NEW SYNTHETIC NANO-AEROSOL FOR ACCELERATED REALISTIC AGEING OF AIR FILTERS

Conference Program & Show Info

FILTECH

October 22 – 24, 2019
Cologne – Germany

The Filtration Event
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Koelnmesse · Cologne · Germany

Plenary and Keynote Lectures...

... presented by leading experts

FILTECH 2019 Conference features over 200 technical papers, a Plenary Lecture and 4 Keynote Lectures presented by leading experts. Delegates profit from high-level knowledge transfer and learn about future trends and perspectives!

Digitalization of Centrifuges – Helpful or senseless?

Prof. Dr. Hermann Nirschl
Karlsruhe Institute of Technology (KIT)
Germany

During the last years digitalization was and is still a major topic in all companies of the process and machinery industry. Besides all business development procedures, the digitalization of processes seems to be a rather challenging task. Although in automotive or aviation industry the future of manufacturing ...

Enhancing Filter Media Performance during Industrial Gas Filtration

Prof. Arunangshu Mukhopadhyay
National Institute of Technology
India

The major challenge towards industrial gas filtration process is collection of finest particles by filter media with least energy and also achieving longest possible life of filter media. This leads to quite significant technological intervention for designing appropriate filter media as well as filtration system...

Air Quality Control & Aerosols

Dr.-Ing. Stefan Haep
IUTA - Institut für Energie- und Umwelttechnik
Germany

The control of gaseous and particulate emissions and immissions caused by industrial processes result in filter solutions typically qualified by standardized test methods. The control of non steady loads, typical for real life operating conditions, requires the redesign of filters and the development of advanced testing ...

Dewatering of Concentrates & Tailings – Large Scale Duties in the Mining Industry

Dr.-Ing. Götz Bickert
GBL Process Pty Ltd.
Australia

Thickening followed by vacuum or pressure filtration is usually applied for both, products (concentrates) and wastes (mine tailings) in huge quantities in the mining industry. While all three unit operations are long known and well understood, the scale but also the abrasiveness of the material still provides huge challenges...

Scientific Committee Chairmen

Dr. Harald Anlauf - Karlsruhe - Germany
Prof. Eberhard Schmidt - Wuppertal - Germany

Scientific Committee

Prof. Mônica Lopes Aguiar - São Carlos - Brazil
Dr. Harald Banzhaf - Ludwigsburg - Germany
Prof. Ching-Jung Chuang - Taoyuan - Taiwan
Prof. Kyung-Ju Choi - Seoul - Korea
Prof. Achim Dittler - Karlsruhe - Germany
Prof. Dr. Kunihiro Fukui - Hiroshima - Japan
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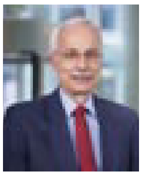
Prof. Leon Gradon - Warsaw - Poland
Prof. Antti Häkkinen - Lappeenranta - Finland
Prof. Eiji Iritani - Nagoya - Japan
Prof. Chikao Kanaoka - Tsubata - Japan
Prof. Gerhard Kasper - Karlsruhe - Germany
Dr. Karsten Keller - Milford - USA
Ir. Hermanes Kleizen - Hengelo - Netherlands
Prof. Gernot Krammer - Graz - Austria
Dr. Thomas Laminger - Vienna - Austria
Dr. Martin Lehmann - Ludwigsburg - Germany
Prof. Markus Lehner - Leoben - Austria
Prof. Dietmar Lerche - Berlin - Germany
Prof. Woon-Fong Wallace Leung - Hong Kong - P.R. China
Prof. Richard Lydon - Haslingden - UK
Dr. Hisao Makino - Yokosuka - Japan
Prof. Gerd Mauschitz - Vienna - Austria
Prof. Arunangshu Mukhopadhyay - Jalandhar - India
Prof. Ioannis Nicolaou - Cyprus
Prof. Hermann Nirschl - Karlsruhe - Germany
Dr. Thomas Peters - Neuss - Germany
Prof. Urs Peuker - Freiberg - Germany
Dr. Graham Rideal - Waverton - UK
Prof. Sandra Mara Santana Rocha - Espirito Santo - Brazil
Prof. Peter Scales - Parkville - Australia
Dr. Christine Sun - Clarksville - USA
Prof. Hans-Joachim Schmid - Paderborn - Germany
Dr. Anthony Stickland - Melbourne - Australia
Prof. Hans Theliander - Gothenburg - Sweden
Prof. Dominique Thomas - Nancy - France
Prof. Bhaskar N. Thorat - Mumbai - India
Prof. Paolo Tronville - Torino - Italy
Prof. Kuo-Lun Tung - Taipei - Taiwan
Prof. Eugène Vorobiev - Compiègne - France
Dr. Matthias Waldenmaier - Kaiserslautern - Germany



Plenary Lecture

Centrifugation – Key Technology for Solid/Liquid/Liquid Separation

Dr. Harald Anlauf

Karlsruhe Institute of Technology (KIT) / Germany

Particle/liquid separation can be focused on very different tasks like thickening, purification, fractionation, sorting, extraction or deliquoring. The separation has to be mastered for wide ranges of particle size and shape, specific solid and liquid weight, slurry concentration, chemical composition and rheology, flow rate, process and technical boundary conditions and last but not least demands on the separation results. To solve all the separation problems beside centrifuges many physically different methods and in total more than 2000 different apparatuses and machines are available at present, but always new developments can be observed…

Session Overview

Monday 21.10.2019 09:00-18:00h
Short Course I · Solid/Liquid Separation
Short Course II · Fine Dust Separation

Tuesday, 22.10.2019

08:30	Registration				
10:15	Opening Session				
10:45 12:00	PL Plenary Lecture – Dr. Harald Anlauf, Academic Director – Karlsruhe Institute of Technology (KIT) / Germany Centrifugation – Key technology for solid/liquid/liquid separation				
	Lunch – Fair				
	Room 1A – 1st floor	Room 1B – 1st floor	Room 2 – 2nd floor	Room 4A – 4th floor	Room 4B – 4th floor
13:00 14:15	K1 Digitalization of Centrifuges – Helpful or senseless?	L1 Particle and Slurry Characterization	M1 Membrane Design and Characterization	G1 Air Filtration	F1 Enhancement of Filter Media by Surface Treatment
	Coffee Break – Fair				
14:45 16:00	K2 Enhancing filter media performance during industrial gas filtration	L2 Particle, Slurry and Cake Characterization	M2 Micro and Ultra Filtration	G2 Cabin Air Filters	F2 Progress in Wire Mesh Development
	Coffee Break – Fair				
16:45 18:00	L3 Cake Filtration - Influences on the Cake Structure	L4 Wet Particle Fractionation	F3 Advanced Filter Media Developments and Manufacturing Methods	G3 Gas and Particle Separation	G4 Mist and Droplet Separation
18:00	Welcome Reception				

Wednesday, 23.10.2019

	Room 1A – 1st floor	Room 1B – 1st floor	Room 2 – 2nd floor	Room 4A – 4th floor	Room 4B – 4th floor
09:00 10:15	L5 Cake Filtration - Characterization, Modelling, Scale-up	G5 Surface Filtration I	M3 Separation of Complex Systems	F4 Quality Control and Pore Size Analysis of Filter Media	F5 Bio-Inspired Innovation of Separation
	Coffee Break – Fair				
10:45 12:00	K3 Air Quality Control & Aerosols	L6 Cake Filtration - Characterization, Modelling, Simulation	M4 Ceramic Membranes and Fouling	G6 Surface Filtration II	F6 Performance Improvements of Nonwovens
	Lunch – Fair				
13:00 14:15	K4 Dewatering of concentrates & tailings in the mining industry	L7 Cake Filtration - Particle Washing	M5 Process and Waste Water Treatment	G7 Filter Test Systems I	F7 Advanced Composite Fiber Materials
	Coffee Break – Fair				
14:45 16:00	L8 Short Oral	L9 Short Oral	M6 Short Oral	G8 Short Oral	G9 Short Oral
16:00 16:45	Poster Presentation	Poster Presentation	Poster Presentation	Poster Presentation	Poster Presentation
16:45 18:00	L10 Centrifugal Sedimentation Decanter Centrifuges	L11 Centrifugal Cake Filtration	F8 Micro and Nanofiltration Media	G10 Filter Test Systems II	G11 Modelling and Simulation

Thursday, 24.10.2019

	Room 1A – 1st floor	Room 1B – 1st floor	Room 2 – 2nd floor	Room 4A – 4th floor	Room 4B – 4th floor
09:00 10:15	L12 Cake Filtration - Continuous Vacuum Filters	L13 Depth Filtration and Adsorption - Granular Beds	F9 Filter Media - Modelling, Artificial Intelligence, Machine Learning	G12 Measurement Techniques I	G13 Filter Element Design
	Coffee Break – Fair				
10:45 12:00	L14 Cake Filtration - Enhancement of Filter Presses	L15 Depth Filtration and Adsorption-Modelling and Simulation	F10 Numerical Analysis of Filter Media Pore Size and Structure	G14 Measurement Techniques II	G15 Filter Medium Design
	Lunch – Fair				
13:00 14:15	L16 Dewaterability of Sludges	L17 Backwashing Filtration	L18 Froth Flotation and Liquid/Gas Separation	G16 Particles for Filter Testing	F11 Numerical Methods for Filter Media Characterization & Improvement
	Coffee Break – Fair				

	Room 1A – 1st floor	Room 2A – 1st floor	Room 4A – 4th floor	Room 4B – 4th floor
14:45 16:00	L19 Liquid/Liquid Separation	L20 Enhancement of Backwashing and Cake Filtration Performance	G17 Monitoring and Control	F12 Advanced Filter Media for Gas Filtration

Programme is subject to amendments. Up-to-date Programme is available at www.Filtech.de

FILTECH 2019 · Conference Programme

Tuesday, October 22, 2019

08:30-10:15 Registration

10:15 - 10:45 Opening Session

PL Plenary Lecture — 10:45–12:00, room 1A

Centrifugation – Key technology for solid/liquid/liquid separation, Dr. Harald Anlauf, Karlsruhe Institute of Technology (KIT), Germany

K1 Keynote Lecture 1 — 13:00–14:15, room 1A
Session Chair: Harald Anlauf

Digitalization of Centrifuges – Helpful or senseless?, Prof. Dr. Hermann Nirschl, Karlsruhe Institute of Technology (KIT), Germany

L1 Particle and Slurry Characterization — 13:00–14:15, room 1B
Session Chair: Anthony Stickland

