

FABRIC FILTERS FOR COAL FIRED POWER STATIONS

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ABSTRACT

Over the last 30 years there has been a significant increase in the use of textiles in coal fired power stations in Australia, Republic of South Africa, China and United States of America. When coal is burnt in a power station approximately 30% of the weight of coal evolves as fly ash particulate emission which must be prevented from passing to the atmosphere.

The paper discusses the use of different fibre polymers and yarn types used in filtration media for filter bags. Woven and needled punched fabric structures have developed to achieve low emissions, high air flows and extended life.

The paper also discusses the current technology and a perspective on the new emerging trends in fabric filter bags in coal fired power stations.

INTRODUCTION.

Historically the development of fabrics for fabric filter bags has been limited because of the restricted availability of suitable polymers. The combination of thermal and chemical conditions in the gas stream of a power station restricts the use of textile polymers which can withstand the conditions. The varying nature of the coal source, operating conditions of the boiler and the type of fabric filter used produces conditions that few polymers can tolerate.

Since the early 1970's in Australia the development of fabric filters in utility boilers has used a limited number of fibre polymers because of limited commercial availability and cost.

POLYMERS.

The following fibre polymers are in common use:

- Fibreglass,
- Homopolymer Acrylic (PAN)
- Polyphenylene Sulfar (PPS)

Also used are:-

- Polyimide (P84)
- Polytetrafluoroethylene (PTFE)

Fibreglass.

This fibre is relatively inexpensive compared to other fibres.

The maximum operating temperature of the fibre is 260°C which offers potential for use in a large cross section of power station and coal types.

However its low flex abrasion and low resistance to mechanical damage limits the fibres use to fabric structures that involve lower stresses during production and use. Therefore almost all of the fibre produced for filter end uses is manufactured into woven fabrics. This limits its expansion into other filtration areas requiring other fabric constructions.

To help the fabrics withstand some of the mechanical stresses and to increase the chemical resistance of the fabric it is commonly treated with a Teflon/Silicon/Graphite finish.

Although Fibreglass fabric filter bags play a large part in the collection of fly ash in the utility boilers in the United States of America there are no utility boilers in Australia using this fibre.

Homopolymer Acrylic (PAN)

The mechanical properties of this fibre allow it to be used for varied fabric constructions. It has relatively good textile fibre properties which allow it to be spun economically into yarns for the production of woven fabrics. Its mechanical properties also allow it to be used for the production of needled fabrics

The chemical resistance properties of the fibre make it ideal for the use in the collection of fly ash particularly for Australian and South African coals with lower sulphur content.

There are several drawbacks however, with PAN fibre which has meant that the usage of the fibre has slowly decreased over recent years.

i PAN's maximum long term operating temperature is 135°C. This means that for the efficient low term life of the bag, attemperation, usually by the induction of ambient air, is required to maintain the gas stream below this temperature. This increase in air volume means that a larger fabric filter with increased cloth area is required for efficient filtration performance. The lower gas temperature can also mean that there is an increased possibility of the fabric experiencing acid dew point excursions. This can degrade the fabric and is an important point to consider especially as higher sulphur content coals are being used.

ii The fibre has an inherent shrinkage problem that becomes evident over longer operating life. This fibre shrinkage can not be eliminated completely by heat setting treatment of the fabric.

During the development of fabric filters in the early 1970's this fibre was easily accessible, comparatively inexpensive, with the results that several large power stations in Australia and South Africa were built using fabric filter bags manufactured using PAN fibre.

Polyphenylene Sulfar (PPS)

The use of this fibre became popular in the 1980's as it became commercially available.

The fibre has an advantage over PAN fibre because of its increased thermal resistance. The fibre can operate at a constant 190°C. This means that the majority of fabric filters can operate without flue gas stream air attemperation. The fabric filter therefore can be smaller in size compared to one using PAN fibre. This is an important factor when retrofitting a fabric filter into an Electrostatic Precipitator casing. At higher operating temperatures there is less chance of fabric operating near or below the acid dew point

The fibre is also less susceptible to shrinkage than PAN, with any fabric shrinkage being mostly eliminated by effective heat setting.

