Roles and functions of technical fibres and textiles in filtration
October 2009

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1. Overview

Technical Textiles are used in filtration to separate and purify industrial products and to clean air, gases, effluents, and a myriad of other filtering or separating applications. It is an ever-growing marketplace, as industrial and environmental demands increase.

Textiles used in filtration are termed “filter media”, or more simply “media”.

The filtration industry is large, global, sophisticated, diverse, and profitable. The two distinct areas of filtration can be best categorised as:

- Separation of Solids from Liquids
- Separation of solids in gases.

It is a high-tech industrial industry with large volumes of product going directly from a manufacturer to an end user such as a food processing company. Processors may also be part of the supply chain as in the manufacture of Aluminium, where bauxite is first mined then refined into Alumina, through several stages of liquid filtration (wet). The Alumina is transported to a smelter where it is converted into Aluminium this process subsequently requires further filtration, which is generally categorised as (“dry”).

The science of fabric permeability or “flows through fabric” is the knowledge needed to engineer specific characteristics into a functional fabric depending on the desired outcome, and the specifications of the solids being filtered. For commercial and environmental motives, it is essential to maximise flows (either air or liquid) through the media whilst ensuring that the minimum amount of particulate passes through the cloth, or does not impede further filtration by plugging the cloth; which can occur if the particle size and shape is such that it embeds itself into the aperture developed between the weave structure and the mechanical finish applied to the cloth to achieve the desired release properties.

Filter media is used in most cases to develop a “cake” (as can be seen in photo on the left) which is the real filtering medium. It is essential that the cake be developed as soon as possible as until such time the process is not functioning effectively and the product has to be recirculated, costing both time and money.

The choice of fibre and textile construction is critical to the performance of a given filter cloth and its processing capabilities with a given slurry composition, the characteristics of which have to be clearly identified and understood to minimise the above mentioned problems.

The various chemical, thermal and pressure conditions that are encountered in the many and varied functionalities of filtration and separation have a profound influence on the type of polymer used, as well as the base product needed. When considering these conditions a sound knowledge of the different performance characteristics of the different polymers, as well as the performance capabilities of the base media have to be understood and considered.
The solids being filtered or separated also have a significant influence on the type of fabric/textile structure being employed. The different types of filter equipment also affect the media selection.

For all the above reasons, a sound knowledge of fibres and textiles is a prerequisite for the separation of solids from both liquids and gases.

2. The role of textiles in filtration

Textiles used in filters can be nonwoven, woven or knitted. The diagram below demonstrates a typical heavy construction (double layer weave) used on some belt filters.

Filters sold through retail outlets are a small percentage of all filters used, and would include such products as household water filters, vacuum cleaner bags, automotive replacement filters etc. The vast majority of filter media supplied to the filtration and separation industry is used in the industrial and commercial sector. The range of cloths used is as wide as the uses themselves. New polymers are used almost as soon as they become available in the ever-increasing pursuit of efficient and effective filtering of products.

As filtration and separation technologies and uses grow, so too does the need for sophisticated filter media. With this increasing sophistication comes the need for greater education into the properties of various fibres, polymers, yarns, felts, woven and knitted products for use in the filtration and separation industries.

3. Demand drivers

The demand drivers for the filtration market are sobering when compared to traditional uses of fabric such as the apparel market, which is driven by consumer’s choice. For example, air filtration is an industrial market driven by:

- Environmental, health & allergy considerations
- State and Federal workplace and building regulations
- Employer and union workplace agreements
- Occupational health & safety
- Fear of litigation... insurers and lawyers!!