Identification and size measurement of plastic microparticles, R. Ben Aïm*, N. Petillon, IFTS - Institute of Filtration & Techniques of Separation; C. Causserand, University of Toulouse, France, I. Robertson, Perkin Elmer Ltd, UK

Measuring solid/liquid separation of viscous polydisperse suspensions at gravity and in centrifugal field, T. Sobisch*, LUM GmbH, D. Lerche, LUM GmbH / Dr. Lerche KG, T. Koch, Kronos International Inc, Germany

Off- and in-line monitoring of processed milk by MRS-Technology, P. Dumeier, D. Lerche*, LUM GmbH; K.-H. Mittenzwey, G. Sinn, Optosphere Spectroscopy GbR, Germany

M1 Membrane Design and Characterization — 13:00–14:15, room 2
Session Chair: Allan Kuo-Lun Tung

High-pressure operation of spiral wound membrane elements: The relevant aspect of permeate channel fluid dynamics, C. Kleffner*, G. Braun, University of Applied Science Cologne; S. Antonyuk, Technische Universität Kaiserslautern, Germany

Flexible polymeric filters with low tortuosity produced in a roll to roll process, L.C. Sørvik*, M.-A. Raux, G. Osborg, H. Hemmen, Condalign AS, Norway

The effect of membrane structure prepared from carboxymethyl cellulose and cellulose nanofibrils for filtration and biochromatographic separation, V. Kokol*, S. Gorgieva, V. Vivod, S. Vajnhandl, University of Maribor; T. Simcic, U. Cernigoj, BIA Separations d.o.o., Slovenia

G1 Air Filtration — 13:00–14:15, room 4A
Session Chair: Dominique Thomas

Back cleanable air filter elements for critical dust systems – US HEPA, IFA H and EN1822 HEPA, M. Wilkens*, Hengst SE, Germany

Energy efficient media solution for eurovent A+ rated filters, C. Desquilles*, P. Blanckaert, Lydall Performance Materials SAS, France; R. Bharadwaj, Lydall Performance Materials, USA

Filtration performance of PAN fiber produced by centrifugal spinning using DMSO and DMF as solvent, A.I.P. Salussoglia*, M.L. Aguiar, Federal University of São Carlos; E.H. Tanabe, Federal University of Santa Maria, Brasil

F1 Enhancement of Filter Media by Surface Treatment — 13:00–14:15, room 4B
Session Chair: Christine Sun

Advances in plasma deposition of functional nanocoatings for filtration applications, F. Legein*, S. Loulidi, Europlasma NV, Belgium

Filter cloths: Bluetes anti-abrasion resin, D. De Angelis*, L.I. Balzaretti, M. Motta, M. Reginato, Testori S.p.A., Italy

Surface modification of RO membrane by grafting hydrophilic switchable polymer brushes, M.A. Abbas, N.M. Ahmad*, National University of Sciences and Technology (NUST), Pakistan

K2 Keynote Lecture 2 — 14:45–16:00, room 1A
Session Chair: Eberhard Schmidt

Enhancing filter media performance during industrial gas filtration, Prof. Dr. Arunangshu Mukhopadhyay, National Institute of Technology, Jalandhar, India

L2 Particle, Slurry and Cake Characterization — 14:45–16:00, room 1B
Session Chair: Dietmar Lerche

The effect of normal load on the shear yield stress of suspensions, A.D. Stickland*, E. Höfgen, The University of Melbourne, Australia

Monitoring technique for mechanical expression using electrokinetic response caused by liquid flow through filter cake, M. Iwata*, K. Shimoizu, T. Iwasakia, Osaka Prefecture University, Japan; M.S. Jami, Islamic University Malaysia, Malaysia

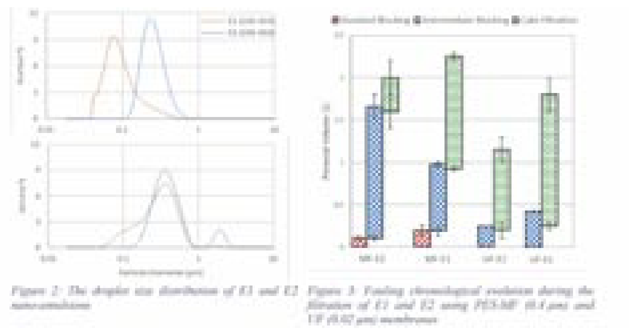
The influence of bimodal particle systems on filter cake structures using micro tomography, E. Löwer*, F. Pfaff, T. Leißner, U.A. Peuker, Technical University Bergakademie Freiberg, Germany

M2 Micro and Ultra Filtration — 14:45–16:00, room 2
Session Chair: Christine Sun

Interaction between polysaccharide and protein on membrane fouling caused by microbial metabolite, N. Katagiri*, R. Matsuyama, E. Iritani, Nagoya University, Japan

Effect of aeration on hollow fiber microfiltration characteristics of activated sludge, K. Kawasaki*, H. Hosokawa, A. Minakuchi, Ehime University, Japan

Influence of oil droplet size distribution on the fouling mechanisms of UF/MF membranes during filtration of oil nano-emulsions, H. Idrees*, M. Abo Zohri, I. ElSherbiny, S. Panglisch, University Duisburg-Essen (UDE), Germany



G2 Cabin Air Filters — 14:45–16:00, room 4A
Session Chair: Martin Lehmann

Cabin air quality and energy savings in electric vehicles by using a smart filtration system, M. Lesage*, D. Chalet, Ecole Centrale de Nantes; L. del Fabbro, E. Le Nain, Renault SAS, J. Migaud*, MANN+HUMMEL France; D. Ebnet, MANN+HUMMEL GmbH, Germany

Test of cabin filters, S. Holfeld*; R. Heidenreich, Institute of Air Handling and Refrigeration (ILK), Germany

Maximising comfort and minimising pollutant exposure in the vehicle cabin using the ventilation system, T. Cardy*, N. Molden, Business Development Manager, Emissions Analytics Ltd, UK

F2 Progress in Wire Mesh Development
Session Chair: Graham Rideal — 14:45–16:00, room 4B

New developments in woven wire filtration media: 3D high perfomance filter cloth; Woven wire mesh combinations in solid-liquid separation, F. Edelmeier*, F. Meyer, Haver & Boecker OHG, Germany

Energy reducing polymeric filtration mesh, J. Kidwell, J. Ferrer, J. Kirk*, SWM International, USA

Multipore™: The state-of-the-art wire mesh, S. Vandendijk*, Parker Hannifin Purolator, Belgium

L3 Cake Filtration - Influences on the Cake Structure
Session Chair: Urs Peuker — 16:45–18:00, room 1A

Investigation of filter cake characteristics regarding particle shape and wettability, M. Brockmann*, T. Leißner, U. A. Peuker, Technical University Bergakademie Freiberg, Germany

Understanding the role of cake structure in the filtration of needle-like crystals in the pharmaceutical industry, G. Perini*, C. Avendaño, T. Vetter, University of Manchester; W. Hicks, A.R. Parsons, AstraZeneca, UK

Evaluation of process strategies to homogenize the lautering filter cake structure and enhance wort production, P.M. Bandelt Riess*, M. Kuhn, H. Briesen, P. Först, Technical University of Munich, Germany

L4 Wet Particle Fractionation
Session Chair: Hermann Nirschl — 16:45–18:00, room 1B

Centrifugal Classification: In-situ Method to determine Separation Efficiency by UV-VIS Spectroscopy, M. Winkler*, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

Automation of particle classification in a tubular centrifuge based on a dynamic short-cut process model, T. Sinn*, M. Gleiß, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

Fractionating of finest particles using the crossflow filtration, P. Lösch*, V. Puderbach, K. Nikolaus, S. Antonyuk, Technische Universität Kaiserslautern, Germany

F3 Advanced Filter Media Developments and Manufacturing Methods
Chair: Harald Anlauf — 14:45–16:00, room 2

High speed laser drilling of precise micro and nano holes in metallic surface filters, T. Barthels*, H. Westergerling, M. Reininghaus, Fraunhofer Institute for Laser Technology ILT, Germany

Augmented filter media development by virtual prototype optimization, T. Gose*, A. Kilian, H. Banzhaf, F. Keller, R. Bernewitz, MANN+HUMMEL GmbH, Germany

Exentis Group AG: Industrialized additive manufacturing, S. Vasic*, Exentis Group AG, Germany

G3 Gas and Particle Separation
Session Chair: Gerhard Kasper — 16:45–18:00, room 4A

Simultaneous dust and noxious gas separation in an entrained-flow adsorber on surface filters, F. Prill, S. Schiller, H.-J. Schmid*, University of Paderborn; M. König, I. Hartmann, DBFZ Deutsches Biomasseforschungszentrum gGmbH, Germany

A new PM2.5 assessment for a gas-liquid cross-flow array system as dust separator, W. Wei*, H. Yu, J. Zhu, Sichuan University, China; T. Laminger, W. Höflinger, Technical University of Vienna, Austria

Influence of the deliquescence and efflorescence of hygroscopic salt particles on the performance of surface filters, D. Horst*, Q. Zhang, E. Schmidt, University of Wuppertal, Germany

G4 Mist and Droplet Separation
Session Chair: Eberhard Schmidt — 16:45–18:00, room 4B

Characterization of performance relevant media properties in oil mist filtration, T. Penner*, J. Meyer, A. Dittler, Karlsruhe Institute of Technology (KIT), W. Heikamp, BinNova Microfiltration GmbH, Germany

Reducing pressure drop of coalescence filtration media by patterned modification of wettability, M. Wittmar*, W. Mölter-Siemens, K. Varzandeh, C. Asbach, Institute for Energy and Environmental Technology e.V. (IUTA); L. Tsarkova, T. Bahners, B. Gerbert, DTNW - Deutsches Textilforschungszentrum Nord-West gGmbH, Germany

New physical principle of dilution system for crankcase ventilation filter testing, S. Schütz*, M. Schmidt, PALAS GmbH, Germany

Wednesday, October 23, 2019

L5 Cake Filtration - Characterization, Modelling, Scale-up
Chair: Anthony Stickland — 09:00–10:15, room 1A

The effect of particle sedimentation on the performance of pressure filters, I.S. Fragkopoulos, F.L. Muller, University of Leeds; N.A. Mitchell, G. Jimeno*, Process Systems Enterprise (PSE) Ltd.; C.S. MacLeod, AstraZeneca; S. Mathew, Pfizer, UK

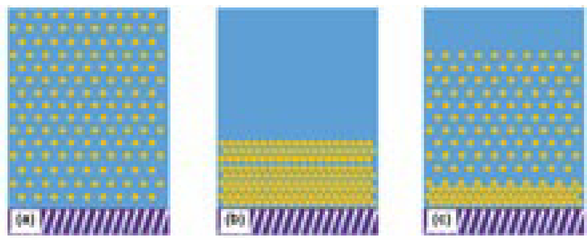


Figure 2: Schematic representation of slurry in systems with (a) no crystal sedimentation prior to filtration, (b) entire crystal sedimentation prior to filtration and (c) partial crystal sedimentation prior to filtration.

