AN ABSTRACT OF A DISSERTATION

LIQUID FILTRATION SIMULATION THROUGH NONWOVEN FIBROUS MATERIALS

Jorge Arturo Destephen Soler

Doctor of Philosophy in Engineering

This work presents a nondeterministic approach, based on the Monte Carlo method, to simulate liquid filtration processes through nonwoven fibrous materials. The real filter material is represented as a multilayer medium with a network of multiply connected pores. To describe the deposition and resuspension of particles on and from the filter medium, the following four mechanisms were considered: particle capture by sieving, particle capture by fibers, particle capture by blocked pores, and particle re–entrainment. The particle capture by fibers and blocked pores and particle re–entrainment depend on the balance between the adhesion and removal forces. The adhesion forces for particles of diameter smaller than 20 μm were determined through the concept of London–Van der Waals forces. For particles of diameter greater than 20 μm gravitational forces were considered. Three-dimensional random flow was assumed to simulate the motion of the particles through the multilayer medium. The pressure drop across the filter medium was calculated as the sum of the pressure drop across the clean filter plus the pressure drop due to the deposited particles.

A FORTRAN program was developed to implement the filtration process model. A study of filter materials efficiencies and pressure drop as a function of fluid flow rate, filter pore size distribution, initial particle concentration, and time was carried out. The filters capacities were determined based on the pressure drop calculations. For a wide range of typical filtration conditions the calculated filter efficiencies predicted the experimental results with a percent difference between 0.5 and 19.3 depending on the particle size. The capacities were predicted with an average discrepancy of 23.0 percent. It was shown that the stochastic mathematical approach used in this research offers great versatility to simulate and study filtration processes through fibrous materials. The computer code was not only able to predict filter performance, but it was also used to describe the dynamic changes in filter medium microscopic structure.

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CERTIFICATE OF APPROVAL OF DISSERTATION

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by

Jorge Arturo Destephen Soler

Graduate Advisory Committee:

[illegible] Choi	10/27/95
Co-Chairperson	date
David W Yarbrough	10/26/95
Co-Chairperson	date
William D Holland	10/26/95
Member	date
[illegible]	10/27/95
Member	date
[illegible]	10/30/95
Member	date
Clayton P. Kerr	10/30/95
Member	date
[illegible]	10-31-95
Member	date

Approved for the Faculty:

[illegible]

Dean of Graduate Studies

11/7/95

Date