Pressure from these issues will not abate in the foreseeable future. Following are further examples:

3.1. Coalmines

A unique example in Australia is that of filtration in coalmines. The carcinogenic properties of Diesel Particulate Matter (DPM) are well documented. Filtration is therefore essential for clean air and working conditions in coalmine. To this end, it has become mandatory for filters to be fitted on all diesel-powered equipment operating in enclosed or confined spaces. It is reported that BHP’s agreement with the CFMEU stipulates that the filters in trucks used in the mines be changed...
every day regardless of vehicle use. The filter must have the added safeguard of being non-flammable to 960°C and able to withstand the explosive atmosphere of an underground coalmine and able to capture the hazardous sub-micron particles down to 0.3 micron in size, the following photograph shows examples of typical cartridge filters used in this type of application. The choice of fibre and construction is critical to the performance of the filter. The Melbourne based company estimates that 7 million metres of filtration fabric is required for this single filter annually.

3.2. The European Apparel and Textile Organisation (Euratex)

In June 2009, a presentation by Dick Hendricks, head of the governing council of Euratex, at the Techtextil conference outlined the European Technology Platforms for the future of textiles and clothing. This strategy features the development of clusters of companies (industry), and related research and education communities, representatives of related industrial sectors and scientific disciplines and public authorities. In essence, it is a serious financial commitment to the most promising areas of fibre and textiles to ensure long-term industry competitiveness to the benefit of economic growth, jobs and sustainable development in Europe.

In a concerted quest to keep the filtration industry within Europe, the Europeans have developed a technology platform called "Cleantec". It is reasoned that the European community has a duty to keep the air and water clean, purified and healthy for the European communities – this duty, Hendricks said "can’t be outsourced to other countries.” Government policy will therefore ensure that this industry stays in Europe.

Product design and safety standard requirements for particular products, and environmental and occupational safety and health legislation on the impacts of industrial processes on the natural environment and workers dictate a vast range of regulations governing these products. These regulations are made in Europe and therefore the logic is that the knowledge and associated products are created in Europe.

4. Available statistics

Filtration primarily uses both woven and nonwoven. For the purposes of this paper statistics on the nonwoven segment were accessed through the American Industrial Nonwovens Association (INDA) worldwide industry outlook report which notes that the filtration industry is growing by 8.2%. It predicts
rapid growth in the coming years, outgrowing other segments (with the exception of hygiene wipes) with an increase of 12.2% by 2012. Statistics on the woven segment were not sourced.¹

Statistic on textiles used in the filtration industry are collected and reported by a number of agencies. They include:

- The Industrial Nonwoven and Disposables Association (INDA) in the US
- The European Nonwoven and Disposables Association (EDANA) in Belgium, and
- David Rigby & Associates based in the UK

Whilst the information differs from organization to organization, all predict strong growth in years to come.

The (albeit dated) DRA (David Rigby) report categorizes all industrial, technical and nonwoven textiles into a series of groups including (but not limited to) GeoTech, BuildTech, ProTech, Packtech, to name a few. The segment “INDUTECH” includes filtration and other industrial applications. The report identifies filtration to be the most important segment within “Indutech”, accounting for over 860,000 tonnes with an estimated value of US$2.7 billion in the year 2000.

5. The filtration industry in Australia

The author estimates the size of the market for technical textiles for filtration media in Australia (used within the filtration and separation industries) to be in excess of AU$130 million per annum with approximately 30% of Australian filter media supplied by Victorian based companies.

¹ Stats on the woven segment were not sourced.
The mining and mineral processing industry in Australia is a significant primary industry and contributor to the Australian economy. It is also a large user of filter media. Many of the global companies have based research and development facilities in Australia providing a significant opportunity for the local technical textile industry to develop specialized cloths that, once proven, can be rolled out to the rest of the world.

There are some niche markets using exotic polymers and fibres, but this is a small percentage, and is currently adequately supplied from the local market. With the emphasis on more and more recycling or reuse, the demand for specialized filtration technologies will increase, again leading to opportunities for research and development, which will then lead to a need for education as the uptake of specialized technologies grows.