FILOS – Module I: The novel software for the reliable analysis of filtration test data and suspension characterization including washing and deliquoring of filter cakes, I. Nicolaou*, NIKIFOS Ltd , Cyprus

FILOS – Module II: The novel software for the reliable selection, performance prediction and optimization of filters for the cake forming filtration of suspensions, I. Nicolaou*, NIKIFOS Ltd, Cyprus

G5 Surface Filtration I
Session Chair: Qian Zhang — 09:00–10:15, room 1B

Cleanable filter media go close to zero emission, H.-J. Imminger*, P. Krug, BWF Tec GmbH & Co. KG, Germany

Investigating the cleaning efficiency of filters clogged with metallic nanoparticles, N. Khirouni*, D. Bemer, Institut National de Recherche et de Sécurité (INRS); A. Charvet, D. Thomas, Lorraine University, France

New test method for bag house filters, R. Heidenreich*, A. Böhme, S. Herrmann, Institute of Air Handling and Refrigeration (ILK), Germany

14.10.2019

M3 Separation of Complex Systems 09:00–10:15, room 2
Session Chair: Thomas Peters

Technical extraction of EPS from streptococcus thermophilus by dynamic cross-flow filtration on a pilot scale, F. Häffele*, H. Nirschl, Karlsruhe Institute of Technology (KIT); J. Bulla, G. Surber, D. Jaros, H. Rohm, Technical University Dresden (TUD), Germany

Bagasse extracts fractionation by combination of membrane and chromatographic technologies, P.-Y. Pontalier*, V. Oriez, J. Peydecastaing, ENSIACET, France

Sustainable production in the metal industry – Separation of valuable components from acidic effluents, F. Rögener*, Technical University Cologne, Germany; J. Lednova, M. Andrianova, Polytechnical University Peter the Great, Russia

F4 Quality Control and Pore Size Analysis of Filter Media 09:00–10:15, room 4A
Session Chair: Antti Häkkinen

Optical quality control of filter media: MIDA X makes hidden defects visible, H. Oerley*, Dr. Schenk GmbH, Germany

Measuring the maximum pore size of a filter, choosing the most statistically robust parameter, K.G. Brocklehurst, G.R. Rideal*, Whitehouse Scientific Ltd, UK

Characterisation of micron pore size filter media comparison of methods, G.R. Rideal*, Whitehouse Scientific Ltd, UK; A. Häkkinen, M. Ängeslavä, Lappeenranta University of Technology (LUT), Finland

F5 Bio-Inspired Innovation of Separation 09:00–10:15, room 4B
Session Chair: Harald Anlauf

Bionics in application: Superhydrophobic functional textiles for the removal of oil contamination from water, I. Noll*, M. Akdere, T. Gries, RWTH Aachen University; M. Mail, W. Barthlott, University of Bonn, Germany

Bio-inspired separation - Formulation of an innovation model and ideation tool to boost innovation in the sector of separation technology, A. Bianciardi*, Politecnico di Milano, Italy

A biomimetic approach for separating microplastics from water, L. Hamann*, Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany

K3 Keynote Lecture 3 10:45–12:00, room 1A
Session Chair: Eberhard Schmidt

Air Quality Control & Aerosols, Dr.-Ing. Stefan Haep, Institute for Energy and Environmental Technology e.V. (IUTA), Germany

L6 Cake Filtration - Characterization, Modelling, Simulation 10:45–12:00, room 1B
Chair: Urs Peuker

Network model of porous media - Review of old ideas with new methods, S. Esser*, E. Löwer, U.A. Peuker, Technical University Bergakademie Freiberg, Germany

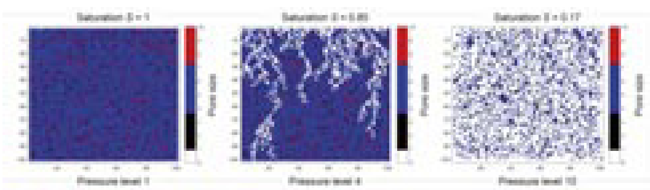


Figure 1: Dewatering equilibrium at different applied pressure levels

Numerical and experimental investigation of filter cake formation during solid-liquid separation by resolved CFD-DEM coupling, V. Puderbach*, S. Antonyuk, Technische Universität Kaiserslautern; K. Schmidt, IT for Engineering (it4e) GmbH, Germany

Simulation based analysis of the multi-stage filter cake washing, T. Sprott*, A. Brückner, B. Hoffner, University of Applied Sciences Mannheim, Germany

M4 Ceramic Membranes and Fouling 10:45–12:00, room 2
Session Chair: Qian Zhang

Ceramic membrane system for drinking water application operating with high flux, M. Kaschek, M. Sartor*, CERAFILTEC Germany GmbH Blue Filtration, Germany; K.G. Gabriel, CERAFILTEC FZCO, Dubai

Improved fouling resistance of ceramic membranes using organic/inorganic modification for water purification, J. Lee*, J.-H. Ha, I.-H. Song, Korea Institute of Materials Science (KIMS), Korea

Impact of insufficient membrane and filter properties: Fouling and functionalization, B. Arlt*, Anton Paar Germany GmbH, Germany; T. Luxbacher, Anton Paar GmbH, Austria

G6 Surface Filtration II 10:45–12:00, room 4A
Session Chair: Monica Aguiar

A comparative investigation of soluble filter cakes upon contact with liquid droplets, A. D. Schwarz*, J. Meyer, A. Dittler, Karlsruhe Institute of Technology (KIT), Germany

Measurement of the porosity of spherical particle deposit formed by filtration: Discussion on the Peclet number effect, J. Nuvoli*, S. Bourrous, F.-X. Ouf, D. Thomas, Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France

Pressure drop evolution during dust loading of hollow-fiber membranes, P. Bulejko*, O. Krištof, T. Sverák, Brno University of Technology; M. Dohnal, Zena Membranes s.r.o., Czech Republic

F6 Performance Improvements of Nonwovens 10:45–12:00, room 4B
Session Chair: Kyung-Ju Choi

New development in bag filtration, C. Rodwewald, D. Steinberger*, PALL GmbH, Germany

Combinatorial optimization of double-layered filtration media for higher performance, J.R. Gorle*, Parker Hannifin, Finland

Flow resistance evaluation through nonwoven filter media, K.-J. Choi*, Clean & Science Co., Ltd., USA

K4 Keynote Lecture 4 13:00–14:15, room 1A
Session Chair: Roger Ben Aim

Dewatering of concentrates and tailings – Large scale duties in the mining industry, Dr.-Ing. Götz Bickert, GBL Process Pty Ltd, Australia

L7 Cake Filtration – Particle Washing 13:00–14:15, room 1B
Session Chair: Ioannis Nicolaou

Washing performance prediction of horizontal vacuum belt filters for different wash modes, G. Krammer*, Graz University of Technology; R. Raberger, Andritz AG, Austria

Characterization and simulation of displacement washing processes in filter cakes, B. Hoffner*, University of Applied Sciences Mannheim, Germany

Dewatering and imbibition effects on the multi-stage cake washing, A. Brückner*, T. Sprott, B. Hoffner, University of Applied Sciences Mannheim, Germany

M5 Process and Waste Water Treatment
13:00 – 14:15, room 2
Session Chair: Wilhelm Höflinger

Recent developments in industrial wastewater treatment by aerobic and anaerobic Membrane Bioreactors, F. Rögener*, M.P. Betz, L. Papendorf, S. Steinhauser, Technical University Cologne, Germany

Membrane bioreactor as polishing step in the treatment of galvanic wastewater, B. Mayr*, T. Garstenauer, EnviCare Engineering GmbH, Austria

Cost-optimized sustainable water management in the mining industry based on membrane processes, T. Peters*, Membrane Consulting, Germany

G7 Filter Test Systems I
13:00 – 14:15, room 4A
Session Chair: Thomas Peters

Filter media testing in accordance with ISO 16890, M. K. Schmidt*, PALAS GmbH, Germany

Two years of filter testing experiences according to new ISO 16890, C. Kappelt*, A. Rudolph, C. Peters, S. Große, Topas GmbH, Germany

Aspects of air filter testing: dust loading, M. Stillwell*, Particle Technology Ltd, UK

F7 Advanced Composite Fiber Materials
13:00 – 14:15, room 4B
Session Chair: Graham Rideal

Sinterflo® FMC (fibre metal composite) – Development and application, B. Allbutt*, Porvair Filtration Group Ltd, UK; A. Goux*, Bekaert Fiber Technologies, Belgium

The advantages of metal fiber media for aircraft hydraulic filtration, J. De Baerdemaeker, A.Goux, M. Van Hooreweder*, J. Mothersbaugh, Bekaert Fiber Technologies, Belgium

Methods to increase the filtration performance of metal woven wire cloths, M. Müller*, Spörl KG, Germany

L8 Short Oral + Poster Presentation
14:45 – 16:00, room 1A
Session Chair: Wilhelm Höflinger

Characterization and Simulation of Porous Structures

Combined porous mesh for filters and capillary fencing devices, V. A. Devisilov*, Yu. M. Novikov, V.A. Bol'shakov, Bauman Moscow State Technical University, Russia,

Geometrical model of the porous structure of the permeable material and the new experimental method of determinig its structural characteristics, V. A. Devisilov*, A.L. Sintsov, E. Yu. Sharai, Bauman Moscow State Technical University, Russia

Characterization of Porous Materials to Meet Regulatory Demands

Addressing liquid filtration regulatory complexity with HACCP, F. Lybrand*, C. Rich, T. Vest, Hollingsworth and Vose Company, USA

Depth Filtration and Adsorption

Metal porous filter development using additive manufacturing, N. Burns*, D. Travis, L. Geekie, A. Molyneux, Croft Additive Manufacturing Ltd; M. Burns, Croft Filters Ltd, UK

Design of a multi-purpose fuel filter sytem to better understand the challenges of biodiesel filtration, B. Csontos*, H. Bernemyr, A. Christiansen Erlandsson, KTH Royal Institute of Technologies; M. Pach, H. Hittig, Scania CV AB, Sweden

A probabilistic-statistical model of change in particle size distribution in fine filters, A.N. Grechushkin*, V.A. Lvov, Bauman Moscow State Technical University, Russia

