Filtration+Separation **September 2005**

Filtration: The marketplace

As Filtech approaches, it seems the perfect time to examine the state of play in filtration and separation. So we asked Dr Graham Rideal, chairman of The Filtration Society, for his insight into industry trends (below). And on page 34, Ken Sutherland backs this up with the filter media perspective…

A US$20 billion incentive

The market size for filtration and separation products was estimated to be over US$20 billion last year spread throughout 24 distinct geographical regions of the world*.

The forces driving this market growth are:

- the demands for improved clarity in water treatment (fresh or waste)
- better indoor air quality (domestic and industrial)
- a universal demand for finer degrees of separation – from hydraulic oils to semi-conductor wash water
- the need for better hot exhaust gas filtration, including diesel exhausts
- the need for higher energy efficiencies in all separation operations
- strengthening environmental legislation.

The overall growth in the industry was forecast to exceed 34% (in constant money terms) from the base year of 2004 through to 2009, a compound annual average growth rate of 6%. This is a conservative estimate.

Recent information from the last American Filtration Society conference in Atlanta USA predicted that the filter market for domestic water coolers alone would develop into a multi-billion dollar business in just two years. The attraction here is for a single multi-purpose cartridge system that will deal with particulate and biological contaminants as well as having an odour control functionality.

On a more basic level of water purification, the objective is simply to produce safe drinking water for developing countries. The fastest growing geographical markets in this sector are China, India and South America.

Current trends in filtration and separation

- Tailor made applications
- Very thin panels
- Membrane cartridges replacing filter bags
- Electrospinning
- Nanofibres from ceramic materials
- Pleating improvements
- Precise slotted media
- Hot gases cleaning in beds of granular solids
- Abnormal materials
- Hydroentanglement
- Very fine fibre webs
- Larger membrane modules
- Media with tapered pores
- Exotic polymers
- Enhanced analytical methods

Figure 1: Challenging filter media with spherical particles gives unambiguous pore size data.

Developing economies

China and India together have a population in excess of 2 billion and their fine chemicals and pharmaceuticals business are ripe for explosive growth. India in particular has the infra structure for significant pharmaceutical growth and aims to replace most of its imported drugs by nationally produced pharmaceuticals within 5 years.

On the horizon hover the problems of diminishing oil and gas availability, the probable return of nuclear power, and the equally probable growth in the use of hydrogen as an energy carrier. These challenges offer a wealth of opportunity to the filtration and separation industry, where high growth rates in membrane systems, thin-layer filtration and the use of ceramics is already visible.

However a significant impediment to growth in developing countries is the problems associated with accurately characterising filter media, and quality assurance issues in general As filters get finer and finer, novel and more accurate methods of testing are required. These include acoustic sensing, in situ NMR measurements, pore size and shape analysis and powerful computer modelling systems.

Conferences such as Filtech 2005 – co-sponsored by The Filtration Society – help to raise awareness of such issues; for this year's conference, for example, of the 42 sessions (oral and poster) 11 or approximately 25% of

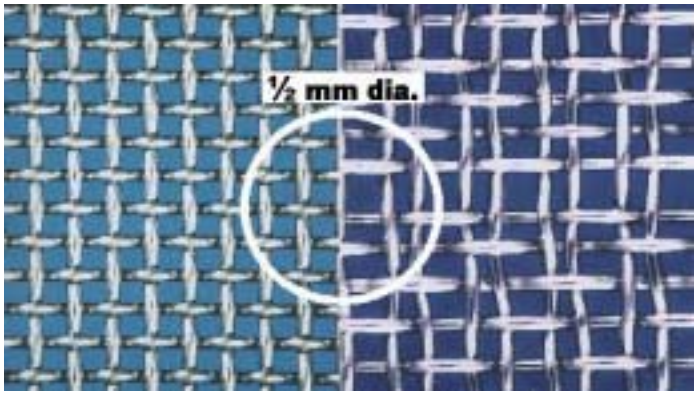

Figure 2: Specifying meshes by wire count rather than aperture size hides poor quality – *courtesy of G Bopp*

the subject matter relates to testing, modelling or process control. And in line with the exponential grown in their filtration and separation industry, this year sees the biggest ever contribution from China who will be submitting almost as many papers as the USA.

Nano science – macro safety

Nanoparticles, nanofilters and nanoaerosols are attracting increasing attention but with them come the unknown baggage of safely. For example, semi-permeable membranes in the brain become totally permeable to nanoparticles that may get into the blood stream. Cerebral 'short circuits' that may result are being investigated as a possible contributory factor to Alzheimer's disease.

We may laugh today at the use of uranium 'crystals' last century to alleviate toothache, but without proper safeguards in nanotechnology, such myopic thinking could create similar health problems in generations to come. It is therefore encouraging to see a paper at Filtech this year entitled 'Filtration of Nanoparticles in Nanofibrous Filters' by L Gradon et al of Warsaw University, Poland.

