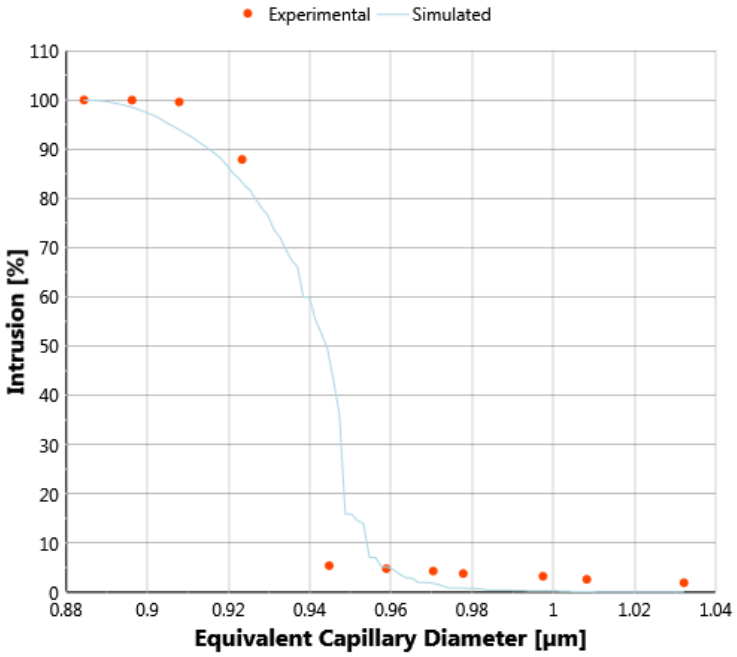
Application note: PoreXpert modelling of the depth filtration characteristics of a cellulose nitrate filter

Introduction

This application note shows how PoreXpert can be used to simulate the depth filtration characteristics of a cellulose nitrate filter using results input directly from a POROLUX™ 1000 porometer supplied by Porometer NV. PoreXpert simulates the 3-dimensional void network of the filter. It then feeds in particles from a size distribution specified by the user. From that, it calculates the depth filtration characteristics of the filter in terms of filtration efficiency with respect to particle size and pressure drop (progressive clogging). In this way, PoreXpert can be used to avoid expensive bench tests. The PoreXpert targeted modification facility can also be used to try out the characteristics of filters whose geometry has been modified within the software, aiding the development of new filter designs.

Porometry

PoreXpert reads in data directly from POROLUX™ 100 and 1000 porometers. It then converts these to an equivalent full intrusion characteristic (as output by a mercury porosimeter). This is expressed as percentage intrusion plotted again the equivalent capillary diameter which can be intruded at that pressure, as shown in the screenshot on the right. PoreXpert then generates a void structure which, if put into a porometer, would match this converted data, as also shown.



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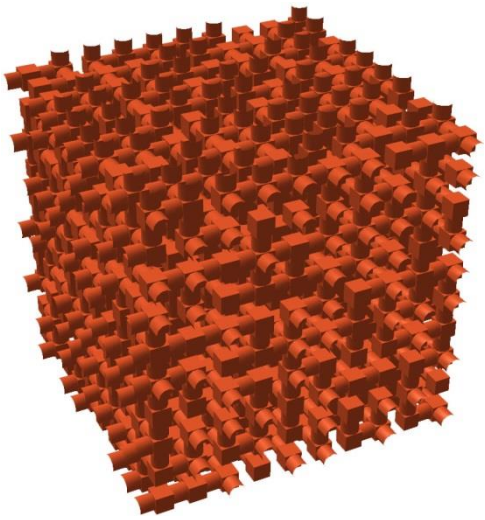
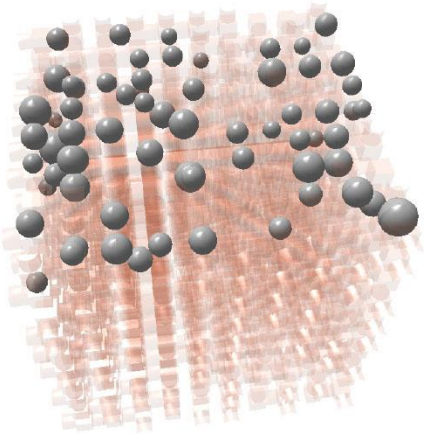
Simulated void structure