Adsorption of humic acid from aqueous solution onto Fe_3O_4 magnetite: effect of temperature, M.A. Zulfikar*, A. Rizqi Utami, M. Yudhistira Azis, H. Setiyanto, Bandung Institute of Technology, Indonesia

L9 Short Oral + Poster Presentation
14:45 – 16:00, room 1B
Session Chair: Harald Anlauf

Backwashing filters

HETA smart filtration 4.0, H. Hensel*, HETA Verfahrenstechnik GmbH, Germany

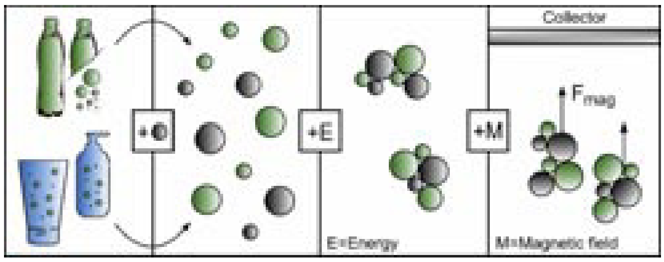
Self Cleaning Filters

Filtering of high solids concentration media using complex powerful to the flow, E.Y. Sharai*, V.A. Devisilov, Bauman Moscow State Technical University, Russia

Simulation of solid particle separation in self-cleaning filter with dynamic filtration, E.Y. Sharai*, V.A. Devisilov, Bauman Moscow State Technical University, Russia

Magnetic Separation

Applied colloidal aggregation: Separation of fine polymer particles from dilute suspensions by magnetic seeded filtration (Microplastics), F. Rhein*, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany



Electrochemical Water Treatment

Electrodegradation of methylene blue using Ce(IV) mediated electrochemical oxidation: Effects of supporting electrolyte, potential oxidation and degradation time, H.Setiyanto*, F.M. Sari, M.A. Zulfikar, Bandung Institute of Technology; V. Saraswaty, Indonesian Institute of Sciences; N. Mufti, State University of Malang, Indonesia

Separation of crude oil from crude oil contaminated water using biowaste-waste polythene composite, K.A. Ibe*, E.E. Elemike, B.C. Okoro, Federal University of Petroleum Resources Effurun, Nigeria

M6 Short Oral + Poster Presentation
14:45 – 16:00, room 2
Session Chair: Thomas Peters

Effect of ethanol concentration on filter cake characteristics in microfiltration of yeast suspension, N. Katagiri*, K. Tomimatsu, E. Iritani, Nagoya University, Japan

Combination of ultrafiltration (UF) and powdered activated carbon (PAC) to remove micropollutants, antibiotic resistant bacteria and phosphorus from wastewater, M. Werner*, MICRODYN-NADIR GmbH, Germany

Microsand cross flow filtration in cooling towers water circuit – a sustainable approach for hvac systems, S. Roel Backes*, Evoqua Water Technologies GmbH, Germany

Application of antifouling filter media based on nanofibres in liquid filtration, I. Vincent*, D. Kimmer, L. Lovecka, M. Kovarova, L. Musilova, D. Vesela, Tomas Bata University, Czech Republic

Integration of functional transmembrane proteins into a membrane for nanofiltration, M. Schwieters*, M. Mathieu, U. Glebe, A. Böker, Fraunhofer Institute for Applied Polymer Research IAP, Germany

Measuring methods for nano filtration membranes and filter materials, X. Puntigam, M. Kalmutzki, P. Pavlov, B. Arlt*, Anton Paar Germany GmbH, Germany

Effect of spacer orientation on the performance of direct contact membrane distillation, Y. Taamneh*, Jordan University of Science and Technology, Jordan

Analytical photo-centrifugal filtration (ACF): Membrane resistance and filterability, S. Boldt, D. Lerche*, LUM GmbH, Berlin, Germany; M. Loginov, UMR STLO, INRA–Agrocampus Ouest, France

G8 Short Oral + Poster Presentation

Session Chair: Jörg Meyer — 14:45–16:00, room 4A

Simulation and experiments on the cake formation in dust filtration with fabric filters, Q. Zhang*, D. Horst, E. Schmidt, University of Wuppertal, Germany

Experiments on the rearrangement behaviour of dust in wall flow filters, S. Jüttermann*, M. Kaul, E. Schmidt, University of Wuppertal, Germany

Investigation of the filtration kinetics of depth filter considering tomographic data, K. Hoppe*, Anhalt University of Applied Sciences; R. Zielke, L. Wischemann, G. Schaldach, W. Tillmann, M. Thommes, D. Pieloth, Dortmund University; D. Renschen, DMT GmbH &Co.KG, Germany

A new set-up for characterisation of particle and agglomerate detachment from an elastic single fibre exposed to air flow at low velocity, L. Poggemann*, F. Klingel, J. Meyer, A. Dittler, Karlsruhe Institute of Technology (KIT), Germany

Experimental characterization of reactive particle structure re-arrangement and detachment from a single fibre exposed to hot air flow, J. Zoller*, J. Meyer, A. Dittler, Karlsruhe Institute of Technology (KIT), Germany

Round robin test to evaluate the test method according to ISO 16890 – Air filters for general ventilation, T. Schuldt*, F. Schmidt, University Duisburg-Essen (UDE); E. Däuber, T. Engelke, Institute for Energy and Environmental Technology e.V. (IUTA), Germany

Generation and characterisation of reactive and inert aerosols, J. Thieringer*, H. Werling, J. Meyer, A. Dittler, Karlsruhe Institute of Technology (KIT), Germany

Characterization of an electrostatically charged water spray for reducing fine dust emissions, M. Zillgitt*, E. Schmidt, University of Wuppertal, Germany

Experimental methods in dust emission prediction, N. Schwindt*, E. Schmidt, University of Wuppertal, Germany

Industrial tests of filter bags "3DESA filtrpatron" with increased filtering area, V.V. Chekalov*, DESA Co. Ltd., Russia

Dust filtration, removing volatile organic compounds of waste tire recycle process, U. Kohowala*, Sigma Technologies, Sri Lanka

G9 Short Oral + Poster Presentation

Session Chair: Gerd Mauschitz — 14:45–16:00, room 4B

Experimental assessment of deposition of synthetic fibrous dust within the ductwork of residential ventilation systems, N. Alessandria, S. Sedlar, G. Mauschitz, T. Laminger*, Technical University of Vienna; A. Svec, Fa. Adalbert Svec, Germany

Controlling specific properties of paper wet laids for air filtration by means of hydro-entanglement, R. Heidenreich*, Institute of Air Handling and Refrigeration (ILK); T. Schulze, Thüringisches Institut für Textil- und Kunststoff-Forschung e.V.; F. Gebauer, Papiertechnische Stiftung (PTS), Germany

Deodorizing filters containing visible light photocatalysts for air purifiers, Y. Lee*, H. Kim, D. Lee, LG Hausys R&D Center, Korea

Evaluation of filtration performance of filters with nanofibers and HEPA, A.I. P. Salussoglia*, V. G. Guerra, M.L. Aguiar, Federal University of São Carlos, Brazil

Efficiency of collection of particulate matter and maximum pressure drop of precoating, B.K.S.A. Andrade*, M.L. Aguiar, Federal University of São Carlos; R. Sartim, Federal University of Espírito Santo, Brazil

Collection efficiency of a bag after 3 years of use in a bag filter, C.R. de Lacerda, B.K.S.A. Andrade*, M.L. Aguiar, Federal University of São Carlos; R. Sartim, ArcelorMittal Global R&D, Brazil

Effect of the temperature on the degradation of polyphenylene sulfide non-woven bag-filter media by NO_2 gas with a continuous-flow exposure method, K. Fukui*, K. Ito, M.I.F. Rozy, T. Fukasawa, T. Ishigami, Hiroshima University, Japan

Modelling of the mechanical aging behaviour of PLA-based nonwovens and monofilaments under filter application-relevant conditions, C. Schippers, L. Tsarkova, Deutsches Textilforschungszentrum Nord-West gGmbH (DTNW); J. S. Gutmann, University Duisburg-Essen (UDE); L. Sinowzik*, R. Taubner, Saxon Textile Research Institute (STFI), Germany

Experimental study on the preparation of ceramic fiber filter element for hot gas filtration, L. Miao*, Z. Ji, X. Wu, Z. Liu, J. Lu, L. Cong, China University of Petroleum (Bejing), China

Production and characterization of filter media obtained by electrospinning for applications in air filtration, D.P.F. Bonfim, V.G. Guerra, M.L. Aguiar*, Federal University of São Carlos, Brazil

Powder sampling with a pressure port of differential pressure gauge on the high pressure natural gas filter, X. Song*, X. Wu, C. Chang, S. Liu, D. Wang, Z. Ji, China University of Petroleum, China

Development and performance test of MIL-88 based filter structure using electrophoretic deposition, J.S. Lee*, J.H. Lee, S.H. Lim, Kookmin University, Korea

Macro-scale simulation of fibrous liquid aerosol filters, J. Niessner*, A. Baumann, D. Hoch, Heilbronn University of Applied Sciences, Germany

Micro-scale simulation of fibrous liquid aerosol filters, D. Hoch*, A. Baumann, J. Niessner, Heilbronn University of Applied Sciences, Germany

L10 Centrifugal Sedimentation - Decanter Centrifuges

Session Chair: Harald Anlauf — 16:45–18:00, room 1A

About dynamic modeling and process simulation of solid bowl centrifuges, M. Gleiß*, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

Dynamic simulation of mechanical dewatering of compressible cake in decanter centrifuges, P. Menesklou*, M. Gleiß, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

L11 Centrifugal Cake Filtration
Session Chair: Karsten Keller — 16:45–18:00, room 1B

The Krauss-Maffei peeler centrifuge with pneumatic cake discharge, G. Grim*, ANDRITZ KMPT GmbH, Germany

Determining the filtration properties of different protein crystals in the centrifugal field using low volume samples, B. Radel*, T.H. Nguyen, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

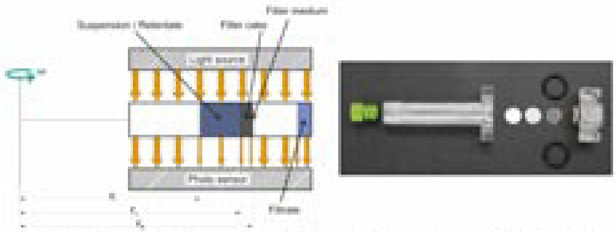


Figure 2: Left: schematic drawing of the filtration cell; right: photograph of the 3D printed filtration cuvette; (Radel et al., 2019)

