

FABRIC FILTER OPTIMIZATION IN CARBON BLACK

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INTRODUCTION

Within the carbon black industry, there is a trend toward consolidation within the major consuming industries. At the same time, there are continued mergers and acquisitions by carbon black producers. There is also a strong management push to adopt “best practices” for manufacturing processes.

The largest single use for carbon black continues to be for reinforcement in tires. In a recent report,¹ Mr. Reg Adams, Managing Director - Artikol, Ltd., estimated that 60% of tires sold globally are produced by six companies. This type of consolidation is also found within the carbon black industry. The top three carbon black producers accounted for 40% of the global capacity in 1998. The top 10 producers owned approximately 65% of the global capacity as shown in Figure 1.

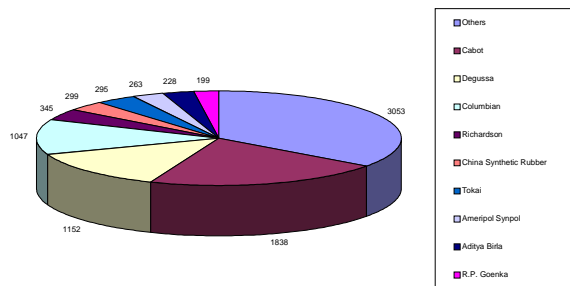


Figure 1: End-1998 Capacity by Owner Company (source: ARTIKOL for Intertech Carbon Black Conference, Padova, Mar. 1999)

Mr. Adams also predicts a 10+% increase in carbon black consumption by 2005. One geographic area that has seen significant growth in carbon black consumption and production over the past 30 years is the Asia/Pacific Region. Aditya Birla, Ltd., with headquarters in India, controls close to 5% of the global carbon black capacity.

Aditya Birla has recognized the trend of increasing consumption within the Asia/Pacific Region and understands the challenges facing today’s carbon black industry. Aditya Birla has taken steps to grow profitably through mergers, acquisitions, and through improved capacity utilization.

It is the purpose of this paper to describe a recent joint initiative taken by Aditya Birla’s Thai Carbon plant in Thailand and W. L. Gore & Associates, Inc. to optimize the purge gas filter and main bag filter processes. The goal of this project was to increase production by improving the airflow through the units.

CARBON BLACK MANUFACTURING

As shown in Attachment 1, the typical carbon black manufacturing process is complex and involves many steps. This is both a labor and capital intensive process. There are at least three important areas in the production of carbon black:

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- 1) Raw materials: The majority of carbon black produced today is made using the oil furnace process. This process is based on the incomplete combustion of oils.
- 2) Reactor vessel linings: The combustion process occurs in refractory lined vessels. This is a high temperature and chemically corrosive application. The refractory linings must be replaced on a regular basis.
- 3) Filtration and housekeeping filters: Carbon black is produced, sized, and conveyed in a powder form. Dust collectors (baghouses) are used to efficiently collect the carbon black particulate and to control fugitive emissions. These baghouses contain fabric filter bags, which need periodic replacement.

Within a carbon black plant, there are three main applications for fabric filters.

These are:

- 1) Main bag filters (MBF): The MBF is the primary filtration baghouse for a carbon black plant. The MBF is used to separate the carbon black particulate from the gas stream exiting the reactor vessel. Because it is located directly downstream from the reactor, the MBF often is a production bottleneck. Typically, a MBF will operate in the 230-260°C range.
- 2) Purge filter (PF): This can also be a bottleneck in the manufacturing process. The PF receives the off-gas from the pelletizing dryer and may limit dryer capacity.
- 3) Miscellaneous filters: Once the carbon black is collected in the MBF, it is conveyed pneumatically and/or mechanically throughout the plant. A carbon black facility will have a number of smaller fabric filter baghouses to vent

these processes and control fugitive emissions.

FILTRATION TYPES

Conventional Filtration: Historically, all of the above applications have used conventional (non-membrane) fabric filters. There have been many advancements made in conventional filtration technology, including the use of texturized fibers, surface coatings, and felts layered with micro-denier fibers. However, as shown in Figure 2, all of these still rely on a two-step filtration process. In the first step, the dust must build up between the interstices of the woven fabric or felt. Formation of this primary cake is often referred to as “seasoning” and is accompanied by an increase in filter resistance (pressure drop). During the seasoning period, emissions can occur.

