

Dedusting of air by filter separation

Physical laws and rules are no secrets, but only circumstances of nature. We do not worm secrets out of nature, but get to know them by tests and examinations.

Much experience is required in order to design filters. You can find several publications by professor Löffler about this theme. In his papers he points out that pre-design of filters is not possible according to the actual state of knowledge.

We are dependant on experiences in the combined effect of various parameters.

These experiences collected in the VDI (Association of German Engineers) guideline 3677 will be of help to you.

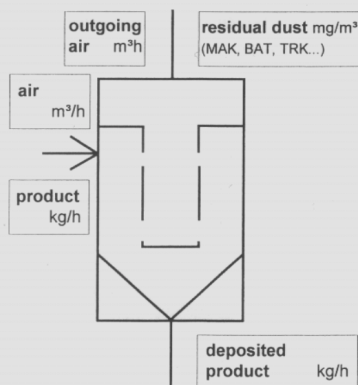


figure 1

■ Tasks

In the case of pneumatic conveying, the filter (separator) has to ensure:

1. the collection and separation of the product
 2. the penetration of transporting air
- This fact causes a conflict: where air can penetrate so also can dust, hence the reason for the residual dust (figure 1).

■ Separators

The first separation procedures were carried out by aid of settling chambers. The air charged with product is transferred into a large room which decreases the air velocity causing the bulk solid particles to fall down.

The next step was the development of the cyclone. Here the bulk solid particle is separated with a high velocity (about 20 m/s) by means of centrifugal force. The air leaves through the top containing a respectively high part of residual dust.

During the continuing development of technical applications, the filtering separator was constructed. At first they were designed as storage filters, meaning the product was collected till the air could no longer penetrate the filter medium. After that they had to be cleaned or replaced by new filter inserts.

In the course of time, this system was converted into an automatic one which cleans the filter by vibration. For many industrial applications, these cleaning methods are not sufficient, which led to the development of filters with air pressure cleaning. These can be employed in the case of continuous operation. The function is as follows: parts of the filter surface in the same filter unit are always available. Here you will find various types of air cleaning, for example a reverse blower. However, in the case of pneumatic conveying, cleaning by compressed air (reverse jet cleaning) is widely used.

By using a differential pressure control

unit, the service life of filter inserts can be prolonged and the air pressure requirement diminished. The rapid development in electronics have made it possible for almost every second filter today to be fitted with a differential pressure control unit.



figure 2

There are different bulk solids and different bulk handling systems. In order to do justice to each one, it may be necessary to use different filter media.

The part of the unit which effects the separation, this means the separation of the product from the air, is described as the filter element in the VDI guideline 3677. This filter element consists of a filter medium and a supporting construction, if necessary.

The first elements were fibrous sleeves. Then the pocket filter was developed. It had the advantage of concentrating much filter surface into a small amount of space. Its disadvantage was that the ratio between the particle's speed of descent and the speed of ascent in the filter increased considerably.

Another development was the cartridge filter which was taken over from the construction of commercial vehicles (air filter). This cartridge filter has the advantage, that much filter surface can be concentrated on a very little space but also has the disadvantage that the ratio between speed of descent and ascent increases.

Another disadvantage is that the available filter surface decreases according to the number of foldings. This can clearly be shown when unrolling such a filter cartridge. You will recognize the stripes of dirt resembling a zebra crossing.

The ts star filter was developed in order to enable a relatively large filter volume to be contained in a small

sized filter structure. The star filter permits a very compact method of construction with optimized speeds within the filtering device (figure 3).

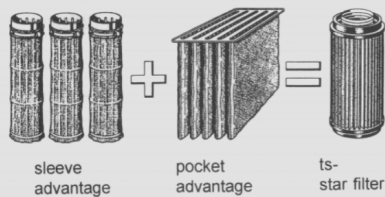


figure 3

The materials-handling technology works with the index " μ ", which means: Quantity of material to be transported in relation to quantity of the transported gas. This proportional number allows a classification into different types of transportation (figure 4).

$$\mu = \frac{\dot{G}_s}{\dot{G}_f}$$

μ = index for product/air ratio
 $\dot{G}_s$ = quantity of product to be conveyed [kg/h]
 $\dot{G}_f$ = quantity of gas to be conveyed [kg/h]

figure 4

Dilute phase conveying
(stationary dilute phase conveying) $\mu < 30$

Dense phase conveying
(non-stationary pulse conveying) $\mu > 30$

Dense phase conveying
(stationary flow conveying) $\mu \gg 30$

A similar index for judging the operability of the filter unit can be applied. Here you take the ratio of the air ascent speed to the descent speed of the bulk solid particle, respectively the bulk solid agglomerate. The procedures in the filter unit can be compared with the dilute phase conveying. (figure 5).

$$K_{Fi} = \frac{V_{st}}{V_{si}}$$

K_{Fi} = index filter
 V_{st} = ascent velocity of air in the filter unit [m/s]
 V_{si} = descent velocity of bulk particle [m/s]

figure 5

■ Application technology

Finer and finer bulk solids are produced today, partly with a grain size of 0.001 mm. Previously the grain size was 0.1 mm and greater. You can find a definition of bulk solid characteristics in the ISO-standard 3435.