CENTRISTAR - A novel software for filter centrifuges, I. Nicolaou*, NIKIFOS Ltd, Cyprus

F8 Micro and Nanofiltration Media
Session Chair: Christine Sun — 16:45–18:00, room 2

Some aspects of application nanostructured filter media in air and water filtration, D. Kimmer*, I. Vincent, L. Lovecka, M. Kovarova, L. Musilova, Tomas Bata University; J. Ondracek, Institute of Chemical Process Fundamentals of the CAS, v. v. i., Czech Republic

Low-cost porous ceramic filters for potential microfiltration and ultrafiltration applications, J.-H. Ha*, J. Lee, I.-H. Song, Korea Institute of Materials Science (KIMS), Korea

Development of microfiltration membranes of biodegradable biomass plastics with the aid of surfactants and their application to depth filtration, T. Tanaka*, H. Minbu, A. Ochiai, M. Taniguchi, Niigata University, Japan

G10 Filter Test Systems II
Session Chair: Achim Dittler — 16:45–18:00, room 4A

Investigation of regeneration stability of pulse-jet regenerated filter media under laboratory test conditions, P. Spanring, N.A. Nowak, T. Laminger*, G. Mauschitz, Vienna University of Technology, Austria

HEPA/ULPA filter leak testing for production control using solid PSL (Polystyrene-Latex) aerosol, M. Gahlert*, A. Rudolph, C. Peters, S. Große, Topas GmbH, Germany

Filter testing regarding separation efficiency in terms of airborne fungal spores, B. Führer*, C. Hartl , P. Lukas., G. Ettenberger, OFI Technology & Innovation Ltd.; M. Nachtnebel, J. Rattenberger, ZFE Graz Centre for Electron Microscopy, Austria

G11 Modelling and Simulation
Session Chair: Paolo Tronville — 16:45–18:00, room 4B

Flow through randomly-oriented fibrous filters, J. Chaudhuri*, K. Boettcher, P. Ehrhard, Technical University Dortmund, Germany

The influence of slip flow on Filtration simulations on the nano scale, L. Cheng*, S. Linden, A. Wiegmann, Math2Market GmbH, Germany

Numerical and experimental investigations on loading-dependent particle deposition in electret filter media, M. Kerner*, S. Antonyuk, Technische Universität Kaiserslautern; K. Schmidt, IT for Engineering (it4e) GmbH; S. Schumacher, C. Asbach, Institute of Energy and Environmental Technology e.V. (IUTA), Germany

Thursday, October 24, 2019

L12 Cake Filtration - Enhancement of Continuous Vacuum Filters
Chair: Gernot Krammer — 09:00–10:15, room 1A

CORES – Vacuum drum filter for highly corrosive media, W. Knobloch*, ANDRITZ KMPT GmbH, Germany

Proof-of-concept of a newly developed device for the coupled generation and separation of crystalline particles, L. Löbnitz, T. Dobler*, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

Prediction of cake solids content in vacuum belt filters from temperature data, T. Kinnarinen*, H. Montonen., M. Huttunen., J. Ahola, T. Lindh., V. Karvonen, A. Häkkinen, Lappeenranta University of Technology (LUT), Finland

L13 Depth Filtration and Adsorption - Granular Beds
Session Chair: Kyung-Ju Choi — 09:00–10:15, room 1B

Feedbacks on performance tests with Filtralite® media compared to conventional media filters at pilot scale, C. Helmer*, O. Danel, J.-F. Robin, A. Brehant, SUEZ Environment CIRSEE, France

New approaches for phosphate recovery applying iron hydroxide containing material in adapted sorption processes, A. Gerbeth*, B. Gemende, T. Riedel, F. Hascher, N. Pausch, University of Applied Sciences Zwickau; M. Leiker, R. Heiduschke, E. Schimann, P.U.S. Produktions- und Umweltservice GmbH, Germany

Performance of adsorption system for water desalination using metal organic framework, N. Genidi*, A.S. Hassan, Hamad Bin Khalifa University, Qatar

F9 Filter Media - Modelling, Artificial Intelligence, Machine Learning
Chair: Ralf Kirsch — 09:00–10:15, room 2

Filtration modeling and simulation with GeoDict, from filter media to filter element, M. Azimian*, S. Linden, L. Cheng, A. Wiegmann, Math2Market GmbH, Germany

Identification of fiber characteristics of a filter media based on artificial intelligence (AI) with GeoDict, A. Grießer, R. Westerteiger, A. Wiegmann*, M. Azimian, Math2Market GmbH, Germany

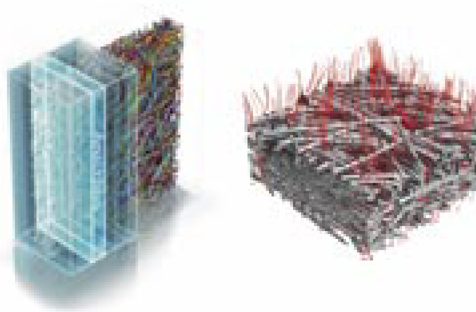


Fig. 1. left: artificial intelligence (AI) -based identification of fiber characteristics, right: particulate flow simulation through the media

Optimizing spunbond nonwovens for filter media production using a novel approach of machine learning and fiber/fluid simulations, S. Gramsch*, A. Sarishvili, A. Schmeißer, Fraunhofer Institute for Industrial Mathematics ITWM, Germany

G12 Measurement Techniques I
Session Chair: Achim Dittler
09:00 – 10:15, room 4A

Investigation of low-cost PM-sensors regarding the suitability for emission measurement for pulse-jet cleaned filters, P. Bächler*, J. Meyer, A. Dittler, Karlsruhe Institute of Technology (KIT), Germany

Measuring PM2.5 for cleanable filter media in ISO 11057 or ASTM D6830 tests using an optical aerosol spectrometer Promo® LED, P. Gäng*, FilTEq-Filtration Testing Equipment and Services GmbH; Germany

A setup for measuring passenger car brake dust particles emissions, M.J. Lehmann*, S.E. Pfannkuch, E. Thébault, A. Beck, MANN+HUMMEL GmbH, Germany

G13 Filter Element Design
Session Chair: Matthias Waldenmaier
09:00 – 10:15, room 4B

Associating filters by series for optimizing the retention capacity of nanoparticles, A. Charvet*, S. Pacault, D. Thomas, Lorraine University, France

A sustainable, modular and lean solution for pocket filter assembly, J. Kowalczuk*, D. Ciocco, A. Schwartz, B. Laurent, et al., Bollhoff Attexor SA, Switzerland

Pre-filter design of high efficient multilayer filter media for pulse cleanable filter cartridges for challenging atmospheric conditions, F. Heuzeroth*, Hengst SE, Germany

L14 Cake Filtration - Enhancement of Filter Presses
Session Chair: Pascal Ginisty
10:45 – 12:00, room 1A

Benefits of filter presses with artificial intelligence (AI) support in the chemical and mining industries, A. Decker*, ANDRITZ Separation GmbH, Germany

In-situ cleaning process of chamber filter presses with sensor-controlled and demand-oriented automation, P. Morsch*, H. Anlauf, H. Nirschl, Karlsruhe Institute of Technology (KIT); R. Werner, D.U. Geier, T. Becker, Technical University of Munich, School of Life Sciences Weihenstephan, Germany

New pilot for sludge electrofiltration and electrodewatering, J. Desabres*, B. Demasures, CHOQUENET SAS; E. Vorobiev, Technical University of Compiègne, France

L15 Depth Filtration and Adsorption – Modelling and Simulation
Chair: Lars Spelter
10:45 – 12:00, room 1B

Modeling the dynamics of filtration processes under variable flow conditions, R. Kirsch, S. Osterroth*, Fraunhofer Institute for Industrial Mathematics (ITWM), Germany

A flexible approach for meso-scale filtration modelling based on open-source CFD, U. Heck*, M. Becker, DHCAE Tools GmbH, Germany

Predicting collision efficiencies of colloidal nanoparticles in single spherical and fibrous collectors: A numerical study, D. Segets*, University Duisburg-Essen (UDE), Germany; H. Lee, D. Pui, University of Minnesota (UMN); S.-C. Chen, Virginia Commonwealth University (VCU), USA

F10 Numerical Analysis of Filter Media Pore Size and Structure
Chair: Ralf Kirsch
10:45 – 12:00, room 2

Simulation-enhanced bubble-point testing capabilities on wire meshes, D. Herper*, GKD - Gebr. Kufferath AG, Germany

Influence of fiber size distribution on the permeability of fibrous filters, N. Bardin-Monnier*, A. Charvet, D. Thomas, Lorraine University, France

A multi-scale study of the permeability of compressed nonwoven filter media, M. Kabel, R. Kirsch, S. Rief*, S. Staub, Fraunhofer Institute for Industrial Mathematics ITWM, Germany

G14 Measurement Techniques II
Session Chair: Gerd Mauschitz
10:45 – 12:00, room 4A

Measurement of the PM2.5 oil concentration in water-oil miscible metal working fluid droplet emissions and a new aerosol generator for high oil-water-droplet concentrations, T. Laminger*, W. Höflinger, Vienna University of Technology, Austria, J. Weber, M. Schmidt, L. Moelter, Palas Gmbh, Germany; R. Piringer, AUVA, Austria

Benefits of single photometer technology in an automated filter tester, G. Patel*, ATI - Air Techniques International, USA

Performance of two online particulate matter measurement principles in a fertilizer industrial prilling tower, E. Krauss *, M.L. Aguiar, Federal University of Sao Carlos, Brazil

G15 Filter Medium Design
Session Chair: Matthias Waldenmaier
10:45 – 12:00, room 4B

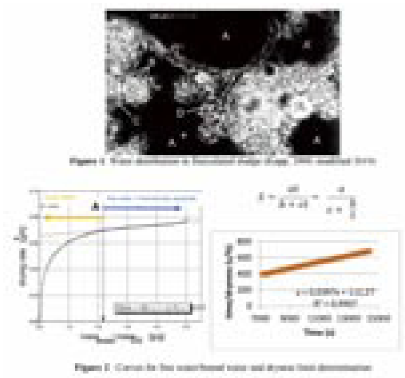
Innovative design, analysis and optimization of woven filter media through experimental and computational methods, M. Azimian*, J. Becker, A. Wiegmann, Math2Market GmbH; A. Mantler, F. Meyer, F. Edelmeier, HAVER & BOECKER OHG, Germany