The fibre is much more expensive than PAN fibre, but can be cost effective over the life of the boiler because of longer filter bag life expectancy and less fabric surface area required for a given boiler output.

The fibre can be affected by high levels of NO_x in the gas stream. Like wise the presence of bromides in the gas stream can have an adverse affect on the life of the filter bags.

Almost all new and retrofit fabric filters today are using PPS fibre. There is also a trend for fabric filters originally fitted with fabric produced using PAN fibre being converted to fabrics using PPS fibre.

Polyimide (P84)

This fibre has a maximum operating temperature of 260°C.

The fibre has not found wide spread use in flue gas filtration in utility power stations for several reasons:

- i the fibre is very expensive.
- ii the fibre is susceptible to acid hydrolysis.

P84 fibre is used in a small number of industrial boilers where the high boiler outlet temperatures limit the use of other fibres.

The fibre has also found a limited use in some power stations where the capture of fine ash particles is required to meet emission standards. The P84 fibre has a trilobal shape which has proven to give improved small dust particle retention due to the fibres increased surface area. The P84 fibre is used as a fine layer on the filtration side of a standard PPS or PAN fabric.

Polytetrafluoroethylene (PTFE)

The maximum operating temperature of this fabric is 260°C. The fibre has excellent chemical resistance to most chemicals.

However very few fabric filters in the power generation industry have been fitted with this fabric for the following reasons:

i The fabric is extremely expensive. The cost of the fabric means that it is used only in conditions that are highly caustic or acidic and operating at high temperatures.

ii The fibre is very smooth and a poor textile fibre. This means that the fabric is hard and expensive to produce. It also means that the fabric is very hard to stabilise in fabric finishing. There can be problems with stretching and/or shrinking during filtration operation. This characteristic is due to the low fibre to fibre surface friction, which also assists its dust release capabilities.

iii The fibre/fabric is a poor filtration fabric. The fibres are very smooth meaning that ash particles are not easily collected. Higher emission levels are expected with this fabric. The low surface friction due to the "non stick" characteristic of the PTFE, allow the dust particles to continue to "work through" the filter media.

FABRIC CONSTRUCTION

Woven fabric and Needled fabric are both used in fabric filters. The type of fabric construction has closely followed the requirements of mechanism of the fabric filter being used.

Typically fabric filters use the following fabric constructions:

Reverse air Fabric filters
Mechanical Shake/Deflate fabric Filters
Reverse Pulse Jet Filters

Woven fabrics
Woven Fabrics (Figure 1)
Needled Fabrics (Figure 2)

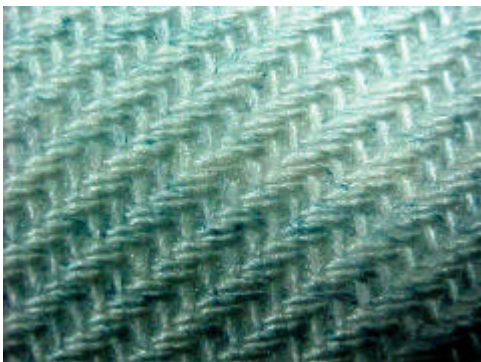


Figure 1 Woven Fabric



Figure 2 Needled Fabric

Table 1 Woven Fabric

Development of Woven Fabric

- | | |
|------------------------------|---------|
| • Fibre glass | <260° C |
| • Homopolymer Acrylic (PAN) | <130° C |
| • Surface Foam Coated PAN | <130° C |
| • Polyphenylene Sulfar (PPS) | <190° C |
| • Blended PPS and PAN | <135° C |
| • Chemical Treatments | |

Table 2 Needled Felted Fabrics

Development of Needled Fabrics

- | | |
|---|---------|
| • Homopolymer Acrylic(PAN) | <130° C |
| • Polyphenylene Sulfar (PPS) | <190° C |
| • PPS With surface Treatments | <190° C |
| • PPS with PTFE encapsulation | <190° C |
| • PPS with Blended or capped webs (P84) | <190° C |
| • PTFE (PTFE) | <260° C |

REVERSE AIR FABRIC FILTERS

This type of fabric filter with a low air to cloth ratio (ATC) gives low mechanical stress to the fabric used in the filters. The use of glass fabric is almost universal in these types of filter in power generation applications.

