TRACKING LOWER TCO

Chris Polizzi, W.L. Gore & Associates Inc., details the pursuit of a lower total cost of ownership at a large kiln baghouse.

Introduction

A newly innovated low drag filter media from W.L. Gore was demonstrated at a US cement plant over a period of 1.5 years. Its performance was evaluated and compared with the existing filter media and newly-installed standard membrane filters from two suppliers. The project aimed not only to increase the overall performance of the main kiln baghouse, while ensuring environmental requirements were met, but also to demonstrate the potential for the new filter bags to significantly decrease the baghouse total cost of ownership (TCO).

This article outlines the demonstration plan and performance data, which proves that the GORE® LOW DRAG™ filter bags exceeded initial performance expectations.

Background

The cement plant in question has an excellent environmental record, winning an environmental award from the Portland Cement Association for its achievements. Built in 2003, the 2.2 million tpy plant makes extensive use of alternative raw materials and fuels, including hazardous liquid waste, recycling more than 0.4 million t of materials in a typical year.

The plant controls particulate matter (PM) emissions from the pyroprocess line and the vertical roller mill by operating a large reverse air baghouse equipped with 14 individual compartments of filter bags, each measuring 298 mm dia. and over 10.5 m in length. Each of the 14 compartments houses 336 filters for a total of 4704 filter bags, equating to 46 000 m^2 of filter media. The baghouse is responsible for cleaning 1.513 million actual cubic meters of air per hour (acm/hour) (Figure 1).

The plant has utilised polytetrafluoroethylene (PTFE) membrane filter bags in the baghouse and typically achieves a 5 year bag life. The membrane is laminated to a fiberglass fabric and the laminate is sewn into the geometry of a typical reverse air filter bag with anti-collapse rings. The filters are fitted over thimbles and clamped into place in the baghouse.

Figure 1. The reverse air baghouse cleans at a rate of 1.513 million acm/hour.

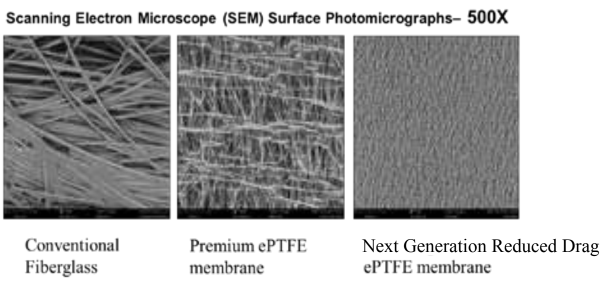

Figure 2. Scanning electron microscope surface photomicrographs showing the structure of different filter media.

PTFE membrane filter bags have many advantages over non-membrane filter bags. The PTFE membrane surface provides filtration efficiency, while ensuring the PM does not become embedded in the support material or substrate. By keeping the PM out of the substrate, the filters often last significantly longer. Additionally, PTFE membrane filters are highly efficient and can capture significant amounts of dust, maintaining that efficiency into the sub-micron dust range. Along with the benefit of longer life and improved environmental performance, PTFE membrane filters generally operate with a lower and more stable differential pressure than non-membrane filter bags. It is for these reasons that much of the cement industry uses PTFE membrane filters as their standard choice of filter media.

Though it is much less marked in membrane filters than in non-membrane filter bags, it is true to say that there is a seasoning effect over the lifetime of a membrane filter bag. Typically, the filter cleaning cycle must increase over time in order to maintain a consistent flange-to-flange differential pressure, which subsequently increases operating costs and, eventually, damages the membrane structure. In an effort to avoid these pitfalls, W.L. Gore designed a new type of membrane filter bag that provides consistently lower filter drag over the entire service life of the bag. In late 2016, the plant agreed to a demonstration project to see how this could impact total cost of ownership (TCO).

The definition of filter drag

Filter drag is the total resistance of the filter media and the dust cake on the surface of the filter media. The higher the resistance, the higher the energy

$$\text{Filter Drag} = \frac{\text{Differential Pressure}}{\text{Air to Cloth Ratio}} = \frac{dP}{A/C} = \frac{\text{mm w.g.}}{\text{m}^3\ /\ \text{min} / \text{m}^2}$$

consumption of the baghouse fan and therefore the higher the cost to move the necessary kiln process airflow across the filter media.

In a baghouse, filter drag is defined as the relationship between operating differential pressure and the actual air-to-cloth ratio at which the baghouse operates:

Given this relationship, achieving lower filter drag brings with it the consequent benefit of either fan energy savings, potential increased airflow, longer filter bag life, or fewer installed filter bags. Furthermore, a plant could change the benefit it wishes to receive almost at any time to adapt to changing market dynamics.[1]

So how is lower filter drag achieved? Essentially, by keeping all the dust on the surface of the membrane and not allowing it to find its way into the internal structure over time, thereby alleviating the need for increased filter cleaning frequency. In