Novel sintered metal filter elements: Performance evaluation in biomass gasification conditions, S. Tuomi*, E. Kurkela, M. Nieminen, M. Kurkela, I. Hiltunen, VTT Technical Research Centre of Finland Ltd, Finland; H. Balzer, A. Wierhake, GKN Sinter Metals Filters GmbH, Germany

Use of metallic filters to prevent the degradation of HEPA filters in case of vapour release, S. Bourrous*, M. Barrault, A. Brunisso, INRS Institut National de Recherche et de Sécurité, France

L16 Dewaterability of Sludges
Session Chair: Pascal Ginisty
13:00 – 14:15, room 1A

Sludge solids concentration: Which are the limits?, P. Ginisty*, IFTS - Institute of Filtration & Techniques of Separation, France; J.B. Kopp, Sewage Sludge Treatment Consulting KBKopp, Germany; A.K. Melsa, L. Spinosa, International Organization for Standardization - ISO TC275/WG6 Working Group



Why dewaterabilty of sewage sludge occurs upstream- a model to quantify the effects, J. B. Kopp*, Sewage Sludge Treatment Consulting KBKopp, Germany

Filtered dry stack tailings: The 'state of play' for high capacity tailings filter plants, R. Whittering*, Ausenco, UK; M. Pyle, G. Lane, Ausenco, Australia

L17 Backwashing Filtration
Session Chair: Gernot Krammer — 13:00–14:15, room 1B

Cost and energy saving through automatic backwash filter in PE production, S. Schöpf, W. Watzinger*, Lenzing Technik GmbH, Germany

Influencing parameters to improve the regeneration efficiency of backwashing filters, P. Morsch*, H. Anlauf, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

Assessment of filter media properties for automatic self-cleaning filters, T. Buchwald*; U. Peuker, Technical University Bergakademie Freiberg, Germany

L18 Froth Flotation and Liquid/Gas Separation
Session Chair: Ioannis Nicolaou — 13:00–14:15, room 2

Optimization of gas input in aqueous two-phase flotation (ATPF) for enzyme purification, L. Jakob*, J. Singer, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany

Air separation from a hydraulic tank using special meshes, A. Zakaria, Abou Bekr Belkaid University, Algeria; J. Gorle*, Parker Hannifin, Finland

G16 Particles for Filter Testing
Session Chair: Thomas Laminger — 13:00–14:15, room 4A

New synthetic nano-aerosol for accelerated realistic ageing of air filters, J. A. Marval Díaz, L. Medina, E. Norata, P. Tronville*, Politecnico di Torino, Italy

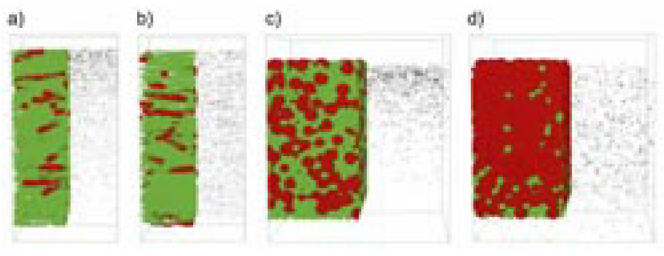
Comparison of different discharging methods and test aerosols for measuring the efficiency of electret filters, S. Schumacher*, R. Jasti, C. Asbach, Institute for Energy and Environmental Technology e.V. (IUTA); M. Kerner, S. Antonyuk, Technische Universität Kaiserslautern, Germany

Testing the efficiency of process filtration of viruses in gases with protein nanoparticle surrogates, M. Nazir*, Memsep Filtration Ltd., UK; R. Dalal, A. Kamble, S. Singh, A. Sharma, R. Dalal, FSP Technologies, India

F11 Numerical Methods for Filter Media Caracterization and Improvement
Chair: Andreas Wiegmann — 13:00–14:15, room 4B

Simulation of fine fiber generation in electrospinning and meltblown for filtration, D. Hietel*, W. Arne, R. Wegener, M. Wieland, Fraunhofer Institute for Industrial Mathematics (ITWM), Germany

Improving depth-filter media using a new multi-scale approach, M. Kuhn*, C. Geerling, H. Briesen, Technical University of Munich; M. Azimian, A. Wiegmann, Math2Market GmbH, Germany



Exemplary results for fibrous (a and b) as well as packed-bed depth-filter media (c and d). In all cases, the right half of the filter structure is hidden to show the internally deposited impurity particles which are displayed in black.Red and green are the two-sized constituents of the corresponding filter media; red is the larger faction. a) and c) are base cases, c) and d) are optimized filter media showing a much more homogenous deposition along the filter depth compared to the base cases.

Computer-aided study of the diesel-water separation efficiency of screen meshes, O. Elsayed*, R. Kirsch, S. Osterroth, Fraunhofer Institute for Industrial Mathematics (ITWM); S. Antonyuk, Technische Universität Kaiserslautern, Germany

L19 Liquid/Liquid Separation
Session Chair: Harald Banzhaf — 14:45–16:00, room 1A

Automatic water disposal for heavy duty and industrial applications – Removal of hydrocarbons to ensure environmental protection, L. Spelter*, J. Neumann, MANN+HUMMEL GmbH, Germany

A methodology for estimating water droplet sizes and predicting filter performance in diesel fuel and lube oil applications, M.F. Alzoubi*, John Crane Inc., USA; E. Barega, T. van der Linde, INDUFIL BV part of John Crane Inc., The Netherlands

Best practice for liquid-liquid separation with cartridge coalescers, C. Rodewald*, D. Steinberger, PALL GmbH, Germany

L20 Enhancement of Backwashing and Cake Filtration Performance
Chair: Harald Anlauf — 14:45–16:00, room 1B

Investigation about cohesion and adhesion in backwashing filtration based on penetrometry and tension tests, Y. Feith*, P. Morsch, H. Anlauf, H. Nirschl, Karlsruhe Institute of Technology (KIT), Germany; P. Ginisty, Institut de la Filtration et des Techniques Séparatives (IFTS), France

Separation and dewatering of biological microparticles from low concentrated suspensions by using the energy efficient thin film filtration, Z. Lam*, H. Anlauf, H. Nirschl; Karlsruhe Institute of Technology (KIT), Germany

Amelioration of phosphoric acid separation from phosphogypsum crystals using physical and chemical techniques, E.A. Abdel-Aal*, Central Metallurgical Research and Development Institute (CMRDI), Egypt

G17 Monitoring and Control
Session Chair: Markus Lehner — 14:45–16:00, room 4A

A new methodology for continuous scanning of particle aerodynamic diameter and application to filtration performance assessment of a room air purifier, S. Payne*, J. Symonds, Cambustion Ltd; T. Johnson, Cambridge University, UK

VisionAir Clean for clean room air change rate optimization, J.W. Rajala*, S. O'Reilly, AAF Flanders, USA

Smart air filtration, air filters go digital - Chances and risks of new roads to market, T. Stoffel*, DELBAG GmbH, Germany

F12 Advanced Filter Media for Gas Filtration
Session Chair: A. Mukhopadhyay — 14:45–16:00, room 4B

Pore size of the spunlaced nonwovens and Optimization of the parameters for air filtration application, A. Patnaik*, L. Maduna, Cape Peninsula University of Technology, South Africa

smartMELAMINE® - The first melamine meltblown nonwoven, C. Löning*, smartMELAMINE d.o.o., Slovenia

Welstrat: An innovative filter media for hot gas filtration application, L. Joshi*, N. Shukla*, Welspun India Ltd., India

Conference Prices	Early Bird until 31.07.2019	Normal Price from 01.08.2019
3-Day-Congress Ticket	€ 630,–	€ 810,–
1-Day-Congress Ticket	€ 300,–	€ 395,–

Short Course Prices	Early Bird until 31.07.2019	Normal Price from 01.08.2019
Short Course I Solid/Liquid Separation	€ 480,–	€ 580,–
Short Course II Fine Dust Separation	€ 480,–	€ 580,–

NEW SYNTHETIC NANO-AEROSOL FOR ACCELERATED REALISTIC AGEING OF AIR FILTERS

Jesús Marval, Luis Medina, Emanuele Norata, Paolo Tronville*
Politecnico di Torino – Corso Duca degli Abruzzi 24, 10129 Turin – Italy

*Corresponding and presenting author

ABSTRACT

To assess reliably the energy impact of air filters, it is essential to ascertain changes of their airflow resistance during their whole service life and not just when they are clean.

Current laboratory standards simulate the ageing of air filters by dispersing and loading synthetic dusts with particle size distribution (PSD) completely different from the particulate matter (PM) found in urban atmospheres. Since the size (diameter) of aerosol particles is especially important in determining the kinetics of the clogging process of an air filter, this technique does not replicate the real behavior of the filters in operation. The current methods used for artificial filter ageing are considered acceptable for rating and comparing the performance of air filters, but do not provide an accurate prediction of their airflow resistance increase in a real environment. Therefore, the duration and energy-use assessment of HVAC filters cannot be reliably estimated by means of current laboratory test dusts.

We describe various methods for generating nanoparticles having approximately the same particle size distribution of a typical urban aerosol, but at higher mass concentrations. The purpose is to allow accelerated ageing in a similar way to what happens in actual service conditions.

The paper describes the thermal aerosol generator chosen to produce the desired particle size distribution of the synthetic aerosol in an existing test rig according to ISO 16890:2016 specifications. This generator produces a high number of nanoparticles by burning a salt stick (e.g. made with KCl) with an oxy-propane flame. The salt vapor condenses in the air stream to form a cloud of ultrafine particles.

We present some preliminary data characterizing this thermal generator and we discuss some critical aspects to standardize the new ageing procedure with a synthetic aerosol closely representing a typical urban atmosphere.

KEYWORDS

Aerosol Generation, Ageing, Dust Loading, Nano Aerosols, Particle Size Distribution, Test Dust.

NEW SYNTHETIC NANO-AEROSOL FOR ACCELERATED REALISTIC AGEING OF AIR FILTERS

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1. INTRODUCTION

The performance of air filters for general ventilation is assessed evaluating their initial airflow resistance and capability to capture particles. However, to assess properly their performance, we need also to evaluate their characteristic evolution during their service life. In fact, their replacement interval and average airflow resistance are directly influenced by the trend characteristics over the time.

The performance of air filters installed in Heating, Ventilation and Air-Conditioning (HVAC) systems depends on the characteristic of the materials and technologies used to manufacture them and on the properties of their challenging aerosol. Its most important property is the particle size distribution (PSD) because it strongly affects the ageing kinetics process.

