FORMAL SOLUTIONS OF MATHEMATICAL MODELS GOVERNING FILTRATION WITH APPLICATIONS RELEVANT TO NASA MARS MISSIONS

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This work is motivated by filtration applications of interest to NASA for deep space missions.

The models are based on two foundational papers by the first author that extend the standard Darcy equation and conservation laws to allow for transient effects and simultaneous occurrence of cake and depth filtration. We will provide a brief overview of applications, along with a summary of related previous modeling work.

Mathematical models that incorporate a variety of filtration mechanisms - incompressible cake filtration, depth filtration, compressible cake filtration, simultaneous depth and incompressible cake filtration, and simultaneous compressible cake and depth filtration – will be discussed. Exact formulae for the pressure drop response of a fully characterized filter for each mechanism will be discussed. Optimization of filter dimensions to meet prescribed mission constraints, such as service life, is of particular interest in this effort.

Two applications of particular interest to NASA are cabin air filtration for which we have developed a 100% stainless steel SuperHEPA filter to replace conventional fiber glass HEPA filters and carbon capture filters to close loop on Hydrogen for closed loop atmosphere regeneration for which we have established the design equations for bench mark OmegAris filters for depth and cake filtration mechanisms. OmegAris Filters have sufficient capacity and would require no regeneration during transit to Mars. Filters with less capacity will require periodic regeneration of the media or filter media changes from an on board inventory. An econometric analysis to show the allocation of man-hours to manage filter regeneration/filter media changes required by all filters with less area than OmegAris filters will also be presented.