Introduction
The operation of a baghouse incurs expenses for fan power, pressurised air, and bag material, as well as the costs of manpower, and those resulting from the loss of production during maintenance. The choice of bag material influences all the other costs. Nevertheless, typically, only the cost of the bags, and maybe the expected bag life, are considered in the purchase decision.

Each filter material is unique. Differences in dust properties and operating conditions require adjustment of the control system. This article will show the influence of the bag material on the operating costs in order to give the baghouse operator a better base for total cost calculation. Details of the development of the pressure drop during a filtration cycle will also be shown. The influence of changes of, for example, the cleaning set point on the filtration cycle time, will be demonstrated, and their influence on the performance of the system will be discussed.

Georg Rathwallner,
Evonik Fibres,
Austria,
quantifies the possible reductions of operating and maintenance costs available by choosing the correct filter media and adopting the right control parameters for the baghouse.

Reprinted from April 2008 WORLD CEMENT
www.worldcement.com
Baghouse costs
Figure 1 shows the operating costs for a baghouse, split into the costs of new bags, bag change and disposal, and ID fan power. The single costs are described in more detail in the rest of the article. The figures for calculation are given in Table 1. Major differences have to be considered for cement plants that have been designed and are operated differently: of the listed details, a quick adaptation to each particular system should be possible to allow a rough calculation.

Breakdown of major costs
New bags
This is the most obvious, and therefore the best evaluated, cost as it represents a large, upfront investment. In fact it is usually the second largest after fan power, if annual costs are compared. With its effect on all other operating costs, the choice of bags has to be made properly, which includes the evaluation of its effect on other costs. Good and stable filtration behaviour is necessary to ensure low and stable pressure drop, and thus low fan power. Sufficient filtration efficiency also prevents dust penetration into the felt cross-section.

Generally, after an initial period, stable behaviour, (i.e. a more or less constant residual pressure drop after cleaning), is achieved.

The upper line in Figure 1 corresponds to high temperature filter material in kilns, while the lower line corresponds to low temperature material in mill filters (e.g. polyester or poly acryl), and is identical with the upper limit considered for bag change and disposal. To compare two filter materials or for a project application, the costs of the bag change (manpower and production loss) and of the disposal of used bags has to be considered as well as the bag costs. This means that double the bag price needs considerably less than double the bag life to result in equal costs. All these costs, calculated on an annual basis, are indirectly dependent on the bag life, as well as the annual costs of the bags.

Bag disposal
The costs for bag disposal depend on available landfill or incineration facilities. The best practice is in-house incineration in the pyroprocess, but this requires according permission. If the preparation of comparable alternative fuels is available, no additional costs arise for organic bag material. In the worst case scenario, the bags have to be disposed of, and are classified as hazardous waste (e.g., in the case of co-incineration of waste in the kiln). Costs of a two-digit percentage of the price of new bags may then arise.

Manpower for bag change
It depends on the location of the plant as to whether the workforce has to be factored into the calculation. If the service is not provided externally, precautions have to be taken to ensure that sufficient manpower is available.

Fan power
The ID fan power is typically responsible for 60% of the total operating costs of a baghouse. New bags are becoming more costly, just in case high temperature filter media are used and a relatively short bag life is achieved. Fan power is more or less linearly dependent on the differential pressure of the system, which, beside the filter layout in general, is determined by the bag material and the operation of the filter.

Production loss
Kiln filters and combined filters for kiln and raw mill are critical, as the pyroprocess is affected and off times result in a loss of production.

A stoppage of a finishing (clinker) mill does not necessarily result in a production loss if it has been designed for a higher capacity than the kiln. The capacity for clinker storage needed for mill service is typically sufficient to cover the clinker produced during a bag change. However, if the finishing mill capacity is designed close to the kiln output, production loss has to be considered. It is not easy, therefore, to state a figure for production loss, as plants with low utilisation of capacity will suffer no losses as a result of shutdown for bag change.

Adjustment of the cleaning set point
A too low cleaning set point leads to over-cleaning, as insufficient dust cake is built up during a filtration cycle, with resulting penetration into the felt. This results in blocking of the bags and shorter and shorter cleaning cycles due to the increase of the residual pressure drop (measured after cleaning).

