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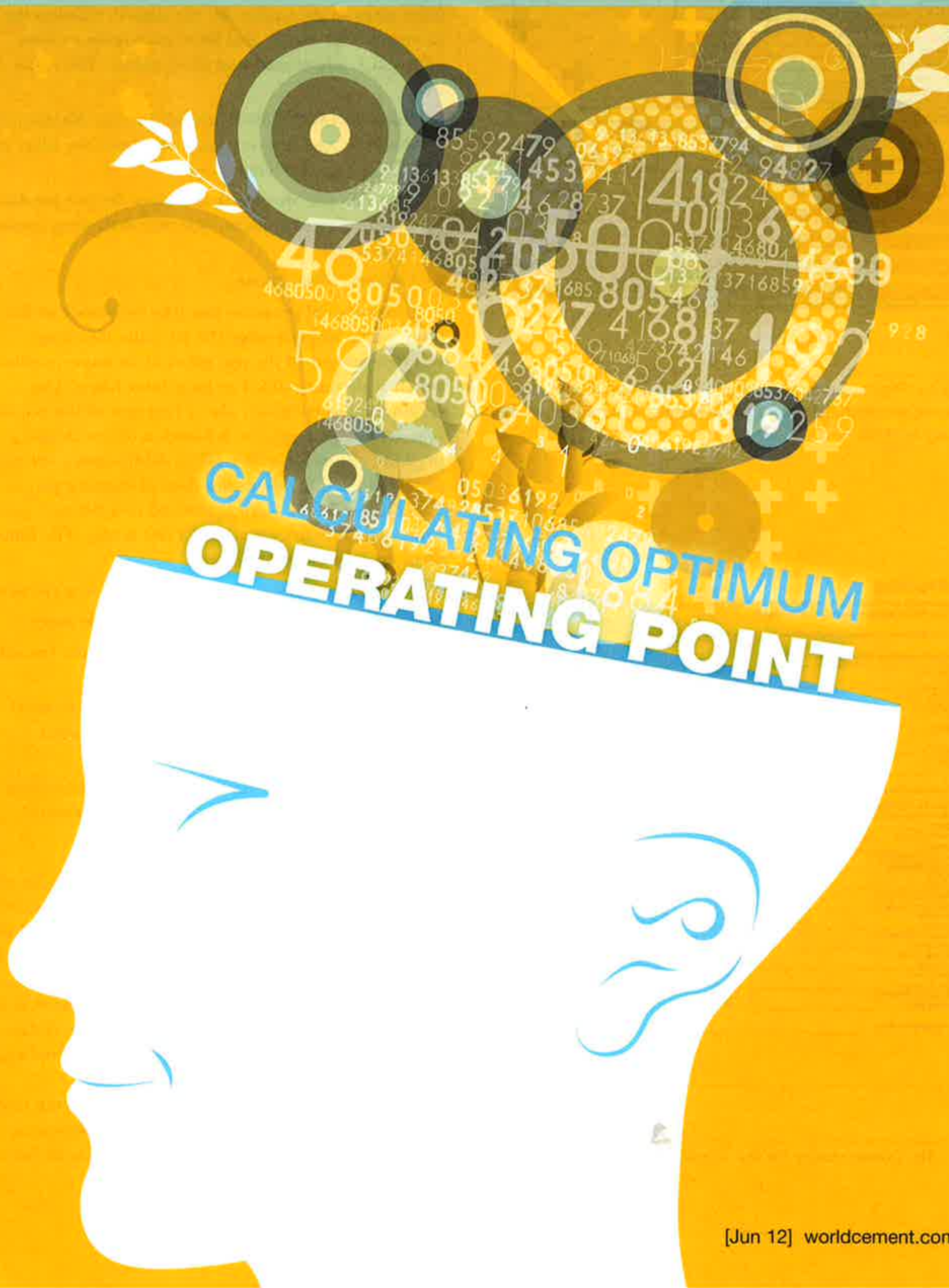
Introduction

Within the scope of the discussion about energy costs of industrial installations, the optimisation of filter plants has an increasing significance. Their energy demand results mainly from the energy consumption of the motors that drive the main ventilating fan as well as the compressed air consumption for cleaning the filter media. Minimising the energy consumption of the entire installation, including the filter, is one of the most important factors when selecting equipment. In addition, the air/gas volumes to be dedusted with filtering separators have increased considerably in recent years, which has led to rising filter dimensions and increasingly longer filter bags. Here the installed cleaning technology and the operating mode (online or offline) play a key role. A major help to filter plant operators looking to optimise the operating parameters is a suitable method for measuring these factors.

