First published in:

2491

FILTECH 2011
CONFERENCE PROCEEDINGS
VOLUME II

CONTENT VOLUME II

Scientific Committee	II-2
Session Survey	II-3
Conference Programme	II-4
Keyword List (Session Indicator)	I-15
Session Chairmen	II-17
Papers G-Sessions	II-19
Papers M-Sessions	II-465
Keyword List (Page Indicator)	II-628

CONTENT VOLUME I

Scientific Committee	I-2
Session Survey	I-3
Conference Programme	I-4
Keyword List (Session Indicator)	I-15
Session Chairmen	I-17
Survey Lectures	I-19
Papers L-Sessions	I-94
Keyword List (Page Indicator)	I-668

Conference Dates:
March 22 – 24, 2011

Venue:
Rhein-Main-Hallen · Rheinstr. 20 · 65028 Wiesbaden · Germany

Organizer:
Filtech Exhibitions Germany
PO Box 1225 · 40637 Meerbusch – Germany
phone: +49 (0) 2132 93 57 60
fax: +49 (0) 2132 93 57 62
e-mail: Info@Filtech.de
web: www.Filtech.de

ISBN 978-3-941655-037-9

COMPARING THE OPERATING BEHAVIOR OF PULSE CLEANED FILTER BAGS WITH THAT OF FLAT MEDIA IN A VDI TESTER

O. Kurtz, G. Kasper, J. Meyer

Karlsruhe Institute of Technology - Institut für Mechanische Verfahrenstechnik und Mechanik – Bereich Gas-Particle-Systeme
Straße am Forum 8, 76131 Karlsruhe

ABSTRACT

Laboratory-scale filter tests according to VDI 3926 (or comparable guidelines) have been used for many years to characterise pulse jet cleaned filter media and to predict their behaviour in bag house filters. A direct comparison of test results with data from actual filter bags in a bag house would therefore be of great interest. This paper first presents design and operating features of a bag filter unit for 3x3 filter hoses with attached VDI test unit, as well as instrumentation to measure filter performance including PM2.5 emissions. It then discusses a strategy for meaningful comparisons on the basis of comparable operating conditions for filtration and cleaning, supported by on-line measurements of pulse intensity and face velocity. Finally, it presents first results of comparison measurements.

KEYWORDS

Gas Filtration, Pulse jet cleaning, Baghouse Filter, Surface Filtration, Dust Emission

1. Introduction

Laboratory-scale filter test rigs according to VDI 3926 (or comparable guidelines) have been used for many years to characterise pulse jet cleaned filter media and provided many valuable insights, also with respect to emission behavior of such media [1,2]. On the other hand, there have always questions about the ability of such tests with small flat filter samples to predict the operating and emission behaviour of bag house filters. To our knowledge, such a side-by-side comparison has never been reported yet.

The paper first describes the design and operating features of a filter test rig for 3x3 filter bags 1.25 m in length, which was specially equipped with instrumentation to obtain on-line operating data such as cleaning intensity, momentary flow rate through filter bags, dust feed, and dust dispersion. It then discusses criteria for a meaningful comparison between the two very different types of equiment on the basis of direct measurements of face velocity and cleaning pulse intensity. Measurements of the transient flow velocity and pulse intensity were performed in situ on filter bags during operation. Operating parameters for the VDI test unit were derived from these measurements. Effects of redispersed dust on neighboring filters were also investigated.

2. Experimental set-up and procedures

Flat sheet filter test rigs

For the examination of the flat sheet filter discs a VDI test rig (VDI 3926, Type 1) was used. Dust is dispersed with a brush dispersing system and neutralized by a ^{85}Kr radiation source before entering the rectangular raw gas channel. The dust mass concentration is monitored online upstream of the filter disc using a continuous photometric measurement. Part of the dust loaded gas is then filtered through the flat sheet media in a cross flow arrangement. A preset maximum differential pressure between the clean and the raw gas side triggers the jet pulse cleaning in the experiments. On the clean gas side an isokinetic extraction has been installed for particle analysis with a specially calibrated optical counter [3], allowing direct measurement of PM2.5 mass emissions. Behind the blow pipe another isokinetic extraction port divides the volume flow between a pair of PM2.5 cyclones (1m^3/h) [2] and a bypass flow. The fine dust is collected on glass fiber filters following the cyclones for gravimetrical analysis of total mass concentration.