A slightly higher cleaning set point may result in stable residual pressure drop and filtration cycle time. The effect on

Reprinted from WORLD CEMENT April 2008
www.worldcement.com
Reprinted from April 2008 WORLD CEMENT
www.worldcement.com
the ID fan power is small in comparison to the achievable prolongation of the bag life (beside, the bag costs, maintenance and production loss have to be considered). If peak loads (high dust content and A/C-ratio) occur for only several hours/days, time controlled cleaning (or pressure drop controlled cleaning with a minimum cycle time) may prevent over-cleaning during this period. The right set point depends on the parameters of the individual system: i.e., A/C-ratio, particle size of the dust, agglomeration behaviour of the dust under operating conditions, bag material (fibre material, as well as air permeability, pore size distribution and coatings), and layout of the filter and cleaning system, to mention the most relevant parameters.

In Figure 2, the different behaviour of two materials under similar conditions (after accelerated ageing in testing in accordance to VDI 3926, with Al₂O₃, at an A/C-ratio of 2 m/min) is shown. The arrows mark the effect of changes of the cleaning set point to the cycle time for the P84/PTFE blend. An increase of the set point by 15% - 20% results in twice the cycle time. The PTFE felt is almost blinded and the cycle times are short, even if a high cleaning set point is considered.

**Pressurised air**

In Figure 1, the costs for pressurised air are not displayed, but would be close to the bottom line. For the initial investment in the pressurised air system, certain quality standards should be ensured. For proper operation, sufficient dehumidification of the compressed air is essential. A dew point of -40°C is more or less standard, while in sensitive applications even lower dew points are approached. Such a low dew point is necessary because, during the pulse, the compressed air expands and may cool down enough to cross the dew point when mixed with the humid gas in the filter. The result is condensation, which leads to a sticky dust cake that is difficult to release. As acidic components are normally present in the flue gas, the condensate may cause damage to bag material, as well as to the metal work.

**Case studies**

**Finishing mill**

Figure 3 shows a comparison of a polyester fine fibre felt and a polyester felt with P84 fibres blended in the filtration side. Details of felt construction and operating conditions are given in Table 2. Both filter materials were used in similar clinker grinding lines under challenging conditions. The following points should be noted:

| 1 | The blend with the multilobal polyimide fibres exhibited good filtration behaviour for five years, ensuring a low and stable pressure drop of approximately 1500 Pa during the entire period. |
| 2 | On the other hand, the polyester fine fibre felt showed penetration of dust through the entire cross-section after only seven months operation. Operated at a comparable differential pressure, it suffered from more frequent cleaning, which led to dust penetration. In addition, emissions occur, as a result of penetration through the felt, and cracks appear due to the increased mechanical burden (abrasion caused by incorporated dust and more frequent pulsing). |
| 3 | Although the P84 blended bags were approximately 60% more expensive, they resulted in much lower annual costs for bag material and the additional benefit of higher process stability and less down times. |

**Kiln/mill filter**

At lower temperatures, PPS is suitable for a kiln or mill filter from the chemical point of view. The high dust content in combined operation often leads to blinding (penetration into the felt) and premature failures. The observed loss of tenacity of the bag material is not due to chemical disintegration, but to abrasion from the incorporated dust in combination with increased mechanical burden caused by higher differential pressure and/or more frequent cleaning. A suitable solution to increase the filtration performance are felts made from P84 or blends with P84 (polyimide) fibres. The multilobal cross-section of the fibres results in better dust capture close to the surface and prevents excessive penetration of dust into the felt. Table 3 shows a comparison of the air permeability of a PPS felt and a special felt construction with P84. The latter one has 3 - 5 times higher permeability after cleaning (laboratory scale simulation of pulse jet cleaning). Figure 4 shows the totally penetrated PPS cross-section after approximately two years operation, at the time of the air permeability measurement. The P84 blend shows no significant penetration into the felt. No picture was available at the time of writing this article, but the good air permeability of the felt proves its excellent condition.

**Summary**

Each filter is unique and the prediction of the behaviour of different filter media demands a thorough review of all process details. Most of the costs are indirectly proportional to the bag life and the fan power, which usually represents the biggest expense factor related to baghouses. Pressure drop, and thus fan power consumption, are strongly influenced by the filter bag construction. Therefore, an economical comparison of different filter media needs to include more than just the price of the bags, divided by years of expected bag life.