The future in filtration and spearation

- Nanotechnology
- PTFE
- Smarter membranes
- Cleaning of Diesel exhausts
- CO_2, H_2 and dioxin separation
- Machinery air intake, especially gas turbines
- New sources from quite un-associated fields
- High efficiency & cheap systems for drinking water
- Composite materials
- New combination materials
- Higher internal air quality
- Hot gas filtration
- Improved media characterisation

Money in waste

Safety and the environment go hand in hand and the filtration and separation industry is being increasingly driven by legislation. The treatment of wastewater has had a profound effect on almost every industry in the last 20 years. Initially, it was viewed as an additional burden on companies already struggling to make a profit, however with careful management and the application of the latest technologies, the old English saying 'where there's muck, there's brass' (where there is waste, there is money!) can really be true. There have been several cases recently where the treatment of wastewater can yield a product as valuable as the primary product in the production line.

This was exemplified in a paper by D. Dubbin of NIRO given at a recent Filtration Society conference entitled 'Reducing Costs – Increasing Profits with Filtration Technologies'. In the production of cheese only 10% of the milk is actually used for cheese, the remaining 90% (whey) is essentially waste. Hitherto, the whey residue was simply washed away to drain but such a practice is now prohibited. The removal of the waste by tanker is prohibitively expensive, while installing on-site evaporation equipment is expensive both in capital and running costs. Such costs could not be factored in without a significant increase the price of the cheese.

Instead, commercial microfiltration systems have been installed, which recover the very low concentrations of fats, proteins and lactose. These high value products have been modified to produce infant formula milk much closer to in composition and functionality to human milk, which represents an $8-10 billion global industry. Other high growth, high margin products using isolated whey proteins include fermented products such flavoured beverages and probiotic yoghurts. So the combined influences of waste disposal legislation and filtration advances, rather than depress the market, may yet turn it on its head whereby the primary product is not the cheese itself but the high value added by-products.

'Gold' in the drains

A similar success story was recently reported[4] entitled 'There's gold in them there drains!' Elemental analysis of roadside drains, particularly those on roundabouts showed a higher concentration of platinum group metals than in many commercial mines.

Similar high yields were also discovered in waste incinerator ash. The next major technological push is to try to commercially recover these valuable products. The benefit to the environment goes without saying.

Environmental legislation was also the driving force in developing new filter media for the textile industry, which relies heavily on the use of large volumes of washing water. It was for this reason that the industrial revolution expressed in the form of textiles was birthed in the North West region of England. There was an ample supply of raw materials – sheep and water. Water provided the energy to drive the looms as well as to wash the fleeces.

Typically, it takes over 100 litres of water to process just 1kg of textile material*. Not only must the washing water be treated to recover important by-products such as lanolin, but bleaching and dyeing chemicals must also be removed before discharge back to the rivers. Coagulation and flocculation processes are used to precipitate the contaminants into large enough coagulants that can then be filtered out using new filter media having pore sizes below 2 microns. The purified water can then be recycled back to the front end of the process*.

The advances in filter media design have not only solved an effluent discharge problem but have also decreased the water dependency by increasing the recycling efficiency. An unlikely beneficiary is the cashmere industry of Mongolia where there is a much more limited supply of water.

A question of quality

As mentioned above, a significant impediment to growth in developing countries is the problems associated with accurately characterising filter media, and quality assurance issues in general.

The pore size measurement of filter media is obviously a fundamental performance parameter as it determines the ability of a filter to trap particulates or liquid mists. There are three quite different approaches*.

Firstly, bubble point testing where the air flow rates through a wetted filter can be theoretically related to the pore size

Figure 3: Traceability to NIST is an important feature of Challenge testing.

Figure 4: Challenge testing may be dry as Sonic testing or via aqueous suspensions

distribution. In this method the larger blocked pores are blown free first and then as the smaller pores are cleared they increasingly contribute to the flow rates. This technique is known as Porometry.

Secondly, there is the more recent and related method of liquid extrusion Porosimetry where the pressures and volumes of a liquid forced out a filled filter medium can give detailed information on pore structure.

Finally, there is the challenge test method where calibrated particles 'challenge' the filter and the downstream sizes compared to those presented to the filter surface. An obvious advantage of the latter is that it is an absolute method involving real (and traceable) particles.

Hitherto test dusts having irregular shapes and broad distributions have been used[8]. Although they still offer an effective and inexpensive way of testing filters and many test standards have been written around them*, new spherical glass bead filter standards now bring enhanced resolution and analytical speeds*.