Liquid (wet) filtration is a sophisticated user of a complex and varied array of media. Woven products are used in around 70% of the marketplace in addition to some specialised needle felts being used. There is also a small quantity of knitted product used in this field, but it is not ideally suited for the exacting conditions encountered in the separation of solids from liquids. This ever-increasing market encourages the development of new and innovative products as more and more demands are placed upon the processors within this industry. It is a significant area for research and development, and, as the developments become effective, for ongoing education of the users, as well as the graduates currently going through the educational establishments, who will become the workforce of tomorrow.

As ores are mined deeper there are new and exciting developments required to meet the demands of dewatering the solids being mined from below the water table. As the precious commodity of water grows in stature, it is imperative that more and more effective dewatering technologies are developed and adopted. What the future holds can only be surmised, but with the increasing speed of developments, it can be stated that well educated engineers will be in greater and greater demand. The education of these engineers will be ongoing to keep abreast of adopted technologies, at an ever-increasing rate.

Dust (dry) filtration is considered a more mature market in Australia, but again it must be stated that as demands grow for improved (cleaner) filtration the situation may alter. The current marketplace in Australia is around AU$60M per annum. The bulk of this would be in commodity needle felts, although the power generation sector does use woven product. The bulk of these products is now produced offshore and brought into the country, as demand requires.

6. Filtration categories requiring textile solutions (in alphabetical order)

- **Cartridge filtration** involves the use of a porous cartridge filter, commonly made of polypropylene (PP) or ceramic, which catches particles as liquids pass through it. Cartridge filtration is an easy filtration method but not suitable for liquids with high turbidity and fouling remains a common problem leading to filter replacement.

- **Centrifugal separators**, also called “centrifugal filters” or “cyclone separators”, use cyclones in which substances, such as immiscible liquids, gases and solids, are separated during rapid rotation from the contaminated fluid. The entrance of the pressurized fluid from which the contaminants must be removed causes the rotation of the cyclone.

- **Chemical filtration** removes contaminants through the use of a chemical medium, such as activated carbon, in the filter. Chemical filtration remains common in the filtration of gases.
• **Electrostatic filtration** is a filtering process that involves electrically charged media that use an electric field to filter substances and remove particles as small as .01 micrometres in size. As substances pass through the charged media, certain particles are attracted to the charged media.

• **Liquid filtration** may involve the removal of articles from a liquid, known as “liquid-solid filtration,” or the separation of liquids from gases known as “gas-liquid filtration”.

• **Membrane filtration** involves the use of a membrane as the filter media to allow the passage of substances such as air and water, while preventing the passage of other substance particles. Membrane filters are small and automated and used for applications that include purifying blood during dialysis treatments, removing bacteria and odours and desalinating water.

• **Nanofiltration** is a type of membrane filtration used to remove extremely small particles. The effectiveness of nanofiltration lies between that of reverse osmosis and ultrafiltration.

• **Oil filtration** is necessary to remove particles and contamination that may hinder the functioning of equipment. Oil filtration remains common in the automotive/trucking and agricultural industries, as well as other industries that utilize equipment requiring the use of motor, hydraulic and other types of oils.

• **Pressure filters**, excluding rotary drum pressure filters, are semi-continuous machines whose collection of filtrate is dependent upon the operating mode of the filter (e.g. constant flow rate, constant pressure or both, with pressure rising and flow rate reducing). Pressure filtration is a batch process and requires a surge tank located upstream from the filter and a batch collection of cake downstream.

• **Reverse osmosis** is a type of filtration method in which water is pushed under pressure through a membrane, while contaminants are prevented from passing through the filter. Filtered contaminants include sodium, phosphorus, aluminium, lead and fluoride.

• **Water filtration** involves the purification of water for drinking purposes. Wastewater is also filtered to remove excess particles.

• **Wet/dry filtration** is a biological filtration process involving the exposure of the filter medium to air to facilitate nitrification. Wet/dry filters are commonly used in aquariums.

• **Ultrafiltration** is a type of membrane filtration that removes particles ranging from 0.002 to 0.1 micrometres in size. Filtered substances include bacteria and viruses.

