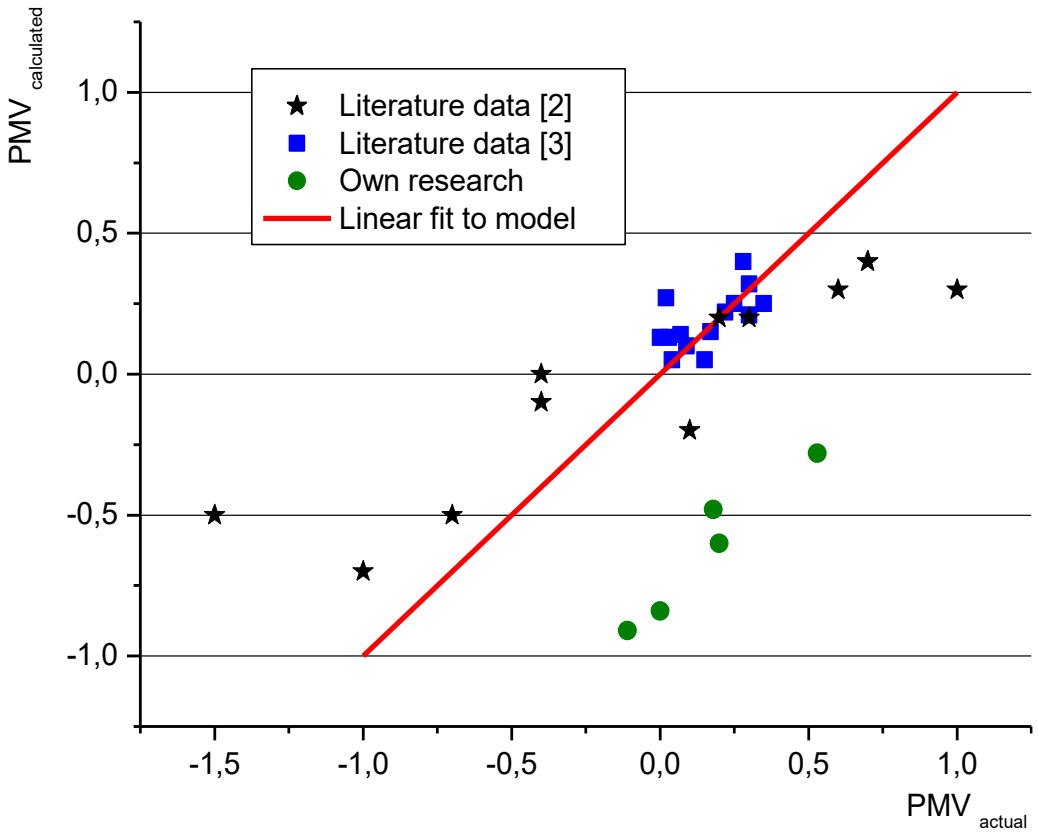
Relationship between temperature and Thermal Sensations Vote

Results and discussion



Relationship between humidity and Thermal Sensations Vote

Results and discussion



Comparison of the results based on the literature with the Fanger model

Conclusions

1. The analysis showed that changes can be made to the thermal comfort model to be consistent with the actual perceptions of passengers on airplanes.

2. There are significant differences between actual thermal sensations (from questionairres) and the Fanger model. Thus, the best solution might be to modify the Fanger model.

References

[1] PN-EN ISO 7730: 2006 *Ergonomics of the thermal environment – Analytical determination and interpretation of thermal comfort Rusing calculation of the PMV and PPD indices and local thermal Comfort criteria*

[2] Park S., Hellwig R.T., Grün G., Holm A. (2011), *Local and overall thermal comfort in an aircraft cabin and their interrelations*, Build Environ, 46, pp. 1056-1064

[3] Giaconia C., Orioli A., Gangi A.D. (2015), *A correlation linking the predicted mean vote and the mean thermal vote based on an investigation on the human thermal comfort in short-haul domestic flights*, Applied Ergonomics 48, pp. 202-213