The air filter clogging tests included in standardized methods provide an abbreviated and cost-effective procedure to evaluate the performance in terms of duration, by using synthetic dusts. The properties of those dusts address the need to simulate the ageing process occurring in a long period (months) by laboratory tests during only a few hours. Furthermore, the synthetic dust shall be easily reproducible and reasonable inexpensive to guarantee that different laboratories can get the same PSD when using them.

To achieve such requirements, ISO 16890 standard series uses ISO Fine A2 dust defined by ISO 12103, which is made up principally of silica. Instead, ANSI/ASHRAE 52.2 standard uses a dust made up by the mixing of three components (72% ISO fine A2 dust, 23% of carbon black content, and 5% of cotton linters), which make it less repeatable and reproducible compared to ISO Fine A2 dust. In both cases, the PSDs of these synthetic dusts are considerably different from the one of a typical urban atmosphere challenging the air filters during their operation. For this reason, we cannot use the laboratory data to predict quantitatively their performance in a real environment. ISO 16890 and ANSI/ASHRAE 52.2 standards are aware of this limitation and state it explicitly.

In developed regions, 80% of the population lives in urban areas [1] where the majority of HVAC systems are installed. In these areas the challenging aerosols contain a larger amount of anthropogenic nanoparticles produced by combustion processes. Therefore, the presence of those ultrafine particles is a fundamental characteristic for the synthetic aerosol in the laboratory, if we want to develop a method providing meaningful data for air filters cleaning outdoor polluted air.

2. URBAN ATMOSPHERIC AEROSOLS VS SYNTHETIC DUSTS

Urban aerosols are composed by very small particles of different origins, mainly in the sub-micrometer size range. The mass PSD of this type of aerosols is characterized by three distinct modes. The first two are known as *nuclei* and *accumulation* mode and include mainly particles whose size is smaller than 1 µm. There are primary particulate emissions from human activities, such as heating, transportation and power generation. The secondary material is generated by gas-to-particle conversion promoted by photochemical processes. The third mode is known as *coarse* mode because it contains larger particles and for this reason, it is relevant for the mass PSD also in urban atmospheres.

The particles of the nuclei and accumulation modes (so-called *fine particles*) represent about the half of the mass PSD and more than 99% of the particles count of the urban aerosols [2]. For these reasons, it is important to know the origins and behavior of the fine particles to address air quality problems related to the urban atmospheric aerosols.

The nuclei mode is generated mainly from anthropogenic sources, such as combustion of fossil fuels and industrial emissions, and gas-to-particle transformations (nucleation). The particles in this mode are sized around 10 nm and below. Very high number concentrations of nuclei occur at relatively short distances from the sources and because of that, coagulation processes take place, originating larger particles. Thus, the small nuclei last relatively short time in the atmosphere and high particle concentrations decay rapidly at about 100 m [2].

The accumulation mode is formed by particles with a volume/mass distribution belonging to the 0.1–2 µm size range [2]. These particles are generated by photochemical reactions between volatile organic compounds (VOC) and nitrogen oxides under the effect of intense sunlight [3]. The coagulation or aggregation processes of the nuclei particles are other sources of the PM in the accumulation mode.

Instead, the coarse mode particles originate mainly from natural and mechanical processes, such as wind-blown dusts, plant and animal matter debris and sea salt sprays; and human sources, like agriculture and mining industries. Because of their large sizes and high mass, these particles stick on surfaces or fall and accumulate by the effects of gravity [3]. Thus, their lifetime in the atmosphere is rather short (hours or days).

It is interesting to note that the mass PSD of different urban areas are similar and generally present the previously mentioned three modes. This occurs regardless of the variability in the PSD within a given city [2].

Results from other studies corroborate this statement, indicating similar characteristics among different urban areas around the world. The work by Stephens [4] and Azimi [5] analyzed 194 long-term PSD datasets from over 10 different locations around Europe and North America, collected between 1996 and 2011. The results indicated lower concentration values for the number size distributions of the recent datasets when compared to the historical data from the decade of 1970 [4], such as the one proposed by Seinfeld [2], which has been used as reference for the definition of standards for air filter performance assessment in ISO 16890.

However, even though this slight difference, the overall pattern of the particle mass/volume distributions of the urban atmospheric aerosols studied by Azimi [5] can be considered as similar between them, and comparable to the historical representations. Particularly, the presence of high concentration values in the sub-micrometer range, corresponding to the previously mentioned fine particles (accumulation and nuclei modes). This supports the use of a reference urban atmospheric aerosol PSD for testing and assessing the performance of HVAC filters.

To use effectively a unique reference PSD to simulate urban atmospheric aerosols, we would need to generate test aerosols in the laboratory with patterns of the particle size distribution like the reference one within an established tolerance. An accelerated ageing of air filters should be achieved by using test aerosols with much higher concentrations than the real atmospheres but maintaining a close representation of the reality in terms of particle size distribution.

Nevertheless, standardized test dusts at the present have volume distributions completely different from the urban atmospheric aerosols. This is the case of the ISO fine A2 dust used by ISO 16890, which contains particles much larger than in the typical urban atmospheres. In Figure 1 we compare the cumulative volume size distribution of the reference urban atmospheric aerosol adopted by ISO 16890 series with the previous and current versions of the ISO 12013, which defines ISO fine A2 dust.

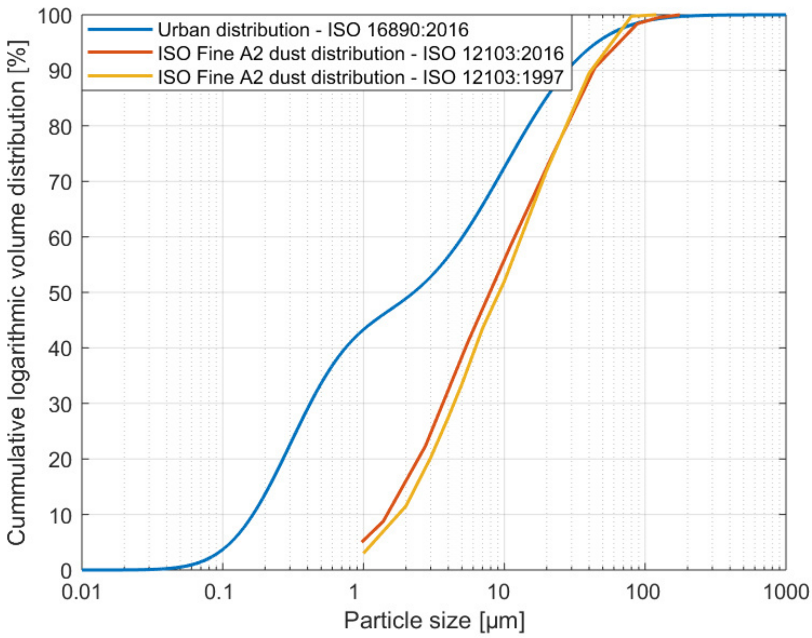

Figure 1 Cumulative PSD plots of a typical urban aerosol adopted by ISO 16890 and ISO Fine A2 synthetic dust.

It is evident that roughly 50% of the particles in the mass distribution of the urban atmospheric aerosol adopted by ISO 16890 series are smaller than the smallest particle size specified by ISO fine A2 dust.

Figure 2 compares the logarithmic volume distribution densities of the ISO fine A2 dusts and the typical urban atmospheric aerosol adopted by ISO 16890. It clearly illustrates the remarkable difference between the two particle size distributions. Because of the much larger particles present in current synthetic test dusts, those cannot reproduce the effects of smaller modes of the urban atmospheric aerosols. Previous analyses [6] compared an urban aerosol volume PSD with two different synthetic aerosols and two standard dusts, showing similar results. Thus, the environmental aerosols challenging the air filters used in HVAC systems during their operation are not properly simulated.

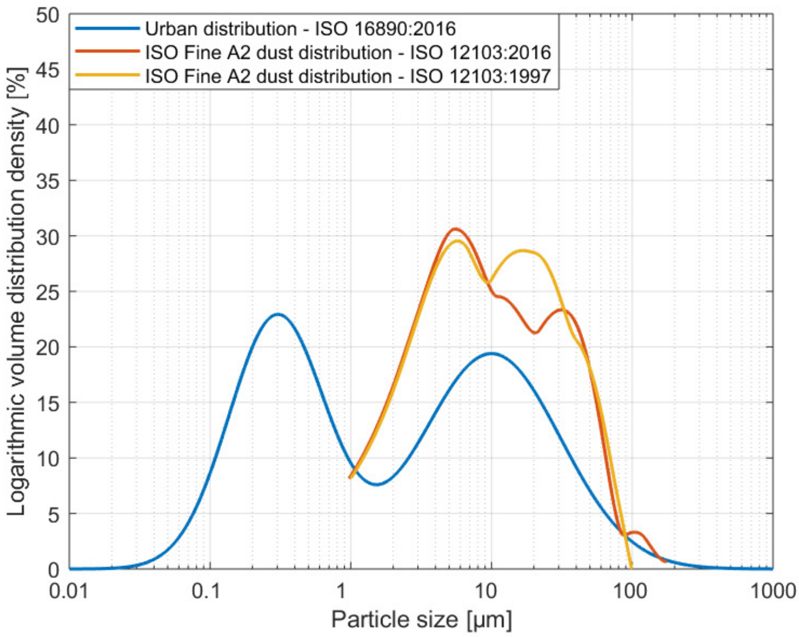

Figure 2 Volume PSD plots of ISO Fine A2 synthetic dust and urban aerosol.

This considerable difference cannot be ignored if we want to implement laboratory tests that can predict reliably the in-situ filter performance, especially because the smaller modes of the number PSD represent the largest portions of the urban atmospheric aerosols.

3. COMPARISON BETWEEN IN-SITU AND ARTIFICIAL FILTER AGEING

There are significant inconsistencies in the estimation of the air filters change interval and in the performance variations during their service life due to the differences between the PSDs of synthetic dusts and urban atmospheric aerosols. For example, existing normalized methods provide a test dust capacity that could be wrongly used to predict the necessary mass of particles causing a specific increase of the resistance to airflow. Long-term data collected from air filters for general ventilation installed in HVAC systems show that filters working in real environments tend to reach the same increase of airflow resistance after capturing much lower mass particles.

We collected the performance data of four 4Vs compact filters of the same manufacturer and model. Two of these filters were installed in a real HVAC system for one year and the other two were clogged artificially in two different laboratories using the same synthetic dust type of two different dust manufacturers to study the reproducibility of that dust. We assume a good reproducibility between the two laboratories as demonstrated by the inter-laboratory exercise coordinated by Eurovent Association.

