AIR FLOW SIMULATION IN THE NASAL CAVITY CONSIDERING LATENT HEAT EFFECT

Sho Hanida[1], Futoshi Mori[2], Kiyoshi Kumahata[3], Masahiro Watanabe[4], Shigeru Ishikawa[5], Teruo Matsuzawa[1]

[1] Japan Advanced Institute of Science and Technology, Japan; [2] The University of Tokyo, Japan; [3]RIKEN, Japan; [4]Fujitsu Ltd, Japan; [5]Kanazawa Municipal Hospital, Japan

Introduction

The nasal cavity has several functions such as temperature and humidity adjustment, smell sensing, dust filtering and etc. to preserve trachea and lungs. The temperature and humidity function adjustment function is important because human lives in various environments. The Computational Fluid Dynamics analysis and examination was continued to clarify to the functions of nasal cavity. Kumahata et al. develop a model for heat and humidity exchange in the nasal cavity and clarify temperature and humidity distribution in the nasal cavity by steady state simulation [kumahata, 2010]. However, latent heat effect was not clarified. Latent heat is an energy flow at the phase-change.

This paper investigate airflow, temperature and humidity transfer in the nasal cavity. The aim of this paper is to clarify the influence of latent heat in the nasal cavity.

Method

The models of airflow in the nasal cavity are incompressible, viscid and laminar, and heat and humidity transport is also considered.

The government equations are Navier-Stokes equation, continue equation, energy equation and water transport equation. Latent heat is defined by specific latent heat times water flux from the nasal cavity wall.

Temperature and humidity of inhaled air is adjusted by heat and humidity exchange through nasal cavity wall. In this simulation, the nasal cavity wall was modelled for heat and humidity exchange that include latent heat.

Calculation Condition

Fig.1 shows the geometry of nasal cavity that was reconstructed from the CT images. Wall-1 is nasal vestibule regions that heat exchange only. Wall-2 is mucus membrane regions that heat and humidity exchange. In this simulation, the several inhaled air conditions was used [Naftali, 2005]. The unsteady velocity profile as sine wave that was calculated from resting tidal volume was defined at the pharynx.

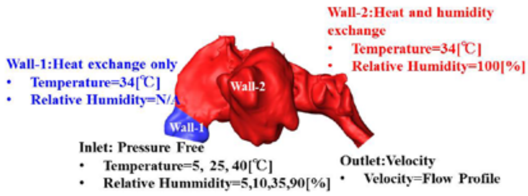

Figure 1: Geometry of Nasal Cavity

Results

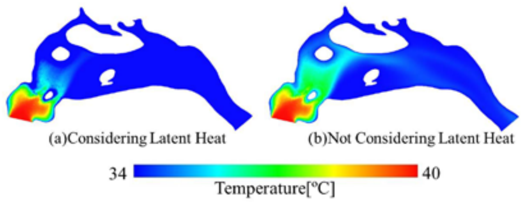

Figure 2: Temperature Distribution [Hot-Dry]

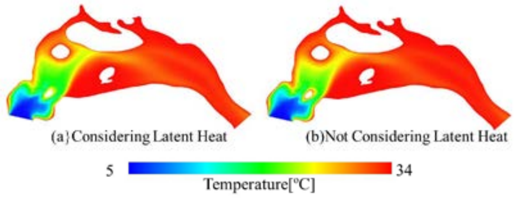

Figure 3: Temperature Distribution [Cold-Dry]

Fig.2 shows the temperature distribution of Hot-Dry case. Fig.2 (a) is result of considering latent heat and Fig.2 (b) is not considering. Fig.2 (a) is cooled more than Fig.2 (b) by evaporation latent heat effect. Fig.3 shows the temperature distribution of Cold-Dry case. It is late that Fig.3 (a) gets warm more than Fig.3 (b) by evaporation latent heat.

Discussion

Latent heat is depends on water flux from the nasal cavity wall. The water flux of hot inhaled air case is more than cold inhaled air case. Therefore, the influence of latent heat was more remarkable at high temperature of inhaled air case.

References

Kumahata *et al*, JBSE, vol.15:565-577, 2010.

Naftali *et al*, Annal Biomech Eng, 33:4:545-553, 2005