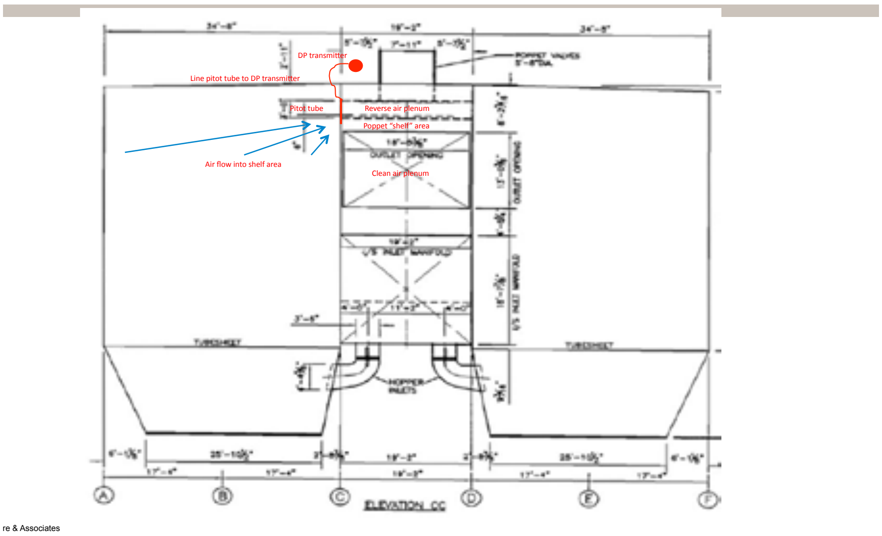

Figure 3. Monitoring plan for trial.

Compartment	Filter media type	Life to date at the beginning of the trial
Module 6	Membrane supplier 1	3 years old – standard drag
Module A	Membrane supplier 1	Brand new – standard drag
Module 8	Membrane supplier 2	Brand new – standard drag
Module 9	Membrane supplier 2	Brand new – low drag

Table 1. **The filter media type installed in each of the four demonstration modules.**

Figure 4. First set of filter drag data.

order to achieve this, an entirely new membrane structure was required (Figure 2).

W.L. Gore developed the Gore LOW DRAG filter bag to meet the needs of fume and fine powder applications. The dense membrane structure captures particulate matter on the surface and prevents penetration beyond that, thus increasing cleaning efficiency compared to standard membrane filters that reduce differential pressure and increase air flow. Cleaner bags require fewer cleaning cycles, resulting in less wear and longer bag life.

The demonstration and installation of monitoring equipment

In order to better understand and quantify the potential benefits of this new filter media, the cement plant set out to perform a trial comparing and contrasting different filter media options. To perform the trial, the plant selected four compartments within the 14-compartment baghouse equipped with specific filter media types and the appropriate monitoring instrumentation. For proper filter drag evaluation and comparison, the plant needed to monitor realtime airflow, temperature, and differential pressure in each of the four modules, so each of the outlets was equipped with pitot tubes and a thermocouple. Two pitot tubes per outlet were used in an effort to take into consideration any potential flow distribution variation. The general layout plan for the monitoring equipment can be seen in Figure 3.

The pitot tube total pressures and static pressure were each combined in a manifold to average the pressure and then attached to a pressure transmitter monitoring the velocity pressure. The 4 – 20 mA signal from the pressure transmitters was sent back to the plant's main control room.

The compartment differential pressure ports were also attached to a pressure transmitter. As with the pressure transmitter for velocity pressure, the 4 – 20 mA signal from the compartment differential pressure was also sent back to the main control room. The velocity pressure, along with the velocity measurement going through the known area of the compartment outlet, allows for a calculation of the actual airflow within the compartment. With 336 filters per compartment and each filter measuring 292 mm dia. x 10.5 m long, the actual air-to-cloth (a/c) ratio can be calculated and this, taken together with the compartment differential pressure as the numerator and the actual a/c ratio as the denominator, provides a figure for the actual filter drag at any moment in time from each of the individual compartments. Based on the equation, the units of filter drag are millimetres of water/cubic metre of air/minute (mm w.g./m^3/min).

The comparison of different filter media

The trial was targeted to begin during the plant's 2017 winter outage, at which point all the filters in the baghouse were 3 years into their anticipated 5 year effective filter bag life. The trial was set up to

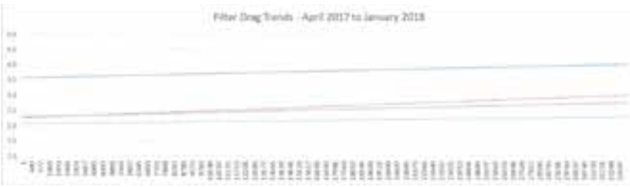

Figure 5. Filter drag trends from April 2017 – January 2018.

Figure 6. After 8 months in operation, the GORE LOW DRAG filter bags compartment is dust free.

compare four different compartments, as outlined in Table 1.

Before the trial, it was anticipated that several of the modules would require some metal fabrication and repair. In order to prepare optimally for the baghouse filter media trial, the three modules that would be getting new bags at the start of the test (module A, 8, and 9) were stripped of old bags. These modules were then inspected for any critical thimble and structural metal repair and the repairs were made. This included some thimble replacements, access door frames, flange repairs, and repairing holes in areas of the floor and walls of the compartments.