This means the filter manufacturer has to cope with additional require-

ments. Not only is the filter medium important, but also the handling and control of the filter unit.

The descent velocity of the dust is a fact which cannot be disregarded when designing a filter unit. Provokingly: more importance has to be attached to the filter unit and its control than to the choice of the filter media. Today the filter medium tends to be more of a regulative element for the individual characteristics of dust.

The transporting air has a great influence on the separating procedure.

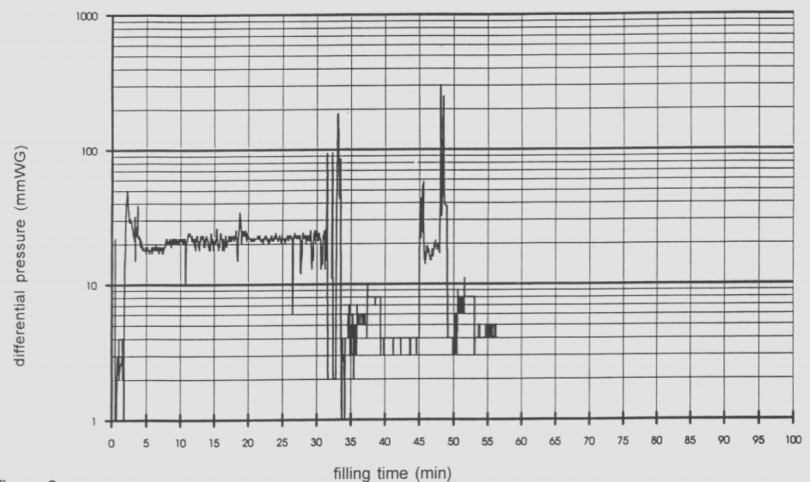


figure 6

Air can be compressed easily, therefore the regulation of the air quantity is another difficulty.

Discharging a tanker, for example, shows this quite clearly. Experience shows that a filter surface of 3 m² is sufficient on a silo if the air quantity can be kept under control. In many cases maximum pressure is used when emptying a tanker. Bridges are built up in the tanker. If the bridges break down, an air venting comes about, which leads to a substantial increase (5 times the amount) in the air quantity. The flow velocity to the filter medium becomes too high and leads to collapsing and clogging of the filter. If no excess pressure valve is provided, the silo may burst.

The latest technology in tankers, as well as the user receiving the correct instruction, enables air venting to lie between 2 and 3.

If the tanker is not operated with accuracy, it can reach up to six times that amount. This provokes the

opening of the pressure cover and thereby releases the pressure into the open. If the safety device is built in, then the pinch valve closes to reduce the pressure.

Approx. 400 m³/h can be filtered with a conveyor pipe line of 80 diameter and approx. 650 m³/h with a conveyor pipe line of 100 diameter. (figure 6)

Today there are two systems of silo filters, one with mechanical cleaning, the other with electropneumatic re-

verse jet cleaning. The filter surface has to be sufficiently dimensioned. In the case of reverse jet cleaning, the filter surface can be decreased (figure 7 and 8).

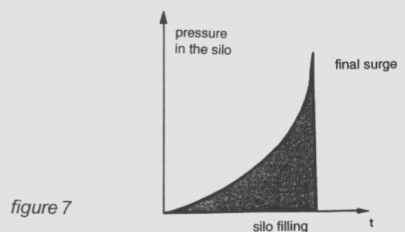


figure 7

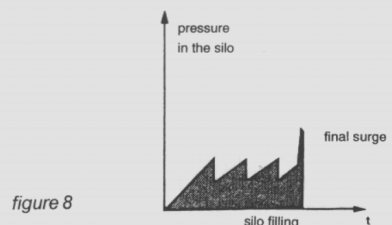


figure 8

A tendency toward fully automatic installations is clearly perceptible in the plant engineering industry. Therefore, the fully automatic silo filling was developed. The pressure in the silo

has to be constantly measured and compared with the set values. If the pressure rises too much, a pinch valve is closed immediately, avoiding an increase of the pressure surge affecting the filter. The over-charging of the silo is prevented by a "full" indicator which closes the pinch valve and activates a signal horn when the "full" signal is given.