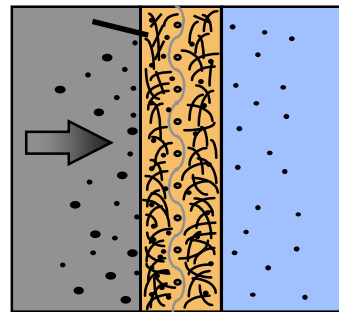


Figure 2: Conventional Filtration

Once the seasoning has been completed, the dust particulate begins to build up on the filter surface (secondary cake). This secondary dust cake enhances the filtration efficiency of the filter, but it also contributes to increasing pressure drop and reduced airflow in the baghouse. The amount and rate of pressure drop increase depends on the filter’s ability to release the cake. Over time, the high pressure drop and emissions are a major reason for filter replacement.

Membrane Filtration: Recently, the carbon black industry looked toward

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membrane (surface filtration) to improve baghouse performance. First introduced by W. L. Gore & Associates, Inc. in 1975 as GORE-TEX® Filtration Products, surface filtration uses a microporous expanded polytetrafluoroethylene (ePTFE) membrane for filtration. The ePTFE membrane is laminated to a fabric or felt backing material as shown in Figure 3. The membrane serves as the primary filtration layer. There is no need to season the filter since the membrane is efficient from start-up. The fabric serves as a support layer and does not provide any filtration. The ePTFE membrane is the primary filtration layer.

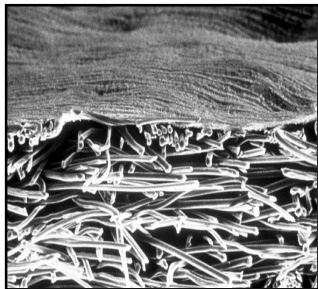


Figure 3: Cross-section of filtration media showing the ePTFE membrane and backing.

There are several benefits associated with membrane filtration, including: 1) lower baghouse pressure drop from improved dust cake release, 2) improved process reliability due to a more stable pressure drop, and 3) increased efficiency, even in the submicron particle size range. The benefits of lower and more stable pressure drop are illustrated in Figure 4.

Initially, a conventional fabric filter material will have a lower pressure drop compared to an ePTFE membrane filter. As the conventional filter develops the primary and secondary cake, the pressure drop increases. This is the result of dust building up inside the filter and incomplete release of the secondary cake during cleaning. Over time, the pressure drop increases to a point where

the process cannot be run efficiently and the filters must be changed.

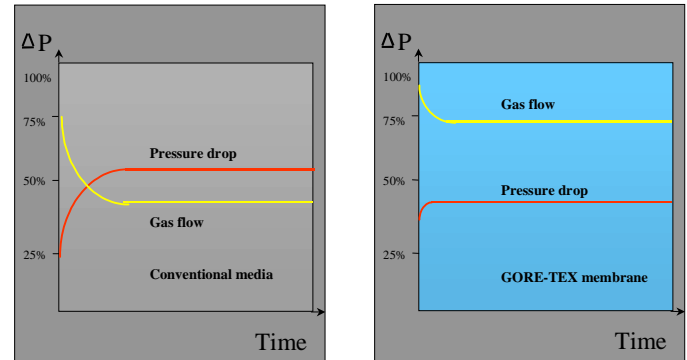


Figure 4: Pressure drop over time for conventional and ePTFE membrane filtration products.

Using membrane filtration, the initial pressure drop only increases slightly due to incomplete dust release. Because the membrane is a permanent filtration surface, the pressure drop remains more constant and stable over a longer period of time.

Membrane Improvements: Just as there have been improvements to conventional filters, there have been advances in membrane filtration as well. One of the most important characteristics of membrane filtration is durability. Durability can be defined as the ability of the membrane to resist mechanical damage over time.

Membrane damage can occur during filter assembly and installation. Precautionary steps taken during manufacturing and installation can reduce the extent of this type of damage. These steps can be as simple as covering any rough surfaces in and around the baghouse. Using an installation sleeve in top load style collectors can prevent membrane scrapes.

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The most significant cause of membrane damage is from mechanical stress during use. The amount of damage depends on the severity and frequency of the cleaning process. In general, the cleaning process in a pulse jet style baghouse is more severe than that found in a reverse air or shaker style baghouse.

