Face the operating costs

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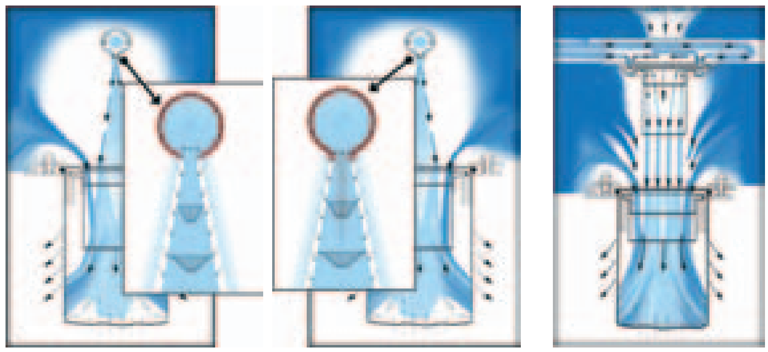
System operators install waste gas purification installations in order to adhere to legal specifications and increase product recovery. For this reason, filtering separators are becoming increasingly important for the removal of particulate matter and more and more also for the removal of gaseous pollutants.

A fundamental technological advantage is the ease with which current limit values are maintained in one single-step process – at high volumetric flows and dust loads. Examples of this can be seen in the usage of these installations in power plant technology, as well as in many processes of cement production. In recent years, these advantages have led to the replacement of centrifugal and electrostatic precipitators (ESP), with filtering separators in general and bag filters in particular. Besides the requirement of high-separation efficiency, bag filters must also be designed to minimise energy consumption.

Energy costs make up a large part of the production costs of cement. And these – on a long term basis – continue to rise, both for fuel and electricity. The cost of electricity has risen approximately 30 per cent since 2005. In the German cement industry, this increase corresponds to an increased cost of approximately €45m per year or nearly €10,000 per industrial workplace. It is estimated that, by 2030, the global energy demand will be about 33GWh.

In the cement industry, electrical energy is used primarily for raw material processing (approximately 35 per cent) and cement grinding (approximately 38 per cent). Heating and cooling the clinker uses approximately 22 per cent of the electrical energy during the manufacturing process. According to the German Cement Works Association (VDZ), energy usage per tonne of cement had risen to 105kWh by the end of the 1990s. For German cement production, this figure has stabilised since the year 2000 to around 100kWh, thanks to measures for more efficient energy use.

Further reductions to energy costs are a common goal throughout the cement production branch, making the use of technology for the greatest possible energy savings increasingly necessary. The following article discusses the measures for design and control technology which contribute to a reduction of the specific energy demands for dust removal. In this context, the reduction of energy demand is highly significant for the existing bag filters in various applications at the cement plant.



a) hole-type nozzle with inlet nozzle

b) ideal nozzle with inlet nozzle

c) Coanda injector with inlet nozzle

Figures 1a, b and c: comparison of different injector systems

Optimising dust collectors to increase energy efficiency

Intensiv-Filter type bag filters are characterised by feeding the raw gas to the bags by cross flow. The raw gas flows through the filter inlet and into the baghouse via a distribution plate. Here, separation takes place and the raw gas flow is uniformly distributed into the filter housing and channelled by cross flow to the filter bags. The particles are separated at the surface of the filter medium or at the surface of the filter cake which has deposited onto the filter medium. The corresponding flow resistances are a result of the pressure losses of the filter cake Δp_{FK} and the filter medium just after jet pulse cleaning (residual pressure loss Δp_0). The cleaned gas flows upwards through the bags (internal flow pressure loss Δp_{SI}). All further flow resistances (raw gas inlet to filter cake surface, clean gas flow from bag outlet to clean gas channel outlet) are summarised to the housing pressure loss Δp_G.