CALCULATING OPTIMUM OPERATING POINT



ProExpertise

Der optimale Betriebspunkt einer Filteranlage*
The optimum operating point of a filtering installation*

Sprache/Language English Deutsch/English

Default Values

Type of dust	Raw meal/kiln dust	
Dust concentration [g/m³]	300	
Operating temperature [°C]	160	Input
Volume flow [m³/h] a.c.	1.200.000	Gross / Calculated
Air-to-cloth ratio [m³/(m²·min)]	1,04	Net
Energy demand for 1 m³ (n.c.) compressed air [kWh/m³]	0,1	
Fan efficiency	0,8	
Annual operating hours [h/a]	8000	
Electricity rate [€/kWh]	0,07	
Filter type	PJM	Input: JC, JN or PJM
Number of bags per chamber	136	
Number of chambers	36	
Number of chambers during cleaning (offline)	2	Input: 0 for Online
Injector type	N	Input: C or N - C = Coanda and N = Nozzle
Filter medium	ProTex PI	Input: Membran, ProTex m-Ar or ProTex PI
Operating mode	Offline	Input: Offline or Online
Bag diameter [m]	0,165	
Bag length [m]	8	
Temperature of compressed air [°C]	20	
Safety factor (leaks and losses)	10%	
Air tank volume [L]	48	
Filter area [m²] (gross)	20303,2	
Filter area [m²] (net)	19175,3	
Number of bags in total	4896	
Number of injectors per injection tube	17	
Number of injection tubes per chamber	8	

Calculation Results

Cycle time [s]	Cleaning pressure [MPa]				
	0,6	0,5	0,4	0,3	0,2
	Average pressure drop (filter bag + filter cake [Pa]				
194	809	815	821	828	863
	Pressure drop (miscellaneous**) [Pa]				
194	320	320	320	320	320
	Total average pressure drop [Pa]				
194	1129	1135	1141	1148	1183
	Compressed air consumption [m³/h n.c.]				
194	1000	868	706	586	377
	Annual energy demand (compressed air + fan) [kWh/a]				
194	4.562.873	4.477.503	4.387.784	4.296.548	4.244.847
	Annual operating costs (compressed air + fan) [€/a]				
194	319.401	313.425	305.745	300.758	297.139

* Estimated operating costs of a baghouse filter plant based on Intensiv-Filter baghouse data.

Figure 1a. ProExpertise input/output form. Case study: high dust concentration, kiln/raw mill dedusting, ProJet mega®, 8 m bag lengths.

ProExpertise

Anfrageformular zur Ermittlung des optimalen Betriebspunktes
Application form to determine the optimal operating point

Bitte füllen Sie die mit * gekennzeichneten Felder aus /*Please fill in the fields marked with* *.

Ihre Kontaktdaten/*Your contact details*:

Anrede *Title:**	Titel *Academic title:**
Vorname *First name:**	Nachname *Last name:**
Firma *Company:**	Straße *Street:**
PLZ *Post code:**	Ort *Town:**
E-Mail:*	Telefon *Phone:**

Ihre Parameter/*Your parameter*:

Hersteller der Filteranlage *Manufacturer of the filtering installation*	Applikation der Entstaubung *Application of dedusting*
Typenbezeichnung *Filter type*	Staubart *Dust type*
Datum der Inbetriebnahme *Date of commissioning*	Volumenstrom [m³/h] i.B. *Volume flow [m³/h] a.c.*
Injektortyp *Injector type*	Betriebsweise *Operating mode*
Betriebstemperatur [° C] *Operating temperature [° C]*	Zykluszeit [s] *Cycle time [s]*
Filtermedium *Filter medium*	Rohgasstaubgehalt [g/m³] *Raw gas dust content [g/m³]*
Schlauchdurchmesser [m] *Bag diameter [m]*	Abreinigungsdruck [bar] *Cleaning pressure [bar]*
Schlauchlänge [m] *Bag length [m]*	Filterdifferenzdruck [Pa] *Filter differential pressure [Pa]*
Kammeranzahl *Number of chambers*	Betriebsstunden [h/a] *Operating hours [h/a]*
Schläuche pro Kammer *Bags per chamber*	Strompreis [€/kWh] *Electricty rate [€/kWh]*

Bemerkungen/*Remarks*:

Figure 1b. Questionnaire for the inquiry of the basic data.