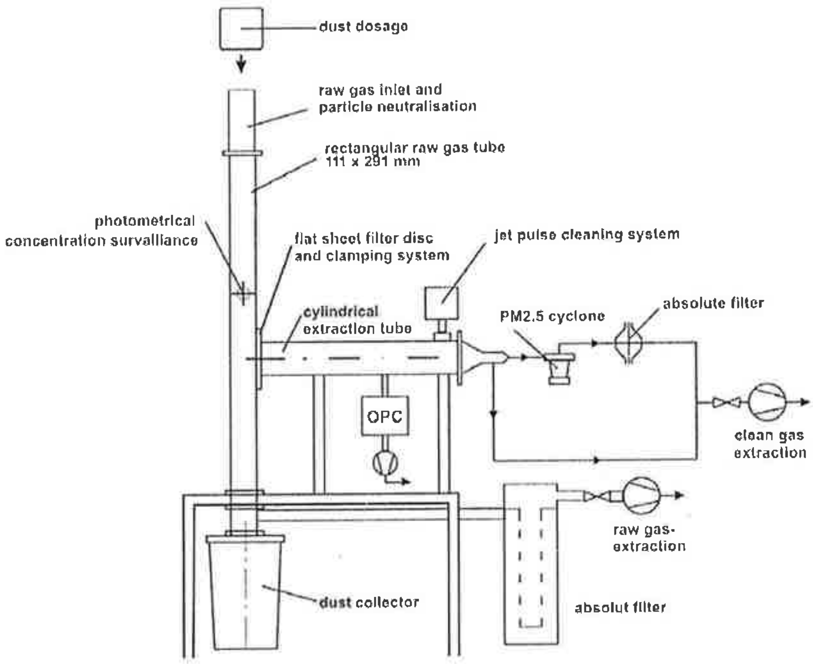

Figure 1: Schematic of flat sheet filter test rig adapted from VDI/DIN 3926 with added instrumentation for particle analysis.

The test conditions were chosen along the lines of VDI 3926: the filter face velocity was 3.3 cm/s; the particle concentration was 10 g/m³. The tank pressure for the cleaning pulse was initially 5 bar, but later adjusted according to the cleaning intensity experiments described below, in order to achieve equivalent cleaning conditions in both the VDI and the bag house test rigs. The maximum differential pressure was set to 1500 Pa above the initial pressure drop of the clean media.

Filter performance was evaluated on the basis of residual pressure drop, the duration of the filter cycle, and emitted PM2.5 mass particle per m^2 of filter surface and per cycle. In addition, the average PM2.5 concentration (averaged for each cycle) was determined from the emissions per cycle and the respective cycle duration. Total mass per cycle and average concentration characterize the filter performance in very different ways [1].

Pilot bag filter test rig

A special pilot filter unit was constructed for experiments with filter bags. It houses 3 rows of 3 filter bags (NBFH). Each bag is equipped with a separate blow pipe, tank and cleaning valve to investigate cleaning patterns. In the context of this paper, both row-by-row (RBR) cleaning and bag-by-bag (BBB) is discussed.

