2010 AFS Student Poster Session

TUESDAY, March 23, 2010

001 Effect Of Liquid Accumulation In Coalescing Filters,
S. Andan, S.I. Hariharan, and G.G. Chase, Microscale Physiochemical Engineering Center, The University of Akron, Akron, OH 44325-3906, 330-972-7943, gchase@uakron.edu

Gas cleaning is important in many industrial applications like compressor mist elimination, automotive engine applications, mist elimination in metal working industries etc. The cleaning methods such as centrifugal separators, vane separators, gravity separators and mist eliminator pads are effective in liquid removal when the droplet size is large. When the droplets are in submicron size range, the only effective filters are coalescing filters made of fibrous materials. Saturation or liquid accumulation is an important parameter in coalescing filtration. The main goal of this work is to predict the liquid saturation and use it to calculate the filter performance. In this model, various mechanisms are proposed to describe the drop growth and break up processes. The model calculates the number of drops at each location with respect to time which is used to calculate saturation and pressure drop. Correlations for drop motion on fibers and break up of drops are used in the model to calculate number of drops on fibers. The sensitivity of model parameters like fiber size, drop size, properties of fluids and the fiber and the correlation parameters towards the filter performance is also determined in this work.

BIOSKETCH

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PROFESSIONAL EXPERIENCE

Process Engineer	Manali Petrochemicals Limited Chennai India	1999-2003
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002 Flow And Particle Simulation In Centrifugal Field,
X. Romaní Fernández, H. Nirschl, Karlsruhe Institute of Technology, Institute of Mechanical Process Engineering and Mechanics.

The knowledge of streams and sedimentation behaviour inside a solid bowl centrifuge is decisive in finding out the geometrical and process parameters that lead to an optimal separation of fine particles. Observation of these phenomena inside centrifuges is very complex, and as a result Computational Fluid Dynamics (CFD) becomes a relevant tool to research them.

Multiphase flow in a solid bowl centrifuge was simulated with the commercial CFD code Fluent. The streams were calculated by solving the Reynolds Averaged Navier Stokes (RANS) equations, whereas the turbulences were modelled with a k-Ɛ approach. The Volume of Fluid Model (VOF) was used to track the interface between air and water in the rotor and the Discrete Phase Model (DPM) to calculate the particle traces by integrating the balance of hydrodynamic forces acting on them. In addition, experimental work on the industrial solid bowl centrifuge was carried out to test the validity of the simulation results.

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003 Experimental Investigation of a New Granular Bed Filter Design, *Kavitha Pathmanathan, Otto K. Sønju and Johan E. Hustad, Presenting Author: Kavitha Pathmanathan, Department: Department of Energy and Process Engineering, University: Norwegian University of Science and Technology (NTNU)*

This paper presents experimental results from laboratory investigation of a Panel Bed Filter (PBF) with novel louver design. The improvement aims in reducing number of gas-entry surfaces per module, number of modules per unit filter, footprint and clean-bed pressure drop. A laboratory scale PBF with the novel design was built and tested to understand the overall performance of the new design. The filter is assembled from fewer louvers with down-shot puff-back mode. The filter has been tested with filtration velocities from 2.5 to 14.9 cm/s using sintered bauxite spherical particles (uniform diameter of 0.662 mm) as filtration medium and standardized arizona test dust contaminant - fine grade (mean diameter of 9 µm) as test dust at 120°C. The lengths of the tests were varied from a few hours to several days. The predetermined pressure-drops values for puff-back were performed from 500 up to 2500 Pascal. The results obtained from the laboratory investigation elucidate good filtration efficiency indicating filter cakes are being formed on each gas-entry surfaces. The clean-bed pressure drop is lower compared to the previous designs and with no increase in the residual pressure drops with time.