Fibreglass fabric filters has played a large part in the collection of fly ash in the utility boilers in The United States of America. These fabric filters have been developed over a large number of years to increase the life of bags using such devices as sonic horns for cleaning. The result is that operation life of the filter bags has been extended to over 10 service years.

The low air to cloth ratio of these fabric filters means that they are large with large cloth area used to ensure efficient filter operation. Very few fabric filters of this type have been installed in recent years in any power station. There are no utility boilers in Australia using this technology.

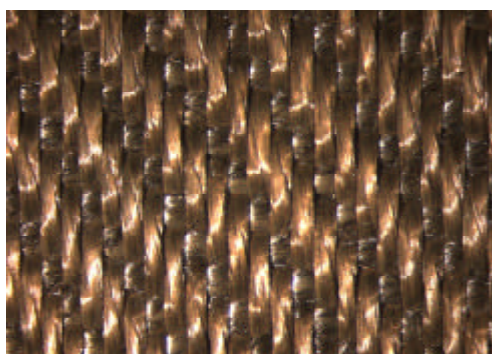


Figure 3. Woven Glass Fabric

Table 3 Typical Glass Fabric Specification

Fibre	Fibre Glass
Weave	3 x 1 Twill
Warp yarns	Multifilament
Weft Yarns	Multifilament - air texturized
Fabric Weight	470 g/m ²
Operating Temperature	260°C
Fabric Finish	Silicon/Graphite/Teflon

MECHANICAL SHAKE/DEFLATE FABRIC FILTERS

During the early 1980's three large power stations were built in Australia with all three stations using fabric filters with mechanical shake/deflate technology. The fabric chosen for the start up operations was woven Homopolymer PAN using identical fabric specification at all three stations.

Since start up, the operation of the station and the variation in fuel parameters from station to station has entailed the changing of the fabric specification to suit the different flue gas conditions. There is a range of fabric specifications which include blends of fibre in the yarns and foam coated fabric. Table 4 gives one variation of fabric used. Figure 4 depicts a foam coated surface used at two of the stations.

The variation in power station parameters also means that there is a range of filter bag operating life from station to station. This life ranges from 30,000 to 65,000 service hours. This extended life was evident in well maintained fabric filters.

No new mechanical shake/deflate fabric filters have been installed since these initial three power stations.

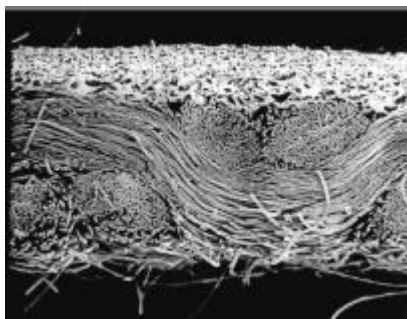


Figure 4 Woven PAN Filter Cloth

Table 4 - Typical Woven Filter Fabric for Mechanical Shake Filters

Fibre	PAN
Fibre Size	2.2 Dtex
Weave Pattern	2 x 2 Twill
Fabric Weight	375 g/m ²
Fabric Thickness	1.2 mm
Air Permeability	9 m ³ /m ² /minute @ 125 Pa Pressure
Fabric Finish	Heat set / singed/ Foam coated surface

REVERSE PULSE JET FABRIC FILTERS.