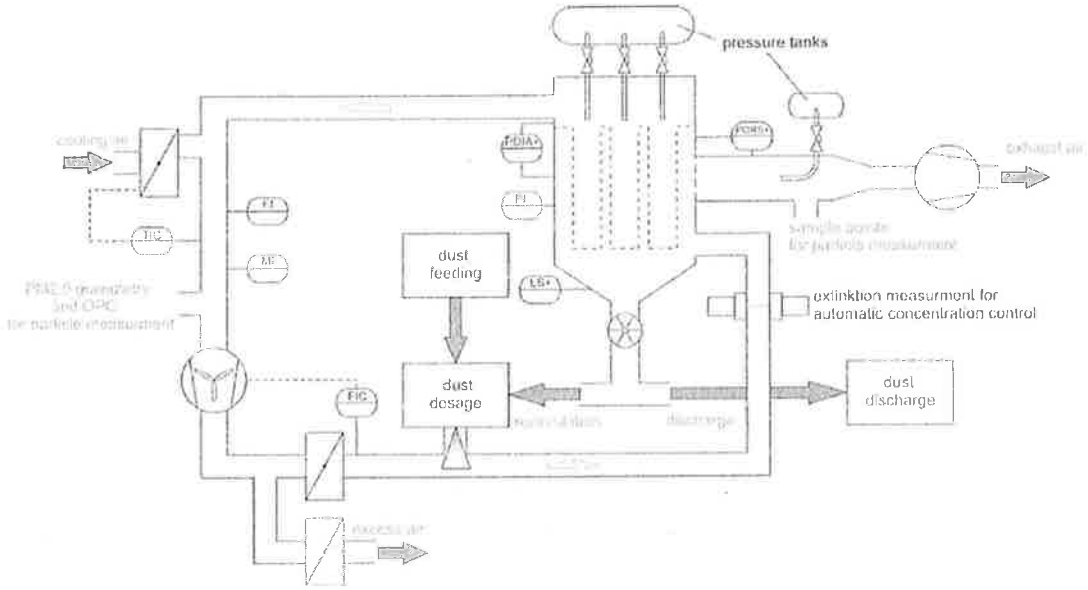

Figure 2: Schematic drawing of the pilot sized filter house test rig (NBFH).

The unit operates with recirculating air, driven by a radial-blow fan followed by flap gates for volume and temperature adjustments. Downstream of the fan the test dust is metered into the air flow via a photometric concentration measurement situated at the entrance to the filter chamber. The nine filter bags have lengths of 1.25 meters and diameters of 120 mm. They are attached to the face plate by MikroPul Venturi bayonet cut connectors. A calibrated mobile flow sensor (Schmidt Technology) is installed on one of the bayonet cut connectors which continuously measures the volume flow through the filter bag, and thus provides on-line data for its momentary average face velocity.

As seen in Fig. 2, a flat sheet filter test unit (identical in design to the clean gas section of the VDI tester) is flanged to the side of the filter chamber. This setup allows simultaneous filter tests, both of filter bags and filter discs under identical conditions, as well as the investigation of interactions between neighboring filter surfaces etc. It further facilitates the comparison between the NBFH and VDI test rig.

Time and size resolved dust emission measurements are performed downstream of both NBFH and flat sheet test component, via an isokinetic sample probe by a PM2.5 cyclone and OPC as described in the preceding section.

Test dust

PURAL SB has been used so far because it shows high particle penetration at acceptable cycle times. It is an inert material that is not harmful to health apart from known fine dust effects. It is free flowing and can easily be detached from most filter media. It does not adhere to the walls of the test rigs, allowing a continuous working process. The cumulative size distribution Q_3 of is shown below.

