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A Fact Finding Mission

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Introduction

Filter bags, no matter which type, have to work for a certain time before being replaced. Typically, a new set has some lifetime warranty provided by the supplier to underline the certainty they will at least work during a defined period. The minimum life span is approximately 4 years and in some cases more than that. Everything below this limit is going to be ineffective from a cost perspective. Various measures are taken to reach this target. The first is to chose the right bag material, matching the gas and operation conditions, second is to optimise the process to allow the fabric to optimally operate i.e. plant set up, by-passing and emergency flaps.

Bag failures

Occasionally it happens that the selected bag material did not perform as expected or some unfavourable plant conditions ended its bag life prematurely.

In this case the supply chain is prepared to help and assist in resolving the problems or to at least find out by bag analysis what happened to the system to reduce the chances of the incident re-occurring in the future.

Typical failure patterns are clogging and blinding caused by dew point crossings, chemical deterioration of the base fibre material by acid or hydrolytic attack (from sulphuric acid and moisture being present in the flue gas, or moist pulsing air), thermal overstressing and not too seldom mechanical damage by incorrect pulsing cycles, pulse air pressure and bent cages.

The verification of such damage is a tedious process, which begins with the damaged bag being sampled, followed by collecting data about flue gas conditions (in normal operation, but also during upset conditions) and very often a bag house inspection and flue gas analysis.

Inspec Fibres provides these services as well as routine analysis to determine the remaining life of P84 polyimide and Procon PPS bags used in various applications.

Examination

Once a bag sample has been taken, the examination begins with a simple macroscopic analysis. The first view very often provides a basic idea of what caused the problem. This is then followed by a set of laboratory analyses to determine the degree of damage and ensure the unit continues to operate.

When the bag is received, it is slit to inspect the inside and outside for discoloration and/or mechanical damage such as holes or rips. This procedure also shows if there is dust on the clean gas side caused by damage or if there was some bleed through occurring (which could be caused by over pulsing or wrong air to cloth ratio for a certain application). Furthermore, discoloration spots would be detected easily since there is

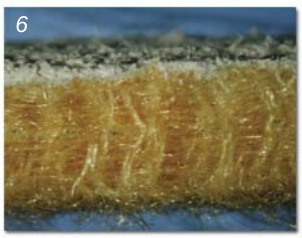


Figure 1 (top left). Pulled bags.

Figure 2 (bottom left). Smoke at the stack.

Figure 3 (bottom left). Slit bag as received at the lab.

Figure 4 (top right). Top end with dust inside.

Figure 5 (bottom centre). Broken glass bag.

Figure 6 (bottom right). Typical cross-section of used bag.

Cement installations (kiln/raw mill) with P84 filter bags

Location	Reference	Fuels	Filter area (m^3)	Air to cloth ratio (m/min)	Fabric	Operating temp (°C)	Peak temp (°C)	Moisture content (Vol. %)
US	Cement clinker cooler	---	---	---	P84	177 - 204	220	---
France	Cement	Natural gas	3210	1.43	P84/P84 P84/PTFE	180	250	11
France	Cement dryer	Natural gas	962	1.11	P84/P84	160	260	15 - 18
France	Cement raw mill /kiln	Coal	13 290	1.00	P84/Hybride	100 - 120	240	17.8
Europe	Cement kiln	---	1134	---	P84/PTFE	200	240	---
Norway	Cement raw mill/kiln	Coal and sec. fuels	8600	1.37	P84/Hybride	120	250	14 - 20
Korea	Cement raw mill/kiln	Coal	3275	1.35	P84/P84	130-160	260	7 - 9
Korea	Cement kiln/dryer	Coal	3275	1.35	P84/P84	160 - 180	260	7 - 9

typically no dust inside the bag.

Signs of contamination are the first hints of a problem in the dust collector unit. Leakages caused by misfits, bad welding, leaking bypasses as well as broken bags could have caused dust to form inside the bag. The result will be increased differential pressure and emission values, which can be hard to overcome.

Samples very clearly show what happened to the unit and if the problem is serious. Very often it also indicates incorrect operating conditions, mechanical damage or the first signs of the wrong bag material being used.