7. **About air filtration**

Air Filters are designed to filter and remove a range of contaminants from the air, including moulds, gases, dirt and odours. There are specific filters available for different needs, as not all filters are designed to remove the same particles. Filters are made from various fibres, yarns and associated constructions and compositions. For example, these include fabrics such as gauze, fibres such as polyester and metals such as stainless steel. Sometimes electric and chemical reactions within the filter itself assist the attraction and removal of harmful elements from the air. An understanding of chemistry is therefore an advantage. Filter
efficiency is determined by a few different factors: the size of the filter fibres, the density of the fibres in the filter and the velocity of the air that moves through the filter.

Air filters are largely used in home or commercial heating ventilation and air conditioning systems (HVAC). A HEPA (high efficiency particulate air) filter is an example of a specific style of filter used in the HVAC systems. The HEPA filter is mainly used to remove small particulates such as allergens and other common irritants from the air. The automotive industry uses air filters extensively in vehicles to help promote engine hygiene. Some domestic and industrial appliances house their own internal air filters to increase air quality. Clean air within individual machines ensures longer life to the unit.

While air filters protect machines (like cars and air conditioners) from damage and premature breakdown, there are many large dust filtration applications that are becoming highly regulated in various parts of the Globe. Although the author believes it is unfortunate that Australia is falling behind other developed markets such as Japan and many European countries, in this area.

One of the larger uses of dry filtration media is in the form of "filter bags" is the power generation industry. Whilst the life expectancy of these filter bags is calculated in numbers of years, some applications have a life expectancy of in excess of 10 years. Given the size of power stations, large quantities of media are being used that are usually a coated homopolymer acrylic. Each individual cell (a single section of the total baghouse capacity) could have in excess of 50,000 square metres of product in use. There can also be multiples of these cells on one site, with some smelters having around 16 cells in operation at any one time. Many of the power stations on the eastern seaboard of Australia use this type of technology. Chinese investment in building power generation plants has stimulated exports of Australian technology in this area. Another large user of filter media is the smelting industry, the filter media is not expected to have the same life span as in power generation, but again it is still required to perform to specification for a multiple of years. The photograph above shows typical dry filtration bags.

Unfortunately the supply of media for dry filtration is seen as commodity product and as such is now predominantly manufactured off shore and the finished product is imported.

8. About liquid filtration

Liquid filtration is a more sophisticated market than that of air filtration, as the uses for filter media in wet applications covers a vast and ever increasing marketplace. Many of the mineral resources found in Australia are processed to some degree before leaving our shores. Much of this processing requires either dewatering of product, or some form of liquid filtration using several variations of filtration for both depth and surface filtration techniques.

As the demands on the textile product can be quite severe, there is a higher degree of knowledge required when working with the filter media in this arena. Alumina refining from bauxite is a good example of the harsh processing environment, processing can vary from site to site as the Bayer process is massaged to
meet the exacting demands of the various end users. Each refinery can process similar base product in a variety of methods. For example, some in pressure filtration do not use a pre-coat filter aid, preferring to use a basic staple yarn plain weave cloth. Whereas other refiners in the same process use a pre-coat and body feed process with their filter aid, allowing the utilisation of a very sophisticated monofilament cloth with a high degree of mechanical finishing imparting special releases properties onto the media. Again in the harsh environment encountered in the Bayer process of Alumina refining, there are special polyamides used to reduce soda levels during late stage washing.

Mineral sands processing, on the other hand, would be seen as a quite simple process where dewatering and some separation takes place on belt presses utilising a fairly open weave structure usually using polyester monofilament or multifilament to provide the belts stability and to reduce the tendency to stretch once in operational use.

Also as the washing of coal becomes more technically demanding, special cloths are being developed to allow maximization of machines on site, whilst ensuring good yields of highly specified end products. It is strange to think that coal is now being worked down to below 5 micron, to produce a high calorific value clean(er) product, as being demanded by some of our export markets.