Figure 5 shows ePTFE membrane laminated to a felt backer. These photos show a membrane crack. This type of damage will reduce the filter's ability to capture and release dust. As a result, filter performance degrades with symptoms such as increased emissions, higher pressure drop, increased dust-to-fiber mechanical wear and, ultimately, bag failure.

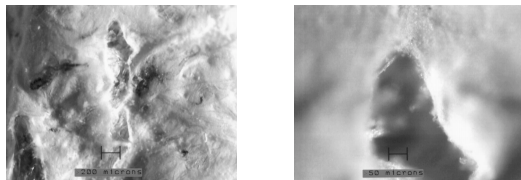


Figure 5: Photographs showing membrane cracking (16 months service)

To address this issue, W. L. Gore & Associates, Inc. developed a new family of ePTFE membranes. These patented membranes provide a much more durable filtration surface while delivering similar airflow and efficiency compared to previous membranes.

The unique properties of these membranes include increased strength and higher airflow. Figure 6 shows the membrane permeability versus strength for several membrane groups. Series A (lower left) represents some of the earliest membranes developed for industrial filtration while series D shows some of the newest membranes. Note that the new membranes have more than double the burst strength of

the oldest membranes at the same permeability.

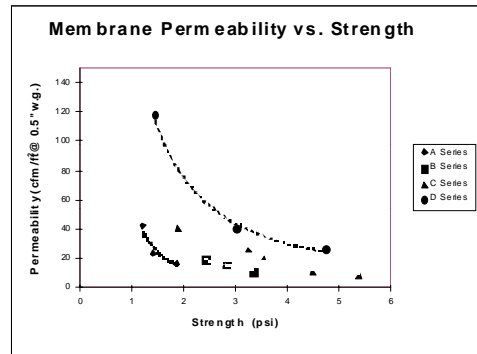


Figure 6: Comparison of permeability vs. strength for ePTFE membranes

These membranes are more resistant to membrane damage resulting from manufacturing, installation, and use. To confirm the laboratory testing, a baghouse trial was initiated. Test filter bags using an older generation membrane were installed alongside filter bags with the new higher strength membranes. All test bags used 14 oz/yd² aramid felt as the backing material.

Test bags were removed after six months and nine months. Photographs of these samples are shown in Figure 7. Due to the opaqueness of the aramid felt, backlighting of the samples was used. The photographs show the backside of the filter. The samples on the left use the older generation membrane and the samples on the right have the new membrane. The dark spots correspond to areas of membrane damage where the dust has penetrated the filter. Note the reduction in bleed-through seen on the new filters.

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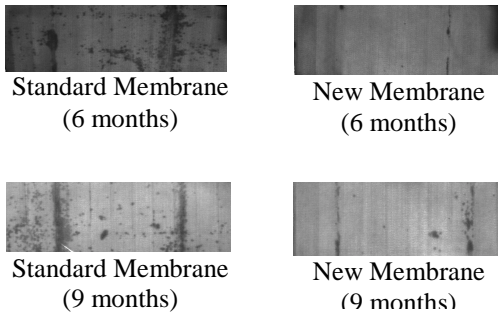


Figure 7: Photographs of the backsides of used filters showing dust bleed-through from membrane damage

CASE HISTORY

Aditya Birla's Thai Carbon operates a 150,000 TPY oil furnace carbon black plant in Angthong, Thailand. The plant managers set a goal to de-bottleneck the manufacturing process and boost the operational efficiency of the plant.

After initial discussions during late 1998, Thai Carbon elected to de-bottleneck the purge gas filters incorporating suggestions from W. L. Gore & Associates, Inc. The goal of the program was to increase throughput. This effort was followed up in 1999 with a decision to de-bottleneck the main bag filter.

Gore suggested to Thai Carbon that GORE-TEX® filters should be used. Over 15 years of experience in carbon black applications have shown Gore that special membranes are required. Carbon black is very fine with a significant portion in the submicron size range. In addition, it can be fluid so the particles will find any leak path through the filter where the membrane is damaged.