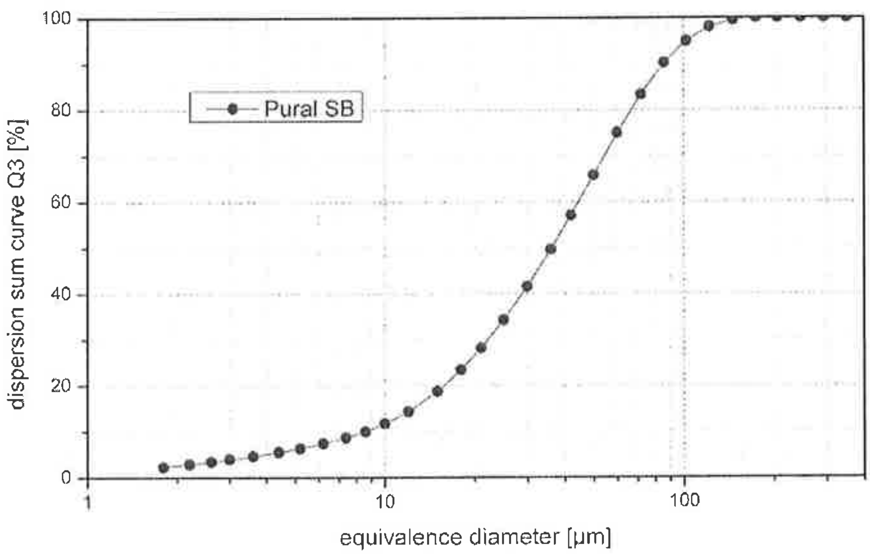

Figure 3: Cumulative volume size distribution Q_3 of the test dust measured with a laser diffraction sensor (Sympatec Helos) combined with a dispersion unit (Sympatec Rodos) operated at 0.5 bar, which best representd the low dispersing forces in the test rigs.

3. Comparison criteria and first results

Superficial velocity on filter surface

The operation of the VDI test rig and the NBFH are very different with regard to the filterface velocity: while the VDI test rig operates at a constant face velocity which is defined by filter area and volumeflow. The NBFH runs at a constant volumetric flow rate. Thus, the flow is constantly redistributed between the 9 individual filter bags, according to the chosen cleaning pattern and the momentary state of loading (i.e. permeability). This leads to characteristic transient filter face velocity cycles shown in Figure 4 for two cases. In the figure the three steps of the RBR and the nine steps of the BBB are clearly visible. The face velocity swings are less pronounced for BBB than for the RBR cleaning rhythm, because nine different loading states cause fewer variations. According to Figure 4, the face velocity on a cleaned filter bag is still about twice as high as on a loaded filter bag. This affects both the dust penetration curve of the filter media and their cleaning behavior. To evaluate the impact of this velocity boost, a separate experiment was performed in which the VDI test rig was run with adjusted face velocities.

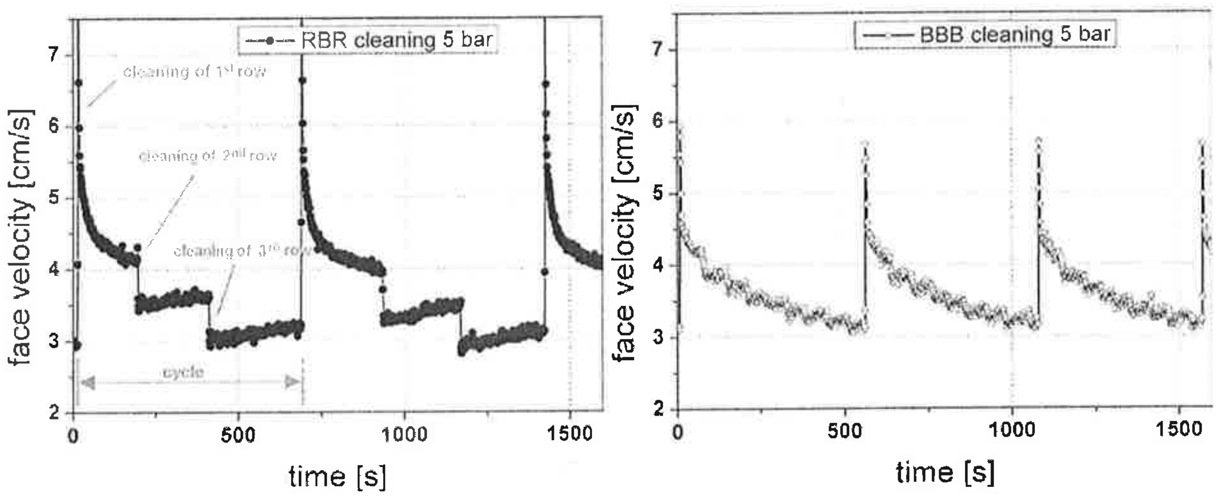

Figure 4 Surface averaged face velocity vs. time for a filter bag in the bag filter unit operated in RBR-mode and in BBB-mode.