In order to achieve stationary operation, ie a stable filter pressure loss Δp_F, the bag filter is cleaned in regular or irregular cycles. We differentiate here between online and offline mode. In online mode, particles found in the raw gas chamber are constantly filtered on. Just after jet pulse cleaning, the particle concentration is extremely high. In this case, and especially with fine-particle dusts with a low agglomeration tendency, a portion of the cleaned particles are redeposited again. This 'internal' dust circulation can account for a significant amount of the filter cake mass, thus contributing to the pressure loss Δp_{FK}. As a basic technical measure for increasing energy efficiency, shut-off devices on the raw and/or clean gas side (flaps, shutters, valves) are used to set the filter modules of the filtering installation into a flow-free state. This is done in the so-called 'offline' or 'semi-offline' mode (for clean-gas side separation only) during cleaning. This measure effectively prevents any further depositing of dust layers. At the same time, cleaning can be done while in offline mode using a low intensity pulse (reservoir pressure, compressed air tank 0.1 to 0.4MPa). In addition to the main effect of significantly decreasing the pressure loss of the filter cake, the compressed air consumption is also significantly reduced.

Furthermore, the installation pressure loss can be checked and optimised using methods of computational fluid dynamics (CFD). CFD simulation makes it possible to predict system behaviour in detail far exceeding traditional and costly test set-ups. Heat transfer, pressure loss behaviour, velocity profiles, particle tracking, flow phenomena and vaporisation processes are analysed using CFD simulation. CFD simulation programs have therefore

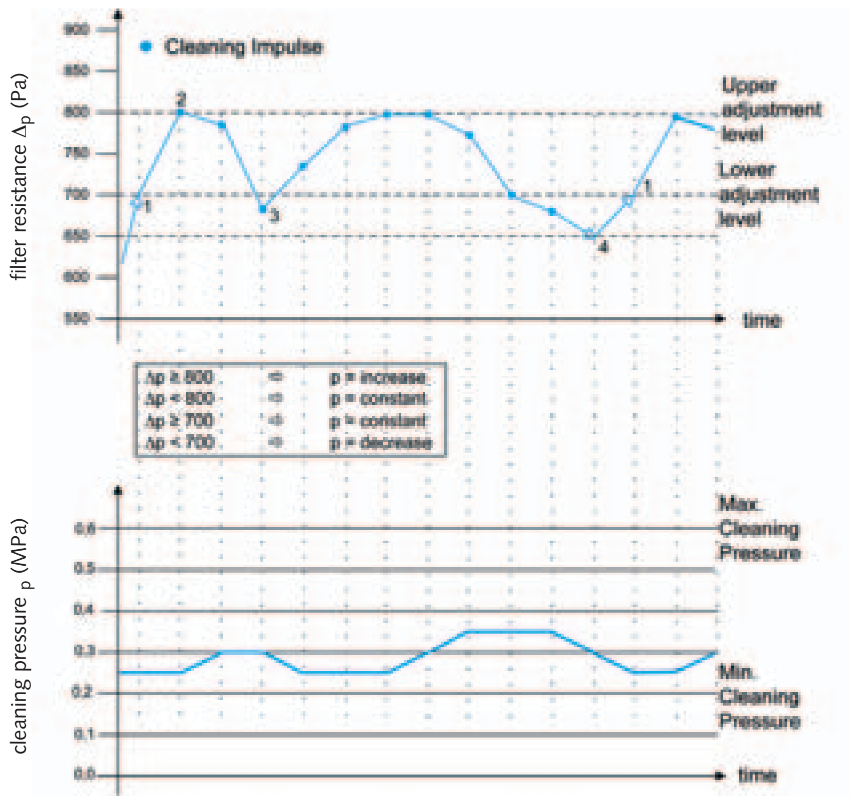


Figure 2: functional diagram of the cleaning procedure

developed into important tools for the analysis and optimisation of process plants and devices which particles flow through. CFD simulations are based on numerical fluid mechanics, the purpose of which is to solve fluid mechanics problems approximatively using numeric methods. At Intensiv-Filter, bag filters and plant components are optimised by networking 3D CAD systems (Solid Works) with the in-house CFD program (CFX).

Injector system

Besides the measures already mentioned, one of the decisive factors for energy-efficient operation of a jet pulse filtering installation is the injector system. The cleaning process must completely remove the filter cake along the entire bag length. At the same time, the dust penetration created by the medium beating back against the supporting cage needs to be minimised by modifying the pressure profiles appropriately.

Many injector systems consist of a blast pipe with simple boreholes as hole-type nozzles (known as a nozzle injector, Figure 1a). This can be significantly improved by extruding the nozzles to an ideal nozzle, thus converting the static energy in the blast-pipe into a directed flow of compressed air (Figure 1b). The cleaning system developed by Intensiv-Filter under the name Coanda Injector exploits the so-called 'Coanda effect'. The compressed air escaping via an annular gap thereby is channelled over a curved surface. The primary air thus follows the boundary layer, which does not separate from the wall due to the geometry of the Coanda Injector.