Although Pulse Jet Fabric Filters have been used for many years in many applications, the use in utility power stations has only begun to increase over the last 20 years. Initially used in retrofitting projects, a number of large power stations were also built in South Africa.

Initially all power station applications used fabric using Homopolymer Acrylic (PAN) fibre. As PPS fibre became available commercially and its performance was accepted, more fabric filters were installed using this fibre.

The increased temperature resistance of the fibre has the affect of eliminating the requirement for air attemperation. This permits lower cloth area compared to a fabric filter using PAN fabric. This is particularly important when converting an Electrostatic Precipitator shell to a fabric filter and space is at a premium.

There has also been a trend of converting earlier fabric filters from PAN fibre to PPS fibre.

Almost all of fabric filters installed on pulse jet filters in Utility boilers are using PPS fibres, whether they are new installations or retrofitted applications. The typical fabric specification for a needled fabric is outlined in Table 5.

The fabric is comprises a woven scrim, fibre web, mechanically entangled. The web equally distributed on each side of the scrim. There will usually be some type of fabric surface finish utilised.(Fig. 5)

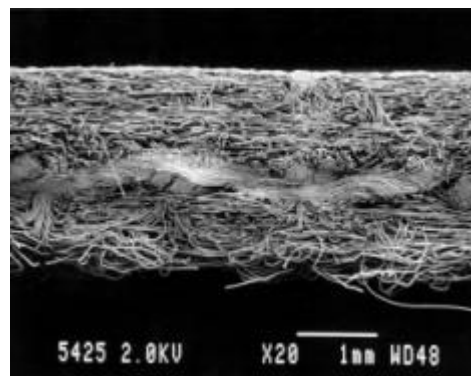


Figure 5 Needled fabric

Table 5 Typical Needled Fabric Specification

Fibre Type	PPS
Fibre Size	2.2 Dtex
Fabric Weight	600 g/m ²
Fabric Thickness	2 - 2.5 mm
Fabric Scrim (Base)	Woven PPS
Air Permeability	10 m ³ /m ² /minute @ 125 Pa Pressure
Fabric Finish	Heat set/ surface treatment

Fabric Finishes

As more power stations with fabric filters have come on line it has become obvious that performance parameters required for the fabric filter varies widely. To facilitate the variations in the gas stream and the properties of the dust cake collected various surface treatments have evolved.

- i Untreated surface (fig. 5)
Used to improved dust collection efficiency when fine dust is being collected
- ii Singed surface (fig. 6)
Used to increase dust cake release properties if the dust cake tends to be adhesive.
- iii Foam coating (fig. 7)
Used to increase dust collection efficiency and maintain lower pressure differential across the fabric filter.
- iv PTFE Membrane (fig. 8)
Used for applications where good cake release is required when collecting very adhesive dusts.
- v PTFE impregnation (fig. 9)
This finish has been proven to increase the chemical resistance of the fabric. This finish also helps also to improve cake release.
- vi Web Caps.
Using fine fibres or fibres with varying cross sections (that provide increased surface areas) on the surface has been proven to increase the filtration efficiency of the fabric. Commonly used are fine PPS fibres. Also being used are trilobal P84 fibres.

