PIV 計測と CFD 解析による衣服内気流の詳細把握に基づく被服時の人体温熱環境評価

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Investigation on Air Flow Inside Clothing Microclimate and Clothed Human Thermal Environment Through PIV Measurement and CFD Analysis

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ABSTRACT

The under-garment air, namely the clothing microclimate is in general different air conditions from the ambient air conditions, and it plays an important role in human thermal environments. Extensive research has been published on clothing insulation, however, knowledge about the formation of the clothing microclimate is limited. In order to develop a methodology to understand the clothing microclimate, in the present study, the applicability of PIV（Particle Image Velocimetry）and CFD（Computational Fluid Dynamic）to clothed human thermal environment is examined. From the comparisons of different air-gap sized clothed humans, the observed distributions of air temperature and air flow are reasonably explained. The relationship between the average Nusselt number and the Rayleigh number agrees well with results of previous studies. From the subjective experiments with wearing different air-gap sized clothing, air flow in clothing microclimate can be induced for loose-fitting wearers, and thus loose-fitting wearers can feel the ventilation inside the clothing microclimate. The

different conditions in clothing microclimate can be considered using the human thermal load evaluation. The human thermal load is lowered for loose fitting because of increases in convective heat loss and evaporative heat loss. A series of studies presented here can be utilized with accuracy for future clothing designs and fabrications.

要　旨

　ヒトが着衣することで，人体と衣服，また衣服と衣服との間に生じる微小な空気層に外環境とは異なる衣服内気候が形成されるが，その形成や影響に関する解明が不十分であり，人体温熱環境評価に十分に反映されていない．実験的手法であるPIVおよび数値解析的手法であるCFDを用いて衣服内気候の把握を行うとともに，それらを活用して人体温熱環境評価を行う方法を検討した．異なる空気層の厚さにおける検討例から，衣服内気温，気流また対流の度合いを示す平均ヌセルト数の変化傾向に関して妥当な結果を得ることができた．また，屋外被験者実験より，異なる空気層の厚さの着衣時における熱損失や気流形成は，人体熱負荷量で定量的に評価ができ，被験者による心理申告と同様の傾向を示した．このことより本手法による一連の評価法は，一定程度の精度にあることが確認でき，今後ウェア設計などへの応用が期待される．