The compartments were then swept and vacuumed before the installation of the three new compartments of filter bags. The fourth compartment, which contained the existing 3 year old filter bags, was also vacuumed to remove any and all particulate dust and rust that had accumulated on the floor of the baghouse.

Once the three different kinds of new filter bags were installed and tensioned appropriately, all four test compartments were leak checked using the fluorescent dust test. It was decided that data on velocity pressure, differential pressure, and temperature would be gathered from the test modules every 10 sec.

Before obtaining the initial set of test data, it was predicted the 3 year old membrane filters would have the highest filter drag of the four modules. Due to the normal seasoning of traditional

***Table 2.* Initial filter drag data (gathered during the first month of the demonstration).**

Compartment	Filter media type	Life to date at the beginning of the trial	Trendline	Filter drag during the initial part of the test (in. water/ft/min)
Module 6	Membrane supplier 1	3 years old – standard drag	Blue	3.6
Module A	Membrane supplier 1	Brand new – standard drag	Purple	2.2
Module 8	Membrane supplier 2	Brand new – standard drag	Red	2.1
Module 9	Membrane supplier 2	Brand new – low drag	Green	1.9

***Table 3.* Filter drag data during the last two weeks of December 2017.**

Compartment	Filter media type	8 months into trial	Trendline	Filter drag during the last two weeks of December 2017 (in. water/ft/min.)
Module 6	Membrane supplier 1	3 years – 8 month old standard drag	Blue	4.0
Module A	Membrane supplier 1	8 month old – standard drag	Purple	2.7
Module 8	Membrane supplier 2	8 month old – standard drag	Red	2.8
Module 9	Membrane supplier 2	8 month old – low drag	Green	2.1

PTFE membrane filter bags throughout their life, this seemed like a reasonable expectation. This normal seasoning occurs in part due to the pore size of traditional PTFE membrane filters, relative to the particulate size of the smaller fraction of baghouse dust filtered in cement kiln baghouses. It was believed the two new compartments of filters with standard drag filters from suppliers 1 and 2 would be lower and likely in the same range, as one another as they were purchased from longstanding global credible filter suppliers. Lastly, it was theorised that, due to a radically new membrane structure optimised for a low-resistance/high-efficiency balance, the GORE LOW DRAG filter bags would start with the lowest filter drag.

The demonstration start-up and data collection

The plant started up following the 2017 winter outage, during which the new modules of test filter media and the monitoring equipment were installed. The early trial data proved to be consistent with the predictions of how each of the filter media would perform. Shortly after the plant was up and running, the first set of filter drag data was collected from the plant's central data acquisition system. This data is plotted in Figure 4 and the initial filter drag values can be seen in Table 2.

As expected, the 3 year old membrane filters from filter bag supplier 1 were operating with the highest filter drag. The brand new standard drag membrane filters performed significantly better, but the brand new GORE LOW DRAG filter bags displayed the lowest filter drag.

Data analysis

With the data acquisition frequency set for 10 sec. intervals, a huge data set was developed over the course of the trial. As shown in Figure 5, the existing membrane filter bags had the highest filter drag, trended upward, and maintained the highest filter drag over the entire time period. The brand new standard drag filter bags from Supplier 1 and Supplier 2 also both trended upward over the 9.5-month timeframe. Meanwhile, the brand new GORE LOW DRAG filter bags maintained a relatively flat filter drag.

During the plant's 2018 winter shutdown, the compartments were inspected visually from the clean side. The inspection of module 9, with the GORE LOW DRAG filter bags installed, revealed the compartment was free of dust (Figure 6).

Conclusion

Eight months into the trial, the GORE LOW DRAG filter bags were operating with a 22% and 25% lower filter drag than the 8 month old standard drag membrane filters and 48% lower than the 3 year, 8 month old standard filter drag filters. Given the filter drag trends observed during the demonstration, along with the membrane properties of all of the filters, it is expected the filter drag differences will continue to improve over time.

Based on the 1.513 million acm/hr the baghouse fan is moving, the data suggests there would be a significant reduction in fan energy requirements through the use of the GORE LOW DRAG filter bags. The 48% reduction in filter drag would allow the inlet static pressure of the fan to be reduced by 2.5 in. water gauge, while maintaining the current airflow. This would create an annual saving of US$174 000, based on the plant's current average electricity costs, thanks to the reduction in fan static pressure. In addition, the lifetime of the GORE LOW DRAG filter bags is expected to be significantly longer because they do not experience the same seasoning effect as the standard membrane filter bags. Longer lifetime and reduced operating costs equate to an impressive reduction in TCO, proving the value of such an investment.

Acknowledgment

The author gratefully acknowledges Jeannette Williams and Louis Raath for their work on the original version of this document.

References

1. POLIZZI, C., 'Knowing your TCO', *World Cement*, Vol. 49, No. 2 (February 2018), pp. 45 – 49.

About the author

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