For environmental reasons, research into the dewatering of tailings is on the increase. With the value of water increasing and it becoming a more valued resource it is increasingly necessary to maximize the dewatering process of tailings. It is no longer thought right to contain tailings until the liquid has sufficiently evaporated to allow easier transportation for adequate disposal. There are pressures to dewater as dry as possible in order to reclaim and reuse the water, but also to salvage more useable product from the tailings, and ultimately produce a final product that has no detrimental effect on the environment.

There are manufacturers based in Australia, who over recent years, have increased their export markets, and continue to do this at an increasing rate.

9. Authors notes

The Filtration and Separation industry has become a global, high-tech and sophisticated industry. To meet the demand that shows little signs of decreasing, it is essential that the engineers coming into the industry are learned and have some basic understanding of the tools they will have at their disposal. One of these being the knowledge of the technical fibres and textiles used in producing many of the filter cloths used throughout the world. Some filter machine manufacturers have identified this need and, have in recent years run training sessions closely linked with trade fairs and conferences. It is obvious from this move that a need for further and ongoing education is required for the existing workforce and also the workforce of the future emerging from our educational institutions.
As stated previously, many of the larger companies working in this industry have leading research and development sectors based in Australia. This has come about due primarily to design major processing plants that have been design with excess capacity to allow major trials to be performed with no detrimental effect to the (all important) throughput of the plants. Additionally, there are many industry practitioners in Victoria who are highly regarded (across many of the areas discussed in this paper) and who are in demand to present papers at international conferences.

With the correct dissemination of knowledge, and ongoing training there is sufficient manufacturing capacity to grow the industry in Australia. It is the author’s view, that given adequate investment, Australia, particularly Victoria, has an opportunity to capitalise on the growing demand for a more informed workforce and to develop an education system that will turn out world-class engineers to work in this highly demanding, and innovative growth industry.
Appendix

10. Representation for the global filtration & separation industry

10.1. Some global filtration associations

10.1.1. USA
° Filter Manufacturers Council (FMC): www.filtercouncil.org
° National Air Filtration Association (NAFA): www.nafahq.org
° American Membrane Technology Association (AMTA): www.membranes-amta.org
° American Filtration and Separation Society (AFS): www.afssociety.org
° Industrial Nonwovens & Disposables Association (NDA)

10.1.2. Japan
° Association of Liquid Filtration and Purification Industry (LFPI) www.lfpi.org/english

10.1.3. Australia
° The Air Pollution Control Equipment Manufacturers Association of Australia (APCEMA)
° The Filtration & Separation Association of Australia (FSAA)

10.1.4. Europe
° The Filtration Society
° EDANA

10.2. Some filtration related trade shows:
° A & WMA’s Annual Conference & Exhibition: www.environment-expert.com/events
° AHR Expo: www.ahrexpo.com
° American Filtration and Separation Society Expo: www.afssociety.org
° INDA: Filtration conference
° EDANA:

10.3. Some filtration publications:
11. About the Filtration & Separation Association of Australasia

The Filtration and Separation Association of Australasia is a forum to develop and advance the Filtration and Separation industry. It represents the common interests of the industry to government bodies and acts as a conduit for information on Global Filtration and Separation issues. The association encourages an internationally competitive and innovative industry and fosters the growth of an appropriately skilled and sustainable workforce through the provision of appropriate training, and inspirational speakers at member events and an annual conference.

The Board of the Filtration and Separation Association of Australasia is made up of personnel from industry, R&D, and Educational Institutions. The Association has various committees to ensure the members interests are met and carried out professionally. The Association is mandated to lobby Governments on issues of importance to the membership.

Being a member of the Filtration and Separation Association of Australasia provides industry practitioners opportunities to discuss issues affecting their industries with peers and have those issues further addressed.

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Images in this document have been sourced from the web.