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CONSIDERING THE EMISSIVITY OF INTERNAL SURFACES WHEN EVALUATING THE INOOOR ENVIRONMENT WITH THE AID OF OPERATIVE TEMPERATURE

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The operative temperature, introduced by Winslow and Gagge in late thirties, serves as a very suitable parameter to evaluate a thermal state from the view of a subject and to predict his thermal comfort. Nevertheless, its usage is connected with one disadvantage. The definition of the operative temperature is based on the absolute black enclosure. This paper is an attempt to find new formulae which could with the aid of the operative temperature discribe the heat exchange between a subject and an enclosure with real (non-black) surfaces.

One simple approach could be started on the basis of the following thermal balance formula to establish the mean radiant temperature neccessary for the evaluation of the operative temperature

$$(T_{cl}^4 - T_r^4).\sigma.\varepsilon_f.\varepsilon_{cl} = \sum[(T_{cl}^4 - T_j^4).\sigma.\varepsilon_j.\varepsilon_{cl}.F_{cl-j}] \qquad (W.m^{-2})$$

and the result could be derived in the form

$$T_r^4 = \sum T_j^4.\varepsilon_j.F_{cl-j}/\varepsilon_f \qquad (K^4)$$

where T_{cl} - mean surface temperature of clothing (K), T_r - mean radiant temperature (K), T_j - temperature of j-th surface (K), F_{cl-j} - shape factor (-), ε_f - emissivity of a fictive uniform enclosure, $\varepsilon_f = \sum\varepsilon_j.F_{cl-j}$.

This approach accounts only the first reflection and its precision decreases with the decreasing emissivity. A more comprehensive solution could be found with the aid of an application of Gluck s "brutto method" to evaluate the radiation heat transfer between the subject and the enclosure. The following formula for the mean radiant temperature could be derived

$$T_r^4 = \sum T_j^4.\varepsilon_j.[F_{cl-j}.(\varepsilon_{cl}.A_{Du} + \varepsilon_f.A) + A_j.\rho_f]/\varepsilon_f.[\varepsilon_{cl}.A_{Du} + A.(\rho_f + \varepsilon_f)]$$

where $\varepsilon_f = \sum\varepsilon_j.A_j/\sum A_j$ and $\rho_f = \sum\rho_j.F_{cl-j}$.

This approach accounts more then one reflection and its precision is sufficient for technical usage.

After the briefly described treatment of the mean radiant temperature the well-known formula for the evaluation of the operative temperature could be used. Nevertheless, this way the operative temperature is defined as the temperature of a uniform enclosure with non-black surfaces with which a subject would exchange the same amount of heat through radiation and convection as with the real non-black enclosure. Such definition could serve as an effective mean for simulation and prediction methods. This way the before mentioned disadvantage of the original definition by Winslow and Gagge could be eliminated.

The presented formulae are an extension of a simplyfied method published earlier by Halahyja and Piršel, which issue from Fanger´s comfort formulae but using instead of predicted mean vote and predicted percentage of dissatisfied as a criterion the operative temperature. The extension towards taking into cosideration the emissive properties of subject's surface and of the enclosure enables one to study the influence of low-emissive materials on man's thermal comfort with the aid of mathematical models.