Cleaning intensity of filter media

Another crucial difference between the two test rigs is the cleaning intensity produced by the jet pulse cleaning system, both in absolute magnitude and distribution across the filter surface. The small, flat filter disk in the VDI rig has a cleaning jet directed centrally towards its back and thus a relatively uniform pressure distribution on the surface, provided the media permeability is not too low. Filter bags in the NBFH on the other hand have a transient differential pressure during jet pulse cleaning which is time and position dependent. In addition, the cleaning may also affect neighboring bags.

As a first step toward comparable cleaning intensities in VDI and NBFH, a characteristic and accessible parameter for the cleaning efficiency was selected. Among several possible criteria, the rise rate of the transient pressure pulse was chosen for the present purpose, because it is proportional to the acceleration of the filter media, which directly correlates with the displacement of the filter cake [4,5,6]. The cleaning pulse intensity was measured in the lower third (800 mm of 1250 mm) of the filter bag by a fast pressure sensor. Figure 5 shows the transient differential pressure measured in a coated filter bag with very low air permeability (6-10 l / dm² min at 200 Pa differential pressure), which was treated to have a permeability accordingly to a dust loaded bag before cleaning.

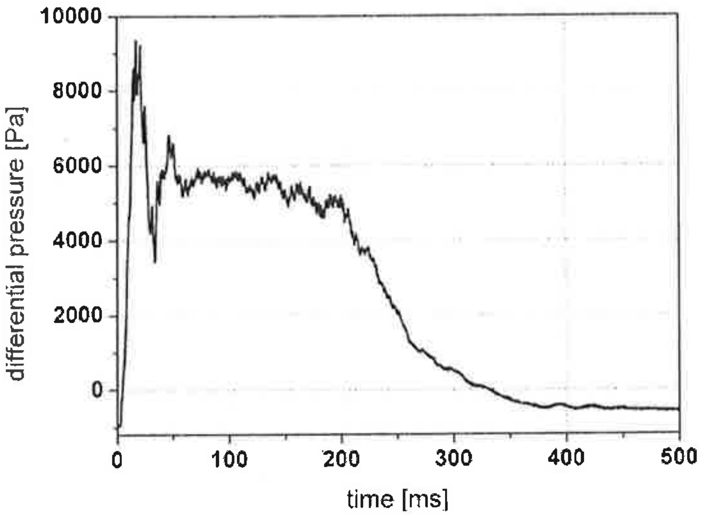

Figure 5: Transient differential pressure signal in a filter bag during a cleaning (tank pressure 5 bar), measured at the distance of 800 mm from the top.

Impact of the transient dust concentration in filter house during cleaning

The differences in design and operation of VDI and NBFH test rigs also result in a significantly different behavior of removed dust. In the VDI test rig, the cross-flow arrangement of the relatively small filter surface results in an efficient removal of both, the dislocated dust cake and the redispersed particles which results in an almost constant dust concentration on the raw gas side. However, in the NBFH each cleaning of neighboring filter bags causes a brief but significant rise in dust concentration. As it is not yet possible to measure the permeability change of an individual filter bag on-line during regular operation, the influence of these concentration peaks was investigated via the attached VDI tube. The distance between the filter disk in this VDI tube and the filter bags in the NBFH can be varied. For the experiments shown here it is identical to the minimum distance between adjacent filter bags. The Δp signal of the VDI filter (Figure 7) shows a discontinuity exactly when the cleaning of neighboring filter bags occurs. The closer the cleaned bag, the higher is the jump in the differential pressure.

