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Numerical analysis of heat and mass transfer processes within an infant radiant warmer

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ABSTRACT

An optimal thermal environment is regarded as a priority in neonatology. Survival of each neonate depends on its ability to regulate its body temperature. While healthy and full-term babies usually have no difficulties in such adaptation, preterm and small neonates often cannot respond to the environmental temperature changes. For this reason, the maintenance of neonates' bodies within a narrow temperature range is essential for their survival and growth. Without an environment in which a preterm neonate can maintain a normal temperature ($\sim 37\ C$), it will risk a cold stress and hypothermia, which may cause an increased morbidity and mortality [1].

A preterm baby is not able to maintain an adequate body temperature without some additional heat source. One of the ways to keep neonates warm are radiant warmers. These devices are situated above a baby lying on an open crib. A child is heated by a source of radiant heat. The power of this source is servo-controlled from the skin temperature [2].

Mathematical models applied to living organisms can provide a better understanding of the thermal processes occurring inside a human body, together with their interactions with the surrounding environment. Therefore, the main goal of this project is to develop a model of a neonate under a radiant warmer that will incorporate heat and mass transfer processes in order to provide a better understanding of how a radiant heat source interacts with a neonate.

The computational mesh of the radiant warmer and baby has been prepared in Tgrid. Further, the numerical model in Fluent incorporates mass conservation, Reynolds Averaged Navier-Stokes (RANS)

equations and energy equation. An incompressible flow is assumed in the model and radiation has been modeled with the Discrete Ordinates model. All the side walls of the model have been treated as open by prescribing pressure inlet boundary conditions. The mattress, on which an infant lies, is assumed to be insulated, and therefore no conduction is taken into account. A temperature boundary condition of 310K is prescribed at the body surface of the newborn. The surface representing a radiant heater that is placed above the baby has a prescribed heat flux of 600W.

The results presented will show a comparison of the heat losses for different positions of the neonate, as well as the partitioning of heat losses with and without the radiant heat source. In the case, when the radiant heat source is turned off, the neonate suffers from cold, and this can be observed from the positive heat flux from the newborn's skin. After adding a heat source into the calculations this heat flux becomes negative which leads to the conclusion that the heat losses are compensated with a radiant source. Finally, in the presentation the multiscale structure of the problem will be fully discussed.

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