Computer-aided Design of the Heating Section of a Continuous Kheer (Rice Pudding)-making Machine

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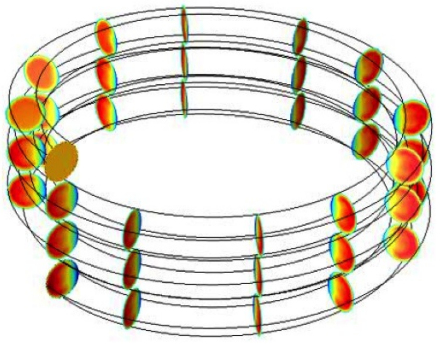
Abstract

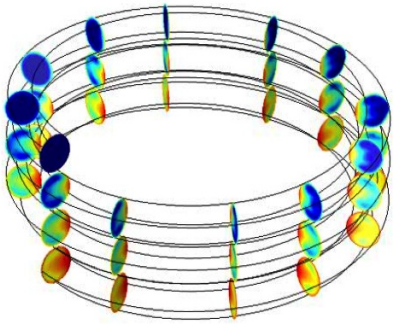
Kheer is a popular Indian dairy dessert prepared from concentrating milk with simultaneous cooking of rice grains. Conventional methods of preparing kheer have limited its mechanized production. Therefore, a conceptual design of continuous kheer-making machine has been prepared which among other components consists of a heating section for cooking kheer. The present study investigates the CFD analysis of fluid flow, heat transfer and fouling characteristics in the cooking section comprising of a helical coil heat exchanger heated with saturated steam on the outside (constant temperature boundary condition). Milk enters the heat exchanger at a high temperature and pressure with dispersed rice particles and the cooked product leaves the heating section with partially disintegrated cooked rice in a viscous fluid. Since flow inside the heat exchanger is turbulent, the k-ε turbulence model is used to study fluid flow and heat transfer. The coupled partial differential equation of fluid flow, heat transfer and kinetics of milk fouling along with appropriate initial and boundary conditions are solved using COMSOL Multiphysics®. Velocity (Figure 1), temperature (Figure 2) and fouling thickness (Figure 3) profiles are obtained as output from the model. The model is complete from the point of view of physics and explains the dynamics of kheer-making as a continuous process. Development of such comprehensive models is appreciated to aid in efficient design of the continuous kheer making machine and to help overcome the adverse effects of milk fouling to obtain a product of desired quality.

Figures used in the abstract



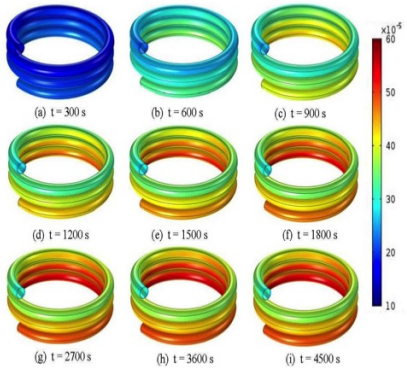
Velocity profile at different cross-sections

Figure 1: Velocity profile at different cross-sections.



Temperature profile at different cross-sections

Figure 2: Temperature profile at different cross-sections.



Fouling thickness along the length

Figure 3: Fouling thickness along the length.