Purge gas filter: In late 1998, the purge gas filter baghouses were equipped with conventional bags, the use of which was identified by the plant managers as a production bottleneck. The initial plan was to add capacity by increasing the size of the

baghouse with an expected investment of approximately \$150,000 USD. Because of the size of the investment, Thai Carbon sought alternative proposals. One of these alternatives was a proposal from Gore to replace the conventional filter bags with GORE-TEX® membrane bags (10 oz. acid resistant fiberglass fabric).

After considering the proposal from Gore, the decision was made to install the membrane filter bags. The goal was increased airflow and reduced pressure drop. In February of 1999, GORE-TEX® filter bags were installed in the Line #1 purge gas filter. When the Line #2 purge gas filter needed replacement in June of 2000, GORE-TEX filter bags were again used. These are reverse air style baghouses.

As the data in Figures 8 and 9 show, the new filter bags delivered: 1) a 25% increase in airflow, 2) >10% increase in production, 3) reduced pressure drop, and 4) increased life expectancy. The net result was a significant reduction in the identified bottleneck.

Line #1 PGF	Units	Conventional filters	GORE-TEX filters
Airflow	NM ³ /Hr.	10,000	12,500
Production rate (N330)	Mt/day	107	120
Max. pressure (dirty side)	Mm of H ₂ O	325	220
Bag life	Months	12	20+

Figure 8: Line #1 purge gas filter comparison showing advantages of GORE-TEX filters

Line #2 PGF	Units	Conventional filters	GORE-TEX filters
Airflow	NM ³ /Hr.	10,000	12,500
Production rate (N330)	Mt/day	100	110
Max. pressure (dirty side)	Mm of H ₂ O	300	200
Bag life	Months	12	12+

Figure 9: Line #2 purge gas filter comparison showing advantages of GORE-TEX filters

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Main gas filter: Thai Carbon had been using conventional fiberglass fabric filters with a PTFE dispersion coating. The bags in this reverse air style baghouse were routinely replaced after 17-18 months, but Thai Carbon noticed increased pressure drop and reduced throughput at 12 months. After evaluating the baghouse operation, Gore suggested an upgrade to the new GORE-TEX® High Durability filter (10 oz. acid resistant fiberglass fabric). These were newly available at the time and provided increased resistance to membrane damage. Additionally, Gore recommended the use of a fiberglass fabric with an acid resistant treatment. While the conventional bags were not failing due to chemical attack, it was believed that the increased life expected from the membrane bags could make chemical attack a limiting factor. The acid resistant treatment was selected over the standard PTFE dispersion treatment due to its greater durability in use. Unlike the PTFE dispersion treatment, the acid resistant finish is covalently bonded to the glass fiber and is more durable.

After 12-plus months of operation, the GORE-TEX HIGH DURABILITY filters are exceeding the expectations of Thai Carbon and Gore. As the data in Figure 10 shows, the new membrane filters are providing increased gas flow and the plant has increased production through the collector.

Main bag filter	Units	Conventional filters	GORE-TEX High Durability filters
Airflow	NM ³ /Hr.	16,000	22,000
Production rate (N330)	Mt/day	100	110
Max. pressure (dirty side)	Mm of H ₂ O	250-350	100-130
Bag life	Months	18	24 (expected)

Figure 10: Main bag filter comparison showing advantages of GORE-TEX High Durability filters

More than just a filter bag:

In addition to the latest membrane filters, Gore also provided technical assistance during installation and startup. Thai Carbon needed to be sure that the filter bags would be properly installed and that the startup would proceed smoothly. This on-site support helped Thai Carbon successfully install and start-up the baghouses.

CONCLUSION

As the carbon black industry enters the 21st century, managers are faced with new challenges. Thai Carbon has elected to proactively address the new demanding market conditions. One project has been the optimization of the purge and main bag filter performance.

Through a joint effort with W. L. Gore & Associates, Inc., Thai Carbon has upgraded from conventional filters to state-of-the-art membrane filters. By incorporating a combination of GORE-TEX membrane filters and process improvements, Thai Carbon's baghouses are now operating at higher efficiency and lower pressure drop. In addition, bag life has been increased.

REFERENCES

1. "Global Carbon Black Consumption Trends," Carbon Black World '99, Reg Adams, Presented April 1999, p.9.

®GORE-TEX is a registered trademark of W. L. Gore & Associates, Inc.

Attachment