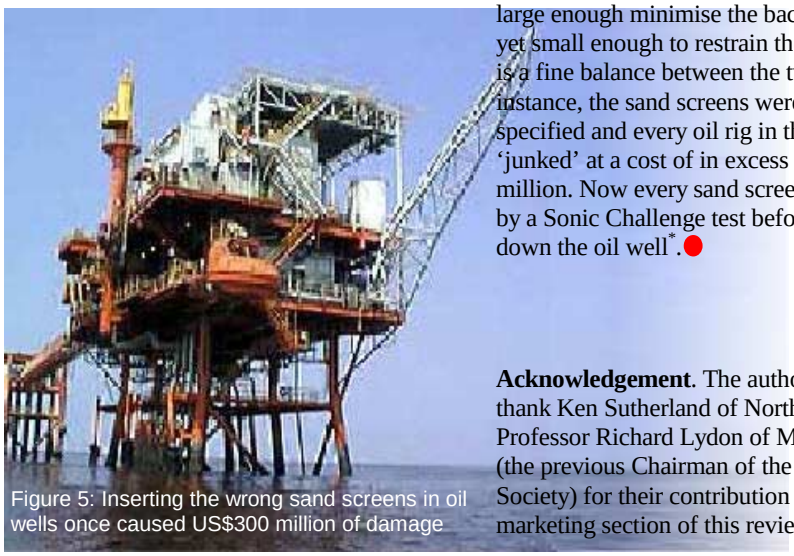

Figure 5: Inserting the wrong sand screens in oil wells once caused US$300 million of damage

Incorporating the latest automatic laser particle size analysis techniques, state of the art challenge test equipment now offer high precision filter testing down to submicron pore sizes*.

In parallel with the development of microscopy and image analysis systems for particle size analysis, diagnostic and particle recognition techniques can now be applied to the analysis of filter surfaces to determine the source of the contamination*.

Most of these methods of filter media characterisation including totally novel approaches will be discussed at Filtech 2005.

A costly mistake

Unfortunately the scientific credibility of the filtration and separation business has sometimes suffered over the years because of unsubstantiated performance claims. For example, one customer was told by an eager salesman that his 40 micron woven mesh could be turned into a 20 micron mesh simply by using two layers! The resultant down time and replacement costs could run into tens of thousands of dollars.

However such financial penalties incurred through a misunderstanding of pore size distribution pale into insignificance compared to those recently experienced in the South China Sea oil wells.

Drilling an offshore oil well to a depth of up to 10 kilometres costs approximately US$20 million. To prevent sand from being pumped along with the oil and eroding the expensive stainless steel pipes, sand screens are used. The pore sizes of the sand screens must be large enough minimise the back pressures, yet small enough to restrain the sand. There is a fine balance between the two. In this instance, the sand screens were incorrectly specified and every oil rig in the field was 'junked' at a cost of in excess of US$300 million. Now every sand screen is checked by a Sonic Challenge test before it is put down the oil well*.

Acknowledgement. The author wishes to thank Ken Sutherland of Northdoe Ltd and Professor Richard Lydon of Madison Filter (the previous Chairman of the Filtration Society) for their contribution to the marketing section of this review.

About the author
Dr Graham Rideal (Chairman of The Filtration Society) graduated from Lancaster University and joined ICI where after 15 years, he became the company consultant in particle size analysis. He is the author of several patents describing the construction of inorganic materials such as foams, films and coatings from nano-sized mineral particles and has published over 30 technical papers. After a period with the BSI advising on test sieve specification, Dr Rideal was invited onto the Bureau of Certified Reference (BCR) panel in Brussels to help develop a new international range of reference standards for particle size analysis. He was the founder of Whitehouse Scientific in 1983, a company specialising in particle size standards. Dr Rideal developed an award winning method of calibrating test sieves using glass microspheres, a technology that has recently been very successfully extended to cover filter media.

*** For references, please contact the Editor.**

The Filtration Society: an introduction

The Filtration Society was established over 40 years ago to advance and disseminate the science and technology of filtration and separation processes. As such, discussion of subjects from embryonic conceptual ideas through to the final engineering and processing equipment is encouraged.

The Society's main objectives are to distil current thinking, as well as consolidate and point to the future. Innovative or distinctive research is rewarded in both young and experienced scientists through the Suttle Award and Gold Medal respectively.

The key forum for discussion has been through conference, over 150 of which have been organised to date. Being a non-profit making charitable organisation, the popularity of a subject does not restrict discussion and technical meetings have been put on for erstwhile minority interest groups such as specialist medical and membrane filtration, some of which have subsequently evolved into major subject areas in their own right.

Over the last year the most popular conferences have been on new filter media, reducing costs and filter testing, the latter attracting an international audience of over 100. Of particular interest in the filter media conference in May this year was the current trends and the future for filtration technologies.