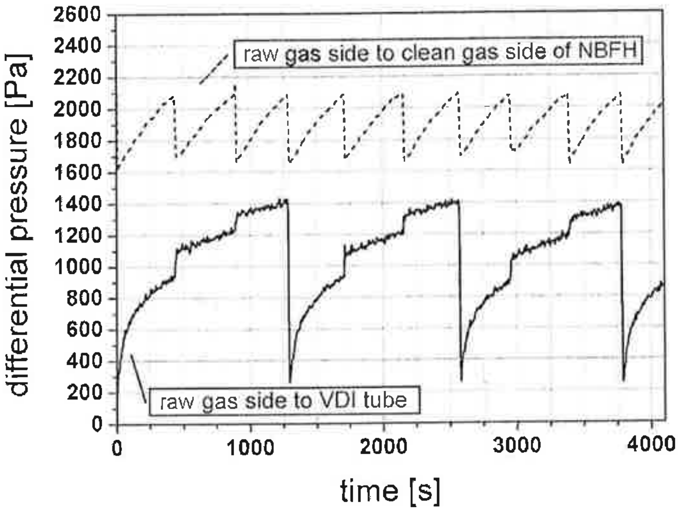

Figure 6: Comparison of differential pressures for NBFH (in RBR mode) and the VDI tube attached to the NBFH. The VDI tube is cleaned synchronously with the filter row furthest away from the flat sheet.

4. Summary

Two different sized filtration devices, a laboratory size VDI-type filter test system and a pilot sized filter bag house (the "NBFH"), are described. Both test rigs have been equipped with additional measurement installations giving access to time resolved local data like emitted particle concentrations and size distributions, flow velocities and regeneration intensities.

Differences in cleaning intensity and face velocity between the two units and their impact on filter performance are measured and discussed.

The long time goal of these studies is the development of improved testing strategies for VDI units to make them more representative for bag house filter operation, based on comparative measurements of filter operation and emission behavior.

5. Acknowledgements

The author gratefully acknowledges the European Consortium for Filtration Technology at the Karlsruhe Institute of Technology (KIT), and the AIF (Arbeitsgemeinschaft industrieller Forschungsvereinigungen) and the EFRE (Europäischer Fonds für regionale Entwicklung) for funding.

6. Literature

[1] J. BINNIG, J. MEYER, G. KASPER; Origin and mechanisms of dust emission from pulse-jet cleaned filter media; Powder Technology 189 (2009), 108-114

[2] J. BINNIG, J. MEYER, G. KASPER; Integration of cyclones an optical particle counter into a filter tester VDI 3926/Type1 to characterize PM2.5 emissions from pulse-jet cleaned filter media; Gefahrstoffe Reinhaltung der Luft, 65/4 (2005), 163-168

[3] J. BINNIG, J. MEYER, G. KASPER; Calibration of an optical particle counter to provide PM2.5 mass for well-defined particle materials; Aerosol Science 38 (2007), 325-332

[4] R. KLINGEL; Untersuchung der Partikelabscheidung aus Gasen an einem Schlauchfilter mit Druckstoßabreinigung; Fortschrittberichte VDI Reihe 3 Nr. 76.; VDI Verlag, Düsseldorf, 1983

[5] F. LÖFFLER; Staubabscheiden. 1. Auflage. Thieme, Stuttgart, 1988 (Lehrbuchreihe Chemieingenieurwesen/Verfahrenstechnik)

[6] J. SIEVERT; Physikalische Vorgänge bei der Regenerierung des Filtermediums in Schlauchfiltern mit Druckstoßabreinigung; Fortschrittberichte VDI Reihe 3 Nr. 161.; VDI Verlag, Düsseldorf, 1988