The Department of Mechanical Engineering presents:

The Ph.D. Dissertation Defense of:

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Innovative Porous Media Approach in Modeling Biofilm Applications, Human Eye and Nanofluid Based Heat Pipes

Biofilm is a dominant form of existence for bacteria in most natural and synthetic environments. Depending on the application area, they can be useful or harmful. They have a helpful influence in bioremediation, microbial enhanced oil recovery, and metal extraction. On the other hand, biofilms are damaging for water pipes, heat exchangers, submarines and body organs. Formation of biofilm within a porous matrix reduces the pore size and total empty space of the system, altering the porosity and permeability of the medium. This change in the pore size distribution can be quantified by expressing the porous structure utilizing a proper geometric network. A multispecies biofilm model is used along with a cell network presentation to establish permeability and porosity distribution during the biofilm formation. Moreover, biofilm formation on the surface of adsorptive media such as granular activated carbon (GAC) has been extensively used to remove organic materials, nitrogen species, heavy metals and other contaminants in wastewater treatment. In this study, a multilayer mass transfer system consisting of the reactor's bulk fluid, diffusion layer, biofilm and GAC is modeled. It is shown that porosity alteration as a result of biofilm formation within the Carbon bed has a noticeable effect on the removal efficiency. In another part of this study a phenomenological model for the biofilm resistance against antibiotic activity is analyzed. The effect of different biofilm physical attributes when exposed to antibiotic treatment is investigated. Pertinent aspects affecting the biofilm resistance characteristics such as transport of the bulk fluid within the reactor, diffusive-reactive transport of the dissolved phase into the biofilm, convective- reactive transport of particulate phase, dynamic biofilm thickness, cell detachment, Extracellular Polymeric Substance (EPS) production and persister cell formation are analyzed and incorporated in the presented model.

The next bio-related aspect considered in the thesis deals with proper modeling of the human eye response to thermal disturbances. Human eye is one of the most sensitive parts of the body when exposed to a thermal heat flux. Since there is no barrier (such as skin) to protect the eye against the absorption of an external thermal wave, the external flux can readily interact with cornea. A compreh ensive thermal analysis has been performed on the eye to properly represent the physiological aspects of the eye by modeling the iris/sclera section of the eye as a porous medium to account for the effect of blood circulation through the eye tissues as well as accounting for natural convection within the anterior chamber.

The last part of the thesis deals with an analytical investigation of the thermal performance of cylindrical and flat shaped heat pipes utilizing nanofluids. The liquid pressure, liquid velocity profile, temperature distribution of the heat pipe wall, temperature gradient along the heat pipe, thermal resistance and maximum heat load are obtained and the existence of an optimum nanoparticle concentration level and wick thickness in maximizing the heat removal capability of the heat pipes was established.