The next stage is a cross-section microscopic analysis to see the degree of dust penetration, indicating remaining filtration capabilities. This is then followed by air permeability tests in all three fabric stages, dust laden, pulsed and washed out.

All this information forms part of the bag analysis report, which details exactly what happened 'dust wise' to the fabric.

A good indication of a bag's remaining life, is the mechanical test for tensile strength and elongation as well as tear strength and Mullen Burst. Compared to the original values a good estimation of the degree of deterioration can be achieved.

What goes much deeper than all the optical verification and mechanical testing is the chemical analysis of the sample. These methods determine the chemical or thermal cause of a problem and very often the degree of degradation as well as predictions for the remaining lifetime. Various methods are used. The remaining solubility of the polymer indicates thermal stresses, the inherent viscosity (measure of the chain length of the polymer) is followed by Fourier Transmission Infrared (FTIR) analysis and hydrazinolysis via High Pressure Liquid Chromatography (HPLC) to accurately visualise the problem.

The findings are compared to laboratory standards developed over a long period of time based on field experience of Inspec Fibres out of all kinds of applications.

Optical microscopy, SEM and RFA dust analysis means that it is possible to understand the dust characteristics and composition as well as particle size distribution.

All these results are used to prepare a recommendation for enhanced filter unit operation or changes to other bag materials to avoid future problems.

Field gas tests

Bag analysis alone is not sufficient to determine the cause or resolve a problem. In this case a field gas test is the next step. A modern mobile gas analyser is used to collect information about the gas composition, specifically with regards to SO_2, SO_3, O_2, CO, NOx and NO_2 contents and the temperature profile.

Inspec Fibres carries out tests on request from operators and conducts gas analyses all over the world, but mostly across Europe.

This is quite a challenge because the set up must enable testing to be carried out during standard and very often upset plant operation. The result of a field test is a composition profile over 12 to 24 h showing all relevant data and peaks to determine the 'real' life

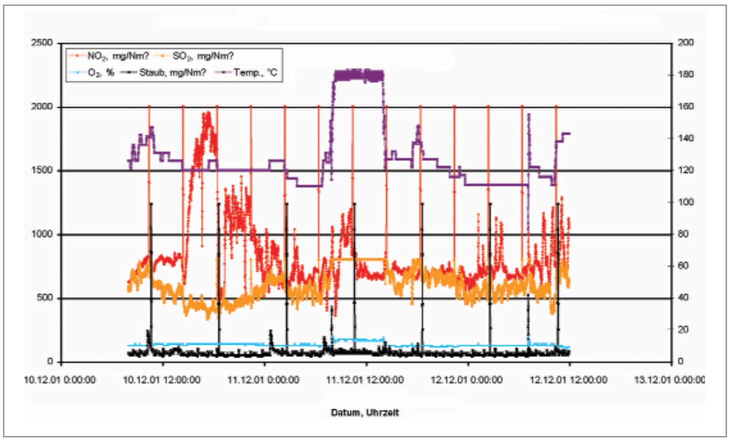


Figure 7. HPLC curves of used vs. new P84 bags.

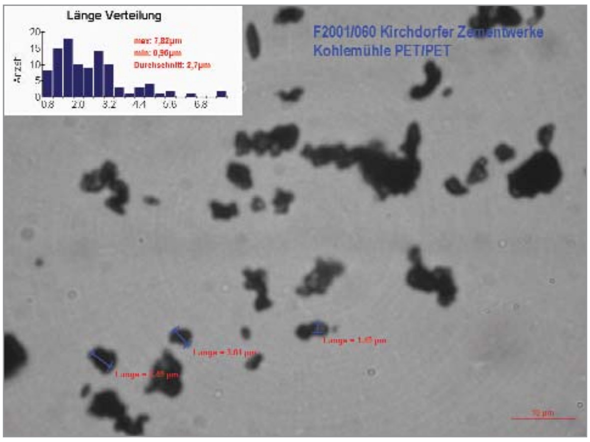


Figure 8. Particle size scan.

