THE PHYSICAL CONSTRAINT FOR CLOTHING COMFORT INDEX

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INTRODUCTION

Dimensionless group concept has widely been used in many fields such as heat transfer, mass transfer and others for a long time. But it is rarely used in clothing comfort. In this paper, the dimensionless groups were introduced to solve heat and moisture interactions during the time dependent process. Nevertheless, it also give some considerations for defining the clothing comfort index.

Two cases were considered. One was that the ambient temperature is changed but leaves the moisture unchanged. The other is that the environmental temperature is unchanged but leaves the moisture changed. The reader will find something interesting in later section.

METHOD

To describe the heat and moisture interaction in fabrics, two assumptions were proposed[1]:

$$\begin{cases} M \equiv \text{Moisture contents for fibre} = \sigma C \quad -\omega T \quad +const \\ m \equiv \text{Moisture contents for fabrics} = \frac{\nu}{\rho} C \quad +M \end{cases} \tag{1}$$

where σ, ν, A, ρ and w are material properties assumed to be time(t) and space(x) independent.

The governing equations[2] are then derived as follows,

$$L\frac{\partial^2 T}{\partial x^2} = \frac{\partial}{\partial t}(T - \nu C) \tag{2}$$

$$D\frac{\partial^2 C}{\partial x^2} = \frac{\partial}{at}(C - AT) \tag{3}$$

where L and D are heat and moisture diffusivities. In this formulation, two interesting example cases are addressed,

$$Case1 : \begin{cases} t = 0, & T = T_i, & C = C_i \\ x = \frac{h}{2}, & T = T_f, & C = C_i \\ x = \frac{-h}{2}, & T = T_f, & C = C_i \end{cases} \quad \text{(T changed, C constant)} \tag{4}$$

$$Case2 : \begin{cases} t = 0, & T = T_i, & C = C_i \\ x = \frac{h}{2}, & T = T_i, & C = C_f \\ x = \frac{-h}{2}, & T = T_i, & C = C_f \end{cases} \quad \text{(T constant. C Changed)} \tag{5}$$

To describe clearly the physical phenomena, several dimensionless groups have been introduced. They are $u = \frac{D}{L}$ (ratio of moisture and heat diffusivity), $p = \frac{2x}{h}$ (dimensionless distance), $q = \frac{4Dt}{h^2}$ (dimensionless time), $\Lambda = \nu\lambda$ (material constant). The G factor $G = \frac{\overline{m} - m(t=0)}{m(t=\infty) - m(t=0)}$ are introduced to explain the competition between heat and moisture, where $\overline{m}$ is the averaged value with respect to h(fabrics thickness). The G factor is a function of temperature(T) and moisture(C). It gives the very interesting physical phenomena addressed later in Fig. 1 and Fig.2.

RESULTS

To simply explain the physical phenomena, two results of Case 1 are discussed here. In Fig.1, for two fabrics made of different fibres($\Lambda = 0.1\&0.9$), their G factor curves intersected near $q = 1$, it means that certain interactive effects occur here. For $q < 1$, the absorptive rate of moisture in the second fabrics($\Lambda = 0.9$) is larger than the first one($\Lambda = 0.1$); But for time beyond $q = 1$, the rate is evidently slower. i.e., according to the moisture contents in fabrics, the first feeling for different fabrics maybe quite different after the characteristic time(eg. $t_c = \frac{h^2}{4D}$ in this case). It perhaps remind us that time effect should be introduced into the clothing comfort index to give user the feeling story.

Typical curves in Case 1 were shown on Fig.2. As expected, for each curve, the second feeling is same as the first touching. i.e., for two fabrics made of the same fibre($\Lambda = 0.5$), the effect caused by different structures($u = 0.1\&0.9$)may persist during the absorpting process. It means, when moisture is the main factor it always take priority of temperature.

CONCLUSION

Dimensionless group concept is useful for developing the clothing comfort generally. The time effect perhaps should be introduced into the clothing comfort index to catch the mixed feeling during the time process. The effects caused by different kinds of materials and structures also need to be considered.

REFERENCE

1. Crank, J. 1960, *Moisture in Textile,* Butterworths

2. Jan, Y.J., Chen, T.C., Soong, S.S. 1994, Heat and Moisture Interaction in Fabrics, Part(I), to be submitted to the *Journal of Textile Research.*