Within the first injector step, an extremely high subpressure is created, which is sucking secondary air and creating a fall jet. Compared to the other variants mentioned, this function shows a greatly increased amount of air (Figure 1c). The fall jet enters the inlet nozzle, in which further secondary air is sucked in. The Coanda Injector therefore creates maximum cleaning intensity at the highest internal bag pressures.

Cleaning control

Today, cleaning is controlled using microprocessor technology and fieldbus systems. The JetBus Controller filter control system developed by Intensiv-Filter is a decentralised, modular control system.

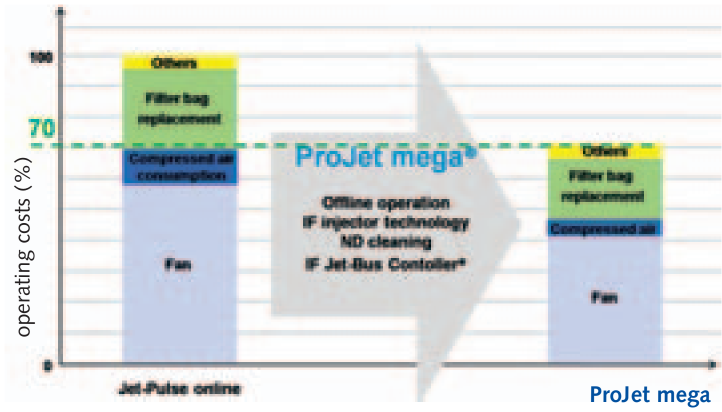


Figure 3: energy-efficient bag filter installations, Intensiv-Filter ProJet mega series with JetBus Controller cleaning

As well as controlling the diaphragm valves, it also controls the pneumatically or electrically actuated raw and clean gas flaps and processes the signals from field sensors, eg 'broken-bag monitors'. When cycling the pressure impulses, it differentiates between an operation with fixed cycles and the differential pressure operation with variable cycle times. The JetBus Controller® offers a further control parameter which allows cleaning to be carried out when needed. By continually adjusting the tank pressure, the compressed air consumption can be adapted to suit the current operating conditions. The standard measurement for this is the filter differential pressure. The filter bags are cleaned by compressed air pulses employing pressures of between 0.1 to 0.6MPa, depending on the cleaning system. For systems in offline mode, cleaning is carried out at pressures of 0.1 to 0.3MPa.

Figure 2 shows the control characteristics of the Intensiv-Filter pressure-controlled cleaning system. The tank pressure needed for cleaning is specified by the system parameters. The top diagram shows the filter differential pressure. The bottom diagram shows the tank pressure. At position 1, the cleaning system is switched on. The cleaning pressure remains unchanged until the upper permitted limit (800Pa) for the differential pressure is reached (position 2). After this point, the cleaning pressure is increased. When the resistance drops below the lower limit (position 3), the cleaning pressure is reduced. Within a specified measuring time, the cleaning system checks the system parameters and adjusts itself to the changing data. If the filter differential pressure falls below the lower maximum permitted limit and continues to fall (position 4), the system switches off the cleaning. When pressure returns to the lower maximum permitted limit (700Pa line), the cleaning resumes. If the cleaning system remains switched off due to low filter differential pressure, forced cleaning can be carried out if necessary to avoid large build-ups of dust. This means that the operating data from the dust removal installation is constantly optimised.

The JetBus Controller particularly lends itself to reducing energy demand, even for dedusting plants with changing demands and for building up a defined filter cake for dry sorption plants. It is an essential element for more energy-efficient dust removal installations, especially when combined with the offline mode. Plants designed to be energy-efficient and first-time experiences with filtering installations which have been converted according to the ProJet mega® series principle show stationary operating conditions at cleaning pressures of <0.3MPa and filter differential pressures of around 1000Pa.

This means a 20 per cent reduction in pressure loss and also a decrease in the compressed air requirements compared to traditional bag filters. In total, operating costs can be lowered by 30 per cent (see Figure 3).

High performance bag filters with increased energy efficiency are available which can reach the level of the operating costs with even higher levels of dust removal efficiency compared to ESPs.