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004 Ceramic Nanofiber Filter Media For Hot Gas Filtration,
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In today's process and power Industries, temperatures of dust laden hot gases are well above 1000° C. Economically, it would be convenient to use high energy potential of hot waste gases in recovery boilers for producing electricity. However, dust contained in hot gases results in a rapid failure of any heat recuperators. In practice, gases need to be cooled before they are transferred to this equipment because filters cannot operate at high temperature. The cooled cleaned gases have low enthalpy and use of any recuperators for recovering heat from these gases becomes economically ineffective. Our main focus is on fabricating ceramic nanofiber filter media to withstand high temperatures and to capture submicron particles. Ceramic nanofibers were successfully synthesized using electrospinning technique. Ceramic nanofibers were incorporated with microfibers and binders to form ceramic composite filter media. Such filters can be used to filter out submicron particle sizes from high temperature gases in the range of 1000°C. Different binders were investigated to withstand high temperature and filter media were tested for their strength using flow rate failure test method. A model was developed based on volume averaged continuum theory to predict the performance of fibrous filter when loaded with solid particles. The model considers the effect of accumulated solid particles inside the fibrous media to predict the evolution of pressure drop and capture efficiency during loading of solid particles. Modeling results were compared with the loading tests carried out using TS1 8130 automated filter tester.

005 Metal Oxide Nanofibrous Filter As Catalyst And Catalyst Support Structures, *S. Swaminathan And G. G. Chase, Deptartment Of Chemical And Biomolecular Engineering, The University Of Akron, Akron. Ohio*

For environmental protection, the suppression of automotive exhausts such as nitrogen oxides (NOx) and carbon monoxide is very important. These gases are potential health hazards and green house gases. Noble metal oxide nanofibers are potential candidates as catalysts for such heterogeneous catalytic reactions. These nanofibers have special electronic and morphological properties as well as high surface energy which result in their unique catalytic activity/selectivity. The noble metals (palladium, platinum and rhodium) have been incorporated into alumina nanofiber support by sol gel processing and electrospinning techniques. The diameters of the nanofibers and nanoparticles were in the range of 60-160nm and 2-10 nm, respectively. These nanofibers have been incorporated into alumina microfibrous filter media by vacuum molding and have subsequently been reduced under flowing hydrogen .The filter was tested in a reactor wherein it was successfully able to convert NO to N2 and CO to CO2. These filters also serve as particulate filters and separate particles from the air stream on the basis of size, shape and charge of the particles. Hence, these filters have advantages such as light weight structure, optimization of precious metals, high capture efficiency, high surface area, highly interconnected network of pores and high permeability.

006 Modeling Particle Filtration And Loading In 3-D Nanofibrous Filters, *S. A. Hosseini and H. Vahedi Tafreshi*, Mechanical Engineering Department, Virginia Commonwealth University, Richmond, Virginia 23284-3015, *Corresponding author, email: htafreshi@vcu.edu, telephone: 804-828-9936, fax: 804-827-7030*

A realistic 3-D modeling study is presented to simulate the pressure drop and collection efficiency of electrospun nanofiber media. The fluid flow is predicted by solving Stokes equations using Fluent CFD code enhanced with in-house subroutines to account for slip effect at the fiber surface as well as particle collection due to Brownian diffusion, and interception mechanisms. Additional subroutines are also developed to allow particle deposition and loading on the surface of the fibers and previously deposited particles. Preliminary results on modeling the particle-loaded media are presented and discussed with respect to pressure drop and instantaneous collection efficiency of the filter media.

BIOSKETCH

S. A. Hosseini is a Mechanical Engineering PhD student in Virginia Commonwealth University. He obtained his MS (2007) and BS (2005) from Sharif University and Tehran University in Iran, respectively. He has one published paper in Chemical Engineering science and three other journal papers under review.