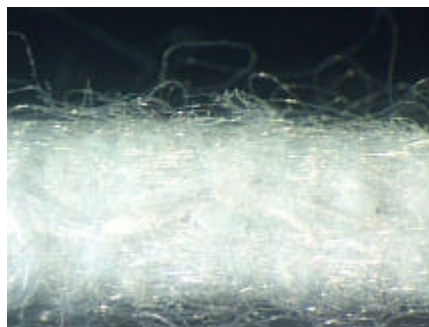


Figure 5 - Needled Fabric with untreated surface

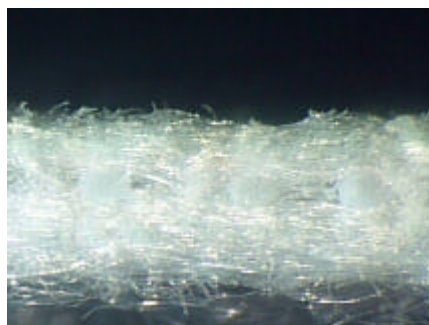


Figure 6 Needled Fabric with Singed surface

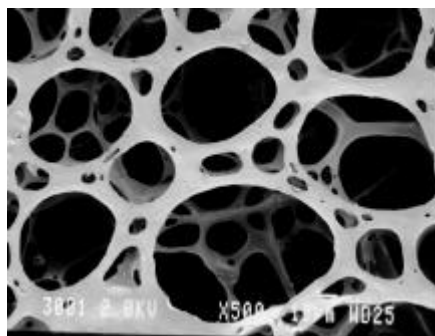


Figure 7 Foam Coated Filtration Surface

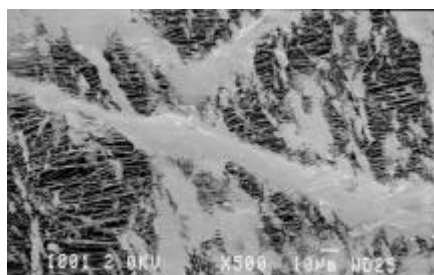


Figure 8 PTFE Membrane



Figure 9 PTFE Impregnation

Future Developments

There will continue to be an increase in the use of fabric filters in the power generation industry. There will also necessarily be a wider range of different coal types used. As has already been established every power station has slightly different fly ash characteristics which means that fabrics will have to be developed to handle these changes.

New fibre polymers and fabric finishes are being investigated to address the expanding requirements for fabric filters.

Alternate technologies such as Star Bags which increase available filtering area are also being introduced.

Star Bags™

Star-Bag™ and Star Cage™ designs were developed to provide the end user with an opportunity to increase available fabric filtering area within the same given footprint occupied by traditional cylindrical and oval filter bags. The Star-Bag™ is designed to offer between 1.7 to 2.4 times traditional filter surface area. This additional area is obtained by sewing the

filter bag in a pleated configuration. The pleats are gathered at the top snap band so that the bag may fit in the same cell plate hole as the standard bag of the same top diameter. The pleats are retained during pulse cleaning cycles by a series of horizontal bands sewn to the fabric.

The Star-Bag™ is not a cartridge filter and does not have the technical and performance limitations imposed by cartridge filter elements such as length and dust loading, and no standard robust filtering media.

The Star-Bag™ is used with a matching design Star-Cage™. These are manufactured using a series of rays to replace the conventional cylindrical bag cage. The rays are formed, using sets of two longitudinal wires. The spacing of these longitudinal wires has been optimised to prevent closing off of the pleats when under negative pressure and allow for maximum surface area gain. The cages are manufactured without traditional horizontal wires, normally exposed to the filter bag, thus reducing wear on the fabric. The top of the Star-Cage™ can be manufactured to match most existing tube sheet and/or venturi configurations.

Aside from additional filter surface area available, the Star-Bag™/Star-Cage™ combination offers other benefits. Improved dust cake release characteristics have been observed due to the increased flex motion of the filter media during pulse cleaning. A broader distribution of dust cake over a greater filtration area provides dramatically reduced air and dust velocity at the face of the filter, yielding lower particulate emissions and a significant reduction in pulse frequency. The substantial decrease in the inner volume of the Star-Bag™ can allow up to 50% reduction in the quantity of compressed air required, at lower pressure, for media cleaning in some applications.



Figure 10 Star Bag/Star Cage Installation

CONCLUSION

The use of fabric filters in power stations will continue to increase in the future. There is a continuing trend to use Pulse Jet cleaning with PPS needle felt.

Fabrics have been developed to suit variable power station operation, coal analysis and filtration equipment design parameters. The fabrics have been to meet emission limits, give extended life and be cost effective over the life time of the power station.

New fibre, fabrics and technologies will continue to be developed to meet future emission limits and operating requirements.