The filter media of those filters is wetlaid glass fiber and their ISO 16890 rating is $ePM_{2.5}$ 90% (F9 per EN779). They could be reported also as ePM_1 86% and ePM_{10} 97%. The pressure drop data of the filters installed in the HVAC system were registered every 15 minutes (averaging 90 measured data taken every 10 seconds) using a Siemens QBM65.1-10 differential manometer. The pressure drop data of the filters clogged artificially in the laboratories were registered at the end of each loading step using an

Aplisens APRE-2000G/N differential pressure sensor. In both cases, the airflow rate was 3400 m^3/h.

Figure 3 shows the HVAC system where we collected the data. This system is serving classroom 1 at Politecnico di Torino, Turin, Italy. Being a real working system, no data is available in two periods, corresponding to a one-month pause during the summer break in August and another two-week pause in December. The HVAC fine filter bank is made up by two full-size (592x592 mm) labeled as *FF1* and *FF2*; and two half-size (592x287 mm) filters. We have been collecting in-situ data during several years of service, even if we report the data for this filter set only.

Figure 3 HVAC unit where monitoring the natural ageing of HVAC air filters.

Figure 4 shows the different curves of airflow resistance data for natural and artificial ageing of filters at 3400 m^3/h airflow rate.

After one year in service (including the pause periods), the filters installed on the HVAC fine filter bank gained an average mass of about 84 grams due to particle collection. This mass gain represents an increase of resistance to airflow of about 89 Pa (measured on HVAC system).

Figure 5 shows the comparison of the in-situ and laboratory airflow resistance measurements performed on the FF1 and FF2 filters in clean and clogged conditions. Both FF1 and FF2 filters have the same trend and almost the same airflow resistance values before and after the natural ageing. We note that the cloud of points corresponding to in-situ measurements is almost completely inside the area delimited by the laboratory measurements, while the in-situ airflow resistance increases with their service time, as expected. The dashed lines report laboratory measurements. The curves on the lower side correspond to FF1 and FF2 filters in clean conditions, while the curves in the upper part were obtained from the same filters at the end of their service life after being naturally clogged.

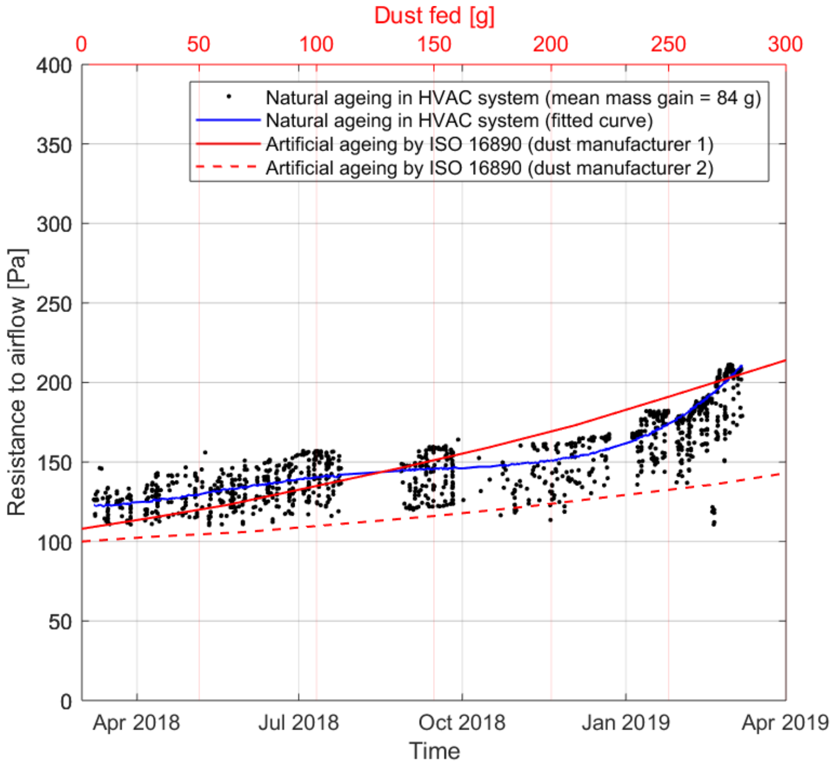

Figure 4 Comparison between artificial ageing and in-situ resistance to airflow data. The bottom x-axis (Time) correlates with the natural ageing data and fitting curve. The top x-axis (Dust fed [g]) is related to the artificial ageing data represented by the red curves.

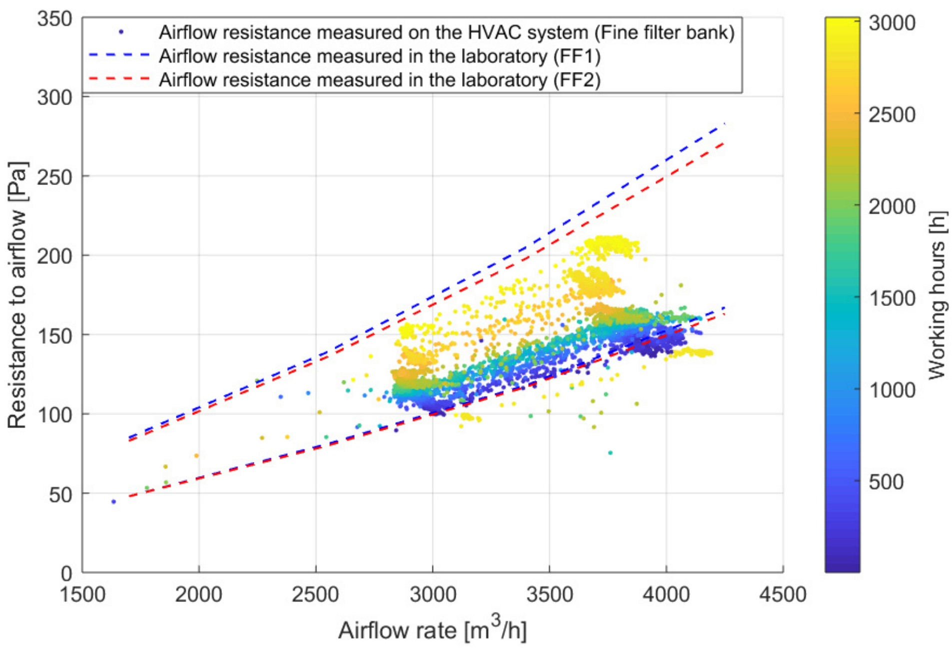

Figure 5 Comparison of airflow resistance measurements of filters installed in a HVAC system. The points cloud corresponds to in-situ measurements.

Figure 6 shows curves representing the filter's mass increase versus the increase of the airflow resistance in the case of natural and artificial ageing. Regarding the former, we only know the total mass increase of the two full-size filters and the increase of resistance to airflow measured on laboratory, so we plotted lines between the initial and the final points highlighting that this could not be the exact trend between them. Regarding the latter, these curves provide the mass of synthetic dust fed causing the increase of the resistance to airflow. For the same resistance to airflow increase of around 84 Pa (mean between the increase of airflow resistance of FF1 and FF2) obtained with around 84 grams of atmospheric particles, the labs loaded an identical air filter with about 250 g of manufacturer 1 synthetic dust and with about 350 g of manufacturer 2 synthetic dust.

In other words, air filters reach the same increase of airflow resistance as in the laboratory with a much smaller amount of particles captured, when challenged with aerosols having PSDs shifted towards smaller sizes (the case of urban atmospheric aerosols). The differences between laboratory results and field data here reported are a clear example of the divergent trends obtained by using synthetic dusts with PSDs very different from the urban atmospheric ones.

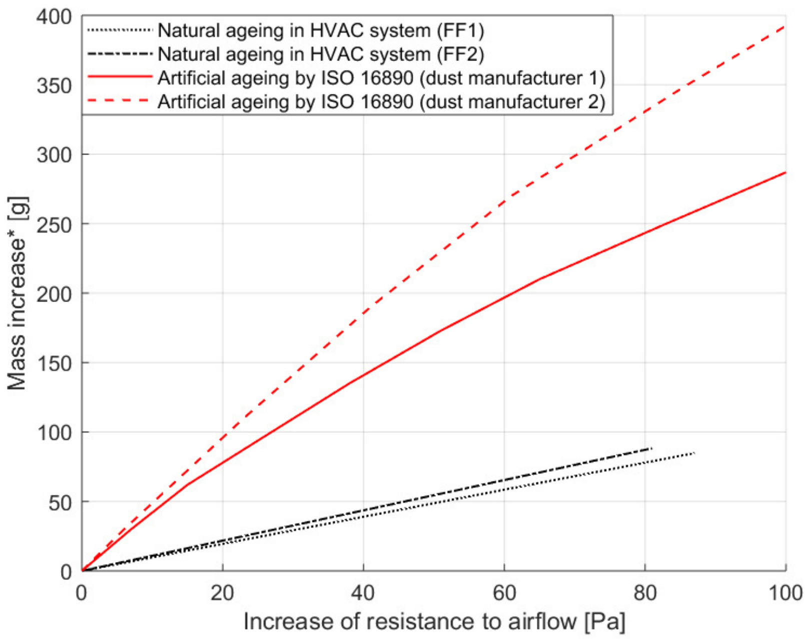

Figure 6 Air filter mass increase comparison between natural and artificial ageing.
**Assuming a gravimetric efficiency of 100% for the artificially clogged filters.*

Throughout the artificial clogging process with normalized synthetic dusts, coarse particles start forming a granular material layer because they stop on the surface of the air filter medium. This layer increases the filter medium efficiency and pressure drop by adding a layer of porous material, whose solid fraction is depending on the deposited particles PSD. In the case, the pressure drop does not depend only on the viscous resistance inside the filter media but also on the inertial resistance on the top of the filter medium. Therefore, the increase of airflow resistance is not linear. This phenomenon is called *surface filtration* and the higher the dust amount covering the filter medium, the higher the filtering efficiency and the increase of pressure drop.

On the other hand, when air filters are challenged by atmospheric aerosols, a completely different phenomenon called *deep filtration* takes place. In this case, particles are small enough to get inside the fibrous medium and do not stop on the medium surface. In this way, particles collected by the fibers decrease the filter permeability and increase its solids fraction. However, the viscous resistance increase is directly proportional to the increase of solid fraction inside the filter medium because the Darcy law, which accounts for viscous resistance only, is still valid.

Current standardized methods for determining air filter duration provide misleading information that is not coherent with the real trend of air filters when challenged by urban aerosols. This represents a limitation for air filters and filtering media manufacturers to optimize their products for minimizing energy consumption and for determining the optimum change interval.

4. METHODS TO GENERATE HIGHLY CONCENTRATED NANO-AEROSOLