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<Technical Note>

Bag Filter Monitoring and Dust Concentration Measuring by means of Triboelectrical Measuring Devices

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The measurement of dust emissions becomes more and more important all over the world. Recently optical dust meters dominate this application field. Due to their advantageous features triboelectrical dust meters achieve an increasing market share. The scope of devices covers simple but very effective filter watchers and also quantitative dust concentration measuring devices.

Key words: bag filter monitoring, dust concentration, triboelectrical measuring devices.

1. Introduction

In a lot of industries the dust emission will be reduced with the help of filters (electrostatic precipitators, bag filters, cyclones,...).

The efficiency of these dedusting plants must been supervised by means of well suited measuring devices.

Since many years the dust concentration measurement will be done with optical devices based on the physical principles light scattering or extinction. The filter monitoring also can be executed with optical devices.

However optical dust meters have some significant disadvantages for the user and so there is a tendency to simple designed devices with easy assembly and small maintenance requirements.

Triboelectrical dust meters can fulfill these wanted demands.

2. Measuring principle

In case of contacting of two solid bodies by friction or touching an electrical charge transfer is caused. Atoms at the body surface exchange electrons and so a border layer with a positive and a negative electrical surface charge in a very small molecular distance is formed. This charge difference is the base for triboelectrical dust meters, which use the charge exchange between measuring probe and nearby streaming or direct impacting dust particles (Fig. 1).

The triboelectrical signal depends on the mechanical and electrical properties of the dust. Apart from the dust concentration it seams that the gas velocity has the most important influence to the triboelectrical charge transfer. There is the following mathematical relation :

$$c_{i.B} = A \cdot cal \cdot v^{exp.} + D$$

$c_{i.B.}$ = Dust concentration (operation conditions)
cal = Measuring signal (raw signal)

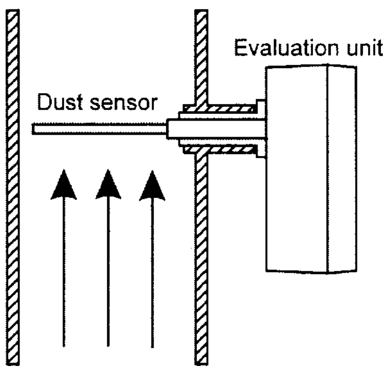

Fig. 1. Priciple of triboelectrical dust measurement.

Fig. 2. PFM 92 C.

Fig. 3. PFM 92.

A, D = Constants
v = Gas velocity

3. Triboelectrical Dust Meters

3.1. Filter monitoring

A very simple and effective device is the filter watcher PFM 92 C (Fig. 2). It consists of a measuring probe, which must been installed in the clean gas duct or in the stack behind a bag filter. The small probe current will be amplified in the probe head which provides an analogue output signal (4~20 mA). This

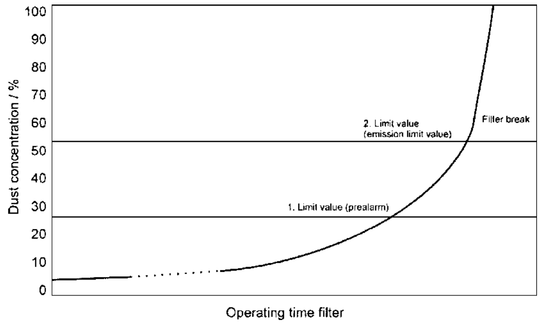

Fig. 4. Continuous monitoring of dust ("Integral on").

signal is proportional to the dust concentration (if the gas velocity is nearly constant).

The PFM 92 C is very well qualified for the creation of complete monitoring systems for production facilities with a lot of bag filters.

A more comfortable version is the filter watcher PFM 92 (Fig. 3). The PFM 92 has two components: the measuring probe and the separate electronic evaluation unit.

Both devices have two operation modes "Integral ON" and "Integral OFF". In the first mode an averaged signal is resulting similar to the 30 minutes mean value demanded by the authorities.

The Fig. 4 shows a typical filter diagram. After installation of new filter bags the dust emission is very low. After an operation time of some months or even years the clean gas concentration is increasing slowly. The PFM 92 series has two internal limit switches. The first limit contact gives a prealarm when a significant increasing of dust emission will be registered. This warning occurs in a very early state of filter damaging (clearly below the emission limit value given by the authorities).

If this warning will be ignored than an accelerated filter wearing leads to an considerable increasing of the dust emission and at least to a filter break. Such an angry incident surely can be avoided. In the case of prealarming the PFM 92 must been switched to the operation mode "Integral OFF".

In this mode the momentaneous values of the relative dust concentration will be measured. The recording of those values allows a very effective filter diagnosis.

A typical example for a very well working bag filter

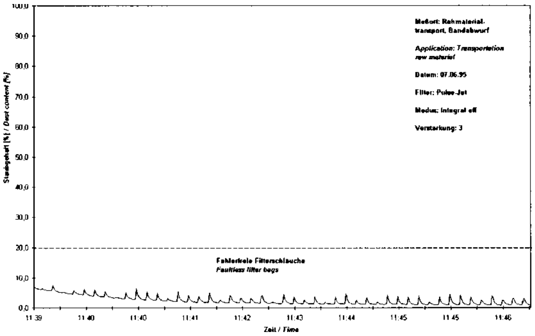

Fig. 5. Typical filter diagram ("Integral off").

shows Fig. 5. The mean dust concentration behind the filter is very small (~2 mg/m³). Only in the short moment of the filter cleaning by pressured air pulses small dust peaks were created.

Contrary is the situation in Fig. 6. This is the emission diagram of a bag filter with 13 rows of filter bags. Represented are two complete cleaning cycles. It is very evident that the filter bags in the rows 7-11 have high dust penetration and must been replaced.

The filter bags of the other rows have a satisfactory efficiency and should remain in operation. In case of expensive filter bags (e.g. in incineration plants) the filter operation costs can be considerable minimised.

With the help of the filter diagrams created by PFM 92 C or PFM 92 it is possible to localise defective filter bags, to find inactive solenoid valves, to evaluate the complete closing of flaps, to examine the correct tighting between clean gas and raw gas room of a filter...

Fig. 7. PFM 92 K.

All these information can be achieved with the PFM 92 or PFM 92 C for fix installation or with the mobile filter diagnosis device PFM 92 K (Fig. 7).

This device has a very easy handling. The probe can be adapted to the dimensions of the duct or stack. The installation is possible in every socket 1" or more. The record of a filter diagram takes a time between 5...15 minutes depending on the filter size. All measuring values are stored electronically.

Fig. 8. PFM 97 W.

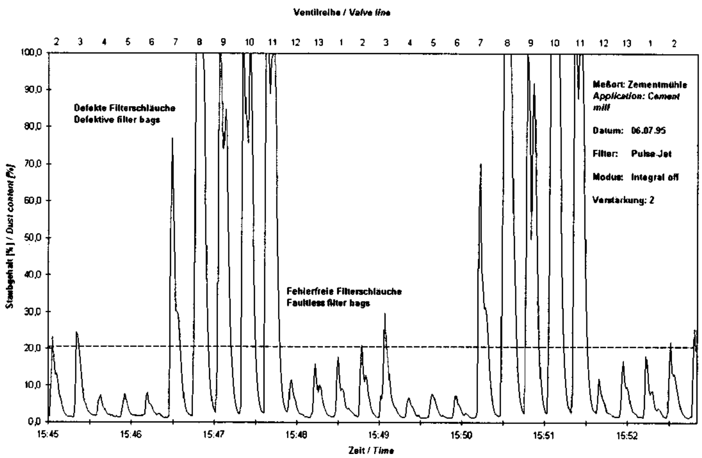

Fig. 6. Filter diagram with faultless and defective filter bags.

Table 1.

Criterion	Optical Dust Meters	Triboelectrical Dust Meters
Design	Complicate structure, sensitive optical and mechanical moved parts	Simple design
Assembly	Rather difficult, specialists and special tools are necessary Two mounting flanges have to be positioned in a very exact manner	Very easy, only one flange is required No special tools, no specialists
Operation	High operation costs due to the required purge air fan	Very low operation costs
Spare parts/Service	Expensive spare parts Maintenance/Service must been done by specialists	Hardly ever spare parts Maintenance/Service can be done by customers
Multi tasking	Only one measuring signal per device	3 measuring signals (dust concentration, gas flow, gas temperature) with only 1 device (PFM 97 W)

3.2. Dust concentration measurements

As mentioned above the gas velocity has an important influence to the triboelectrical signal. For quantitative dust measurements this effect must been compensated.

The dust concentration measuring device PFM 97 W (Fig. 8) meets this requirement. The PFM 97 W consists of a measuring probe with two parallel triboelectrical dust sensors and a Pitot type differential pressure probe for measurement of gas velocity. The probe is completed by a temperature measurement PT 100.

The second part of the device is the electronic evuluation unit. In this unit the standardised dust concentration will be calculated. Changing of the gas flow will be taken into consideration by a special software.

The PFM 97 W has three output signals :

– Dust concentration
– Gas flow
– Gas temperature

That means the PFM 97 W realises 3 measuring tasks. Necessary is only one mounting flange.

All described dust meters are designed for in-situ measurements. They need a dry gas atmosphere without any water droplets. The dust measurement in wet gases can be done with extractive working devices.

The most sophisticated device in this application field is the PFM 97 ED (Fig. 9)

With the help of a special probe a representative gas sample will be taken. This gas sample will be dried and diluted with clean, heated air. The flow of the measuring gas is supervised and in the case of plugging an automatical back flushing will be activated. The measuring cell contains a triboelectrical sensor. Due to this design features it is possible to measure emissions under very difficult conditions (wet gases, sticky dust)

Fig. 9. PFM 97 ED

3.3. Comparison triboelectrical versus optical dust meters

For the practical use triboelectrical dust meters have the following advantages compared with optical devices.

4. Conclusion

Beginning with the assembly till to the operation optical dust meters are connected with high expenses. In contrast triboelectrical dust meters have a simple design and considerable lower costs.

Since many years triboelectrical filter watchers have an important market share. Now the application field of triboelectrical dust meters is extended to quantitative dust concentration measurement including difficult gas atmospheres.