After finishing of the silo filling, the filter is recleaned automatically and the pinch valve is closed. The pinch valve can be opened again from the switch board. This has the advantage that a silo can only be filled when cleared by the plant personnel. This avoids incorrect fillings (figure 9).

- How thick must the filter aid layer be to guarantee a certain dust residue? (figure 11)

in stage 2:

- The reaction of our filter insert in relation to the bulk material? (figure 10)

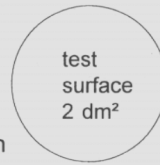
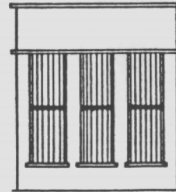


figure 11

in stage 3:

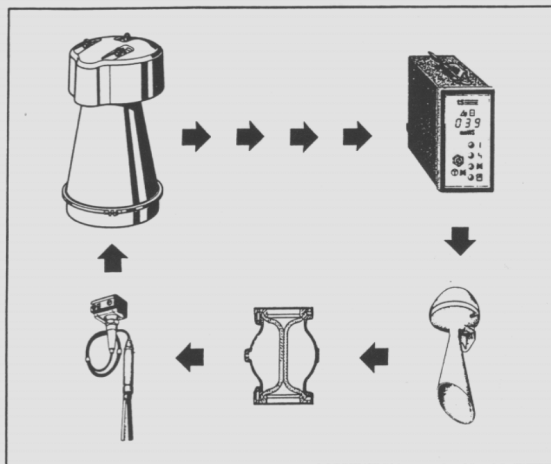
- the behaviour of the bulk material in the filter unit



ts-filter unit
figure 12

Silofilter with reverse jet cleaning and fully automatic process control for separating dust from conveying air

Remote Signal/Control Module MSM-2 with control signals for installation in the control panel



"Full" indicator for the "full" signal (signal is given to the process control)

Pinch Valve automatically cuts any conveying in process, if there is too much pressure in the silo or after the "full" signal has been given

Signal Horn for letting the driver know that the silo is full

figure 9

■ Test method

For the design of filters we have a three-stage test method, which tries to find out:

in stage 1:

- The behaviour of the bulk material at the filter medium
- How much dust residue is there?
- Can the filter cake be thrown off?



ts-starfilter

figure 10

During the last few years dust explosions were examined intensively. Therefore, the filter manufacturers have developed a compression- and pressure-proof design of filter and alternatively a pressure relief device which is sufficient in many cases.

Each dust is assigned to a dust explosion category. The diagram shows the frequency of the dust explosion category relating to more than 500 examined dusts (figure 13).

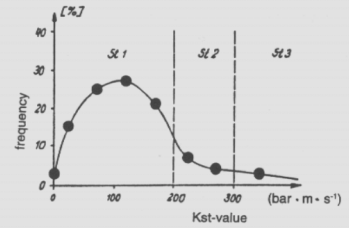


figure 13

Connection between the Kst-value and the dust explosion category

Dust explosion category	Kst (bar·m/s)
St 0	0
St 1	up to 200
St 2	201-300
St 3	over 300

Kst-values of technical fine dusts
Strong ignition source

kind of dust	P _{max} (bar)	Kst-value (bar·m/s)
PVC	6,7- 8,5	27- 98
Milk powder	8,1- 9,7	58-130
Polyethylene	7,4- 8,8	54-131
Sugar	8,2- 9,4	59-165
Resin	7,8- 8,9	108-174
Cellulose	8,0- 9,8	56-229
Pigments	6,5-10,7	28-344
Aluminium	5,4-12,9	16-750

ts-systemfilter had several reasons for being dissatisfied with the pressure relief positioned on the dirty air side. In our opinion the dirty air side pressure relief caused problems. For one thing, the igniting product blows away horizontally and possibly the flames likewise.

Therefore, ts-systemfilter in co-operation with the BVS in Dortmund tried successfully to position the pressure relief at the clean air side.