Determination of the optimum cycle time

The pressure losses, and hence the ventilating fan power demand, can be precalculated on the basis of the basic equation of the cake-building filtration using the filter expert system, ProExpertise. Amongst other factors, the optimum operating point of a bag filter is based on the geometrical parameters of the filter. This also includes, for example, the filter surface, the bag length, the design of the raw gas and clean gas chambers and the control dampers. Other criteria are the process parameters such as the volume flow, the raw gas concentration, the temperature, etc.

Intensiv-Filter conducted trials in a bench-scale unit (by directive VDI 3926) as well as in a half-technical filter plant to determine for the data evaluation the required filter media and filter cake resistance for different kinds of dust and filter media. The dusts were:

- Pural Sb (Al_2O_3) dust: critical dust for filtration that does not agglomerate and penetrates the filter media with a high tendency.
- Kiln/raw mill dust: this was taken from a product flow in a cement plant, raw mill dedusting (without separator).
- Cement, 5900 Blaine.

The residual pressure loss (the resistance of the filter media directly after the jet-pulse cleaning) was determined in the test plant in an experimental bench-scale unit (10 x 4 m long filter bags). The residual pressure loss is also a function of the required regeneration energy, i.e. a function of the cleaning pressure (from 0.1 to 0.5 MPa). Additionally, the results were validated by operating data of existing plants.

All filter media were submitted to a defined ageing process to guarantee stationary test terms. The following filter media were field-tested:

- Standard polyester (PES) needle felt as a reference.
- ePTFE membrane laminated on a glass fabric.
- ProTex® PES: a special microfibre needle felt quality (with reduced differential pressure).[1]
- ProTex® m-Ar: a special meta-Aramid (Nomex) microfibre needle felt quality (with reduced differential pressure).[2]
- ProTex® PI: a special Polyimid (P84) microfibre needle felt quality (with reduced differential pressure).[2]

Figure 1a and 1b show the input/output form of the filter expert system, as well as the questionnaire for the analysis of the basic data. Process parameters and the geometrical data of the different modular Intensiv-Filter systems can be given directly in the data bank. Also, the evaluation and calculation of bag filters regardless of manufacturer is possible if certain geometrical data are known. The results of the calculations with ProExpertise are shown in tabular form and graphically.

Figure 2 shows an example of the operating costs for a kiln/raw mill dust removal. The consumption of compressed air is the prevailing factor, with very short cycle times, which leads to rising operating costs. The operating costs further increase after crossing a minimum value (optimum operating point) due to the increased filter cake resistance and the higher energy consumption of the main ventilating fan. Low values of the pressure loss tend to show in the lower operating costs, as a result of the lower costs for compressed air compared with the costs for the motor power of the ventilating fan. This results in an optimum operating point, with relatively short cycle times.

With high raw gas dust content the optimum operating point further moves to shorter cycle times because the power demand is determined by the high resistance of the quickly increasing filter cake. The image changes completely if only a little dust must be separated. The operating point of the filter plant with maximum energy efficiency moves with very low raw gas dust loadings (e.g., ≤20 g/m³) to longer cleaning cycle times.

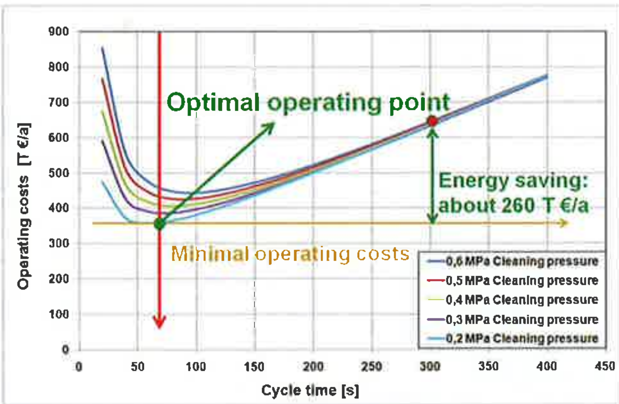


Figure 2. Optimisation of the operating point depending on the cleaning pressure. Case study: High dust concentration, kiln/raw mill dedusting, ProJet mega®, 8 m bag lengths.