007 Effects Of Fiber Size And Fiber Orientation On Pressure Drop And Collection Efficiency Of Fibrous Filters, *S. Fotovati1, H. Vahedi Tafreshi1*, and B. Pourdeyhimi2, 1 Mechanical Engineering Department, Virginia Commonwealth University, Richmond, Virginia 23284-3015, 2 Nonwovens Cooperative Research Center, The Nonwovens Institute, NC State University, Raleigh, NC 27695-8301, *Corresponding author, email: htafreshi@vcu.edu, telephone: 804-828-9936, fax: 804-827-7030*

In this work, we summarize the results of our study on the influence of fiber size and fiber orientation on the pressure drop and collection efficiency of fibrous air filters. The study has been conducted by generating 3-D virtual structures which resemble the microstructure of a fibrous medium. Our results indicate that Figure of Merit of a typical filter medium increases with increasing the fibers' through-plane orientation. The fibers' in-plane orientation, however, were found to have no significant influence on the filter's performance. Our CFD simulations of fibrous media with different fiber diameters indicate that Figure of Merit of poly-disperse filter media increases with increasing fiber diameter ratios for Brownian particles (nm), and decreases for larger particles. It has also been shown that by increasing percentage of coarse fibers, Figure of Merit increases for nanoparticles and decreases for larger particles.

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The presenter is Shahryar Fotovati who is a Mechanical Engineering PhD student in Virginia Commonwealth University.

Shahryar got his BS and MS in Mechanical Engineering from Persian Gulf University (2001) and Shiraz University (2007) in Iran.

008 Layer Orientation In Pleated Media, *R.Bharadwaj and G.G. Chase*, Microscale Physiochemical Engineering Center, Department of Chemical and Biomolecular Engineering, The University of Akron, OH 44325-3906, *Corresponding Author, Tel: 330-972-7943, Fax: 330-972-5856, gchase@uakron.edu, http://www.engineering.uakron.edu/%7Echem/fclty/chase/chase.html*

Experimental observations have shown layer orientation is more important than individual fiber orientation. Layered orientation in filter media affects the permeability and the separation efficiency of coalescing filters. A filter media performs differently with respect to different axis, which depends on the orientation of fibers with respect to the direction of the flow. During Coalescence oil droplets get bigger and tend to move on fibers, these fibers can aid in the drainage of oil if they are placed appropriately with respect to the flow and gravity. The main objective of this work is to study the effects of Layer orientation and test its performance for different angles with respect to the flow. It incorporates stacking micro fiber sheets at different angles (0,30,45,60and 90). For capture of liquid droplets the decrease in pressure drop obtained is offset by the decrease in capture efficiency, resulting in nearly constant quality factor regardless of fiber orientation. However, in coalescing filter media the improvement in liquid drainage from the filter can improve the quality factor from 20 to 60%. Stacking media at different angles to the flow changes the average fiber angle of the media, which can be measured by the fiber mapping method. In coalescing filter media the layered orientation can have an added benefit of reducing the liquid saturation in the filter media, which leads to an improved quality factor for the filter media. The stacked sheets design can be extended to a pleated structure, which could be easier to construct from an industrial point of view. Introducing angles (0,30,45,60,90) in the pleated structures can vary the performance on coalescence filtration. A regular pleated media performs much better than a layered media and this performance can be further improved by incorporating angles in the pleated structure.

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009 Improving Performance And Drainage Of Coalescing Filters, *Shagufta U. Patel & George G. Chase*, Department of Chemical and Bimolecular Engineering, The University of Akron, Akron, OH, United States, *Corresponding Author Tel: +1 330-972-7943, Fax: +1 330-972-5856, gchase@uakron.edu*

Coalescing filters are used to remove liquid aerosols from gas streams. The captured liquid typically drains from the filter by action of gravity. The saturation or hold-up of liquid in the filter constricts the gas flow, increases pressure drop, and increases the operating costs of the filter. Filter performance can be improved if the liquid saturation is reduced without reduction in capture efficiency. In this paper filter media are modified with drainage structures to reduce saturation and to reduce drag resistance. The media are tested in horizontal and vertical orientations to determine whether their orientation with gravity influences the performance. The experimental results show that with no drainage channels the media oriented with flow vertically downward operates the best whereas with drainage channels the horizontally oriented media had the best performance. The results also show embedded woven drainage channels at 45 degree downward angles have the overall best performance. The surface properties as well as pore size distribution of the woven and nonwoven drainage channels are varied to achieve optimum filter performance. The results show significant improvements in filter performance.