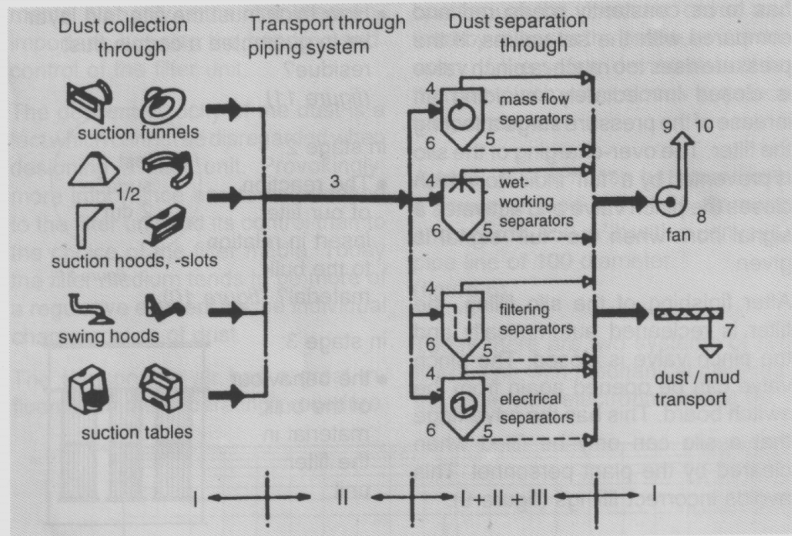
There is no danger that the pressure relief at the clean air side will not respond in the case of a clogged filter. On the contrary, the tests showed that the filter inserts serve as a flame barrier and that the pressure is relieved vertically upwards. The advantage is that the pressure can be relieved over the roof into the open air in many cases. In the case of lateral pressure relief, this must be channelled through the wall.

■ Maintenance

A filter unit should be maintained and checked regularly like any other technical device. This guarantees a continuous function of the filter.

Service plan (figure 14)

- 1, 2, 3 Measuring of the air velocities
- 4 Operation pressure difference (set-point marking)
- 5 Control of function of the dust and mud discharging devices
- 6 Power input of auxilliary drives
- 7 Control of function of the dust and mud conveying
- 8 Power input of fan
- 9 Total volume flow
- 10 Dust and noise emission



I=daily control of operation, II=monthly maintenance, III=yearly main service (check)
figure 14

Guaranteed value

Guaranteed value		Coefficient	☐	◐	◑	⊙	Technical guidelines for proof
Collection	Pollutant concentration in the object area	mg/m³	x	•	•	—	ZH 1 / 561 VDI - 2265
	Flow velocity of extracted air	V_o m/s	x	x	x	—	DIN 1952
		V_z m/s	x	x	x	—	
		V_R m/s	•	•	•	•	
Fan	Suction volume flow (Air flow rate of fan)	m³/h	•	•	•	•	DIN 1945
	Total pressure difference	Pa	•	•	•	•	VDE - 0410
	Required power	kW	•	•	•	•	
	Sound level	d B(A)	•	•	•	•	
Separator	Power of auxiliary drives	kW	•	•	•	•	VDE - 0410
	Water requirement	l/h	—	•	—	—	VDI - 3679
	Compressed air/cleaning air	m³/h	—	—	•	—	VDI - 3677
	Filter surface load	bar	—	—	•	—	"
	Pressure difference during operation	m³/m²h Pa	•	•	•	•	DIN - 1945
Clean air	Dust concentration	mg/m³	•	•	•	•	VDI - 2066
	Dust ejection	kg/h	•	•	•	•	"
	Temperature	K	•	•	•	•	DIN - 1953
	Relative humidity	%	•	•	•	•	"

• = required, x =desired, — = as far as possible

figure 15

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VDI Filtertechnik, VDI-Verlag, Düsseldorf

VDMA Umweltschutz
Maschinenbau-Verlag, Frankfurt

Technical guidelines

ISO 3435
Klassifizierung und Symbolisierung von Schüttgütern

VDI 2031
Feinheitsbestimmungen an technischen Stäuben

VDI 2066 Bl. 1
Staubmessungen in strömenden Gasen
Gravimetrische Bestimmung der Staubbelastung - Übersicht -

VDI 2066 Bl. 2
Manuelle Staubmessung in strömenden Gasen, Gravimetrische Bestimmung der Staubbelastung - Filterkopfgerät -

VDI 2260
Technische Gewährleistung für Entstauber

VDI 2262
Staubbekämpfung am Arbeitsplatz

VDI 2263
Verhütung von Staubbränden und Staubexplosionen

VDI 2264
Betrieb und Wartung von Abscheideanlagen

VDI 2329
Pneumatische Förderanlagen

VDI 3671
Technische Gewährleistungen für pneumatische Förderanlagen

VDI 3673
Druckentlastung von Staubexplosionen

VDI 3677
Filternde Abscheider

VDI 3926
Prüfung von Filtermedien für Abreinigungsfilter

FEM 2 311
Lagerung von Schüttgütern - Terminologie -

FEM 2 412
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FEM 2 461
Garantie-Bedingungen für Pneumatische Förderanlagen

FEM 2 481
Spezifische Schüttguteigenschaften bei der pneumatischen Förderung, Definition und Festlegung der Meßverfahren

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