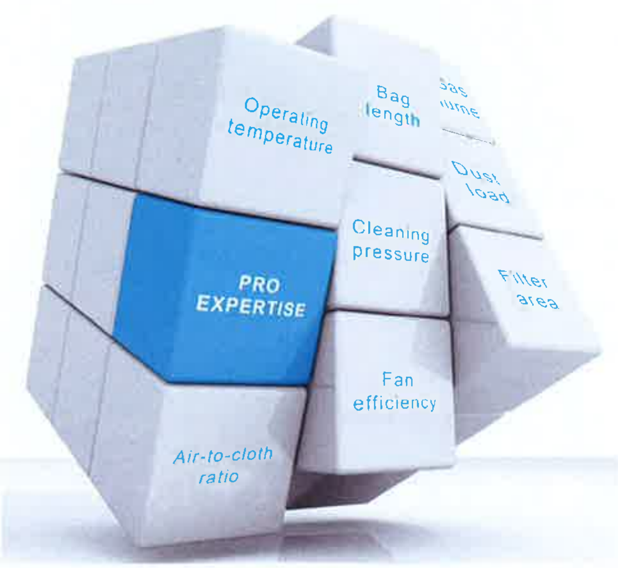


Figure 3. Process parameters as well as the geometrical data for the evaluation of a filter plant.

The filter expert system is also able to compare different filter dimensions. Filters with varying bag lengths and with different numbers of bags can be analysed with regard to energy demand and operating expenses. Additionally, the filter expert system includes possible variations concerning the type of filter medium used. Therefore, it is possible to calculate, for example, the energy savings gained by using filter bags of the ProTex® generation in comparison to standard filter bags. At the same time, the compressed air necessary for the jet-pulse cleaning is calculated for the respective configuration. With ProExpertise it is possible to pre-calculate, from an energy point of view, the optimum operating point that is cycle time and cleaning pressure. The plant operator can also decide whether a planned increase of the plant capacity, i.e. a rise of the air-to-cloth ratio with the existing filter plant, can be carried out or whether upgrade measures become necessary. The basic data of ProExpertise is extended continuously by other dust and product data, filter media data and operating data. The next stage of expansion will also include the costs for depreciation and demand for service and spare parts, such as filter bags and cleaning components.

Case study

In a case study the relevant operating data of an existing installation were gathered and analysed with ProExpertise (Figure 1a). The analysed filter, a ProJet mega® bag filter with 8 m long filter bags, is used for the dust removal of a kiln and raw mill.

The reason for the interpretation with ProExpertise was the high dust concentration, which increased the pressure loss. The energy demand of the main fan increased significantly with the rising pressure loss. The associated energy costs also increased.

The task was to reduce the pressure loss by determining the optimum operating point with the expert system. The evaluation resulted in the cycle time for the periodical cleaning being adjusted. In this case, operating costs were reduced by approximately 20%. A further reduction of the pressure loss is possible with the ProTex filter media, and the energy demand is lowered once more by approximately 15%.

Conclusion

ProExpertise is a new tool for the engineer, which predicts operating expenses for existing and new installations with high accuracy by the input of the essential geometry and operating parameters of the bag filter. The operating costs for the dust removal and the product separation can be considerably reduced by the setting of optimum operating parameters and, if necessary, through upgrading to more energy-efficient filter media.

Reference

1. KLEIN, G.-M., NEUHAUS, T., BAI, P., SCHROOTEN, T., and DANIEL, T., Verminderung der durch die Partikelablagerung verursachten Druckverluste in industriellen Schlauchfiltern. *F&S Filtrieren und Separieren* 23, No. 3 (2009), pp. 134 – 139.
2. NEUHAUS, T, BAI, P., SCHROOTEN, T., and KLEIN, G.-M.: Steigerung der Energieeffizienz in der industriellen Gasreinigung durch optimierte Oberflächenfiltration. *Gefahrstoffe – Reinhaltung der Luft* 70, No. 6 (2009), pp. 231 – 236.