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P2_2 Hot Air in the House of Commons

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Abstract

The power output associated with the heat flow from respiration of 650 MPs debating in the House of Commons was calculated. Heat flow directly into the air and from latent heat release during re-condensation of water vapour added to the exhaled breath was found to be 10.34 kW in total.

Introduction

Discussions in the UK's House of Commons, particularly during Prime Minister's questions, are well known for fiery exchanges. Given the lively nature of these debates, does the hot air exhaled by MPs constitute a significant heat source? This was investigated by quantifying the two primary ways respiration causes heat flow from the human body to the surroundings.

Direct heat input

Members of Parliament lose heat via conduction, convection and radiation - in this discussion only the contributions from their respiration are considered. Air enters the lungs at ambient temperature T_a (293 K) and is heated to body temperature T_b (310 K) before exiting [1]. The associated rate of heat loss from an MP's body, i.e. the heat flow into the surroundings, is thus given by,

$$\frac{dQ}{dt} = \frac{dm}{dt}\ C_{air}\,(T_b - T_a), \qquad (1)$$

where C_{air} is the heat capacity of air, 1.007 kJ $kg^{-1}K^{-1}$ [2], and *dm/dt* is the mass flow rate of breathing. This was estimated to be 2.28 $\times 10^{-4}$ kg s^{-1} by multiplying averaged volume flow rates during prolonged talking, 2×10^{-4} m^3 s^{-1} [3], with the density of air, (at T_b and standard pressure) 1.14 kg m^{-3}. The latter was calculated using the ideal gas law. Substituting into equation (1) and multiplying by the number of MPs, 650, gives a heat flow of 2.54 kW.

Latent heat release

Exhaled breath is saturated since water readily evaporates from the alveolar membranes [1]. When this water re-condenses the latent heat released constitutes a significant heat source. In order to obtain an upper limit for this effect, it was assumed that the ambient air is already saturated so that any added water vapour would rapidly condense. Since the saturated vapour pressure, P_s, increases with temperature, there is a difference between the saturated vapour densities inside and outside the lungs, $\Delta\rho_w$, that can be found from $P_s(T)$ and the ideal gas law.

$$\Delta\rho_w = \frac{M}{R}\left(\frac{P_S(T_b)}{T_b} - \frac{P_S(T_a)}{T_a}\right), \qquad (2)$$

where M is the molar mass of water, R is the gas constant and T_a and T_b are as defined above. $\Delta\rho_w$ is thus the mass of water per unit volume of breath that condenses onto the chamber of the House of Commons as the mixture of exhaled and ambient air rapidly tends to T_a. Values for $P_s(T)$ are given in standard references obtained by integrating the Clausius-Clapeyron equation [4] combined with empirical data. Here the simple linear fit was used for this, given by Tabata [4], providing values of 2.289 kPa for $P_s(T_a)$ and 6.229 kPa for $P_s(T_b)$.

Substituting into equation (2) gives of $\Delta\rho_w$ as 0.0266 kg m^{-3} and the resulting heat flow of breath per MP is,

$$\frac{dQ}{dt} = \frac{dV}{dt}\,\Delta\rho_w\,L\,, \qquad (3)$$

where *dV/dt* is the MP's breathing volume flow rate of 2x10^{-4} m^3 s^{-1} and *L* is the latent heat of vaporisation for water, 2.257 x 10^3 kJ kg^{-1} [2].

Substituting the quoted values into equation (3) and multiplying by the number of MPs gives a heat input of 7.8 kW due to latent heat release alone. Hence the total heat flow using equations (1) and (3) is 10.34 kW, assuming equal hot air production regardless of party affiliation and that all MPs are present. This is likely an overestimate since it was also assumed that all MPs are talking continuously.

Conclusion

Respiration constitutes approximately 14 % of the total heat loss from the body under normal conditions [5]. Nevertheless, the total heat loss via respiration from the honourable members of the House of Commons was found to be substantial. A subsequent paper is proposed to investigate whether this is sufficient to partly replace conventional heating, leading to lower parliamentary energy costs. Further work should include modelling the heat transfer from the MPs beyond respiration effects, which is complicated by the presence of multi-layered clothing.

References

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