Figure 9. Baghouse inspection.

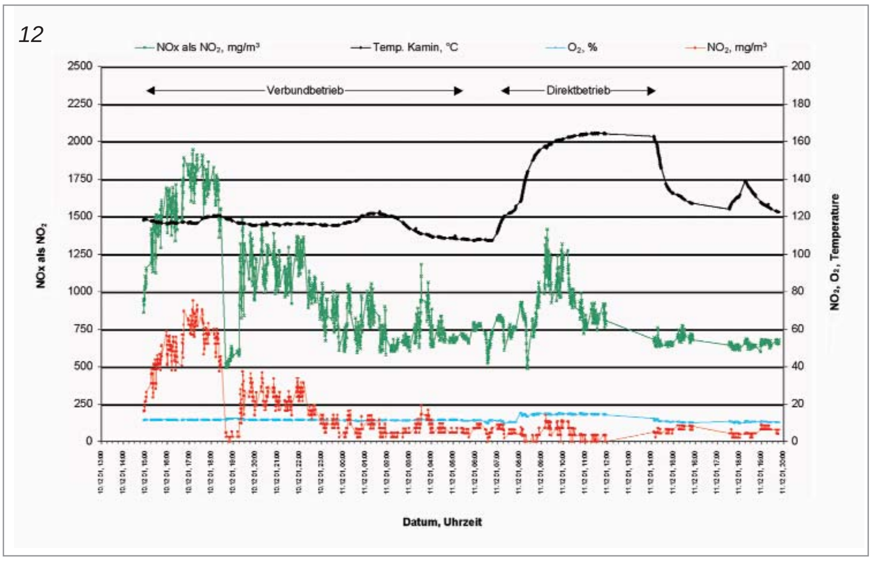
Figure 10. Gas testing in a cement plant.

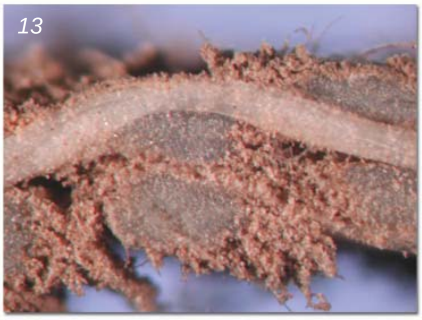
Figure 11. Stack probe connected to the unit.

Figure 12. A dry kiln in direct and compound operation.

Figure 13. Dust migration through the glass fabric.

Figure 14. Delaminated membrane.





condition that the fabric has to survive.

Figure 12 shows a typical diagram for a cement plant with a dry kiln in direct and compound operation.

Once this has taken place, a relatively good fingerprint of the whole situation has been completed and a clear picture of why the problem has occurred can be drawn.

All this research is for the use of needle felted or woven filter fabrics made of polyester, PAN, m-aramides, PPS or P84. The whole situation changes when it comes to woven glass bags with PTFE membranes. Their failure patterns differ a lot as well as the sensibility of the fabrics, which are different to synthetic fibre materials.

The main problem lies in the mechanical sensibility due to the brittleness of the glass backing fabric and the extremely thin e-PTFE layer on the filtration side.

Failure indications are typically either increased dust emissions, which is a sign of broken bags, or a differential pressure increase caused by blinding and chicken effects (dust deposition behind the membrane). Delamination and particular membrane damage on the surface allow such problems to arise. The cause is rarely chemical deterioration. In most cases the mechanical burden is responsible for the premature failure and therefore the bag analysis is reduced to microscopic examination of the surface and the cross-section of the bags as well as remaining air permeability. Problems are overcome by changing to less sensitive needle felted materials, reduction of the air to cloth ratio, increased number of cage wires or cyclones upstream of the bag unit to reduce dust burden and abrasion.

Conclusion

However, these tests are performed after difficulties have occurred. As no one in the industry wants to run into all these problems and tries to avoid them, it has become very common to make it clear that bag material provides good performance with a high probability, therefore tests should not be needed. Downtime is the last thing operators are interested in and emission regulations are tight, which means that the unit cannot be bypassed for bag changes.