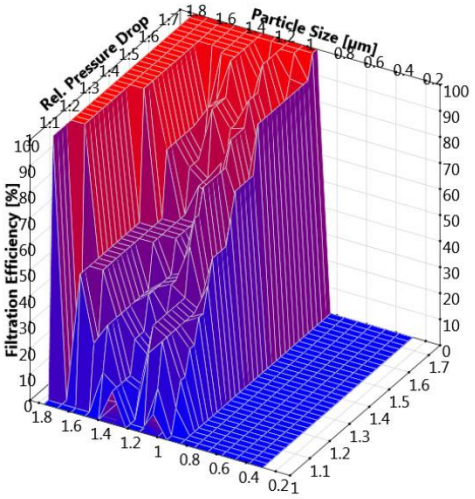
The simulated void structure of the filter is approximated as an array of cubic pores connected by narrower cylindrical 'throats'. The figure shows a structure containing 1000 pores connected by up to 3000 throats, which connects together and repeats in every direction to form an infinitely large structure (with periodic boundary conditions). Much larger, and therefore more realistic structures, can be generated for you – see Conclusion below.



Filtration characteristic

Once constructed, the simulated void structure can be used to investigate many other properties, such as void sizes, connectivity, wetting and absolute permeability. Here we will demonstrate just one – the filtration characteristic. First, the user specifies a particle size distribution. Then PoreXpert randomly chooses particles from this distribution and feeds them one by one into the filter, carried along by calculated flow streams. They may stay on the surface of the filter, as shown in the screenshot below, or be trapped (strained) in the body of the filter, or they may pass through.





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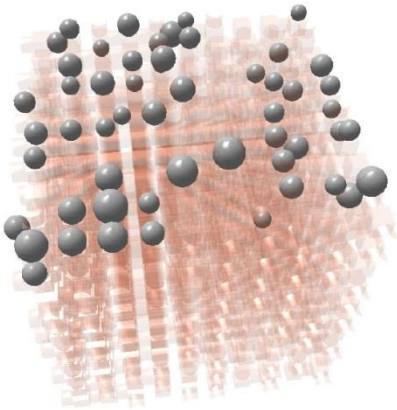
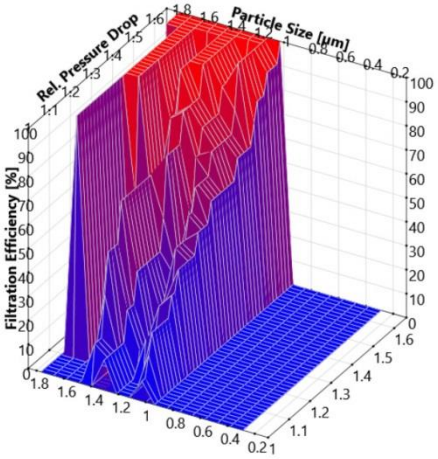
If a particle is trapped, then PoreXpert recalculates all the flow routes through the filter before sending another particle towards it. At each filtration event, it records the pressure drop across the filter which gradually builds up as the filter clogs. At the end of the simulation, a graph is plotted of filtration efficiency (100% = all particles trapped) against pressure drop and particle size, as shown on the previous page.

Simulated geometry modification for development of new filters

Once the void structure has been generated, it can then be modified to simulate the characteristics of a newly proposed filter. In the screenshots below, the pore sizes have been increased by 5%, and the throat sizes by 15%. The particle size distribution has been kept the same. Careful comparison with the previous filtration characteristic graph shows that the filter has become less efficient.





Automated reporting

For ease of use, and particularly for quality control purposes, standard batches of commands can be repeatedly run by the software, and a report of all the results can be automatically generated in pdf format. Such a report, shown all the simulations described in these Application Notes and a few more, are enclosed in this brochure.

Conclusion

PoreXpert provides a brand new and very powerful tool for characterising your current filters, and developing new ones. Even more realistic and subtle structures can be simulated for your filters by contacting PoreXpert Ltd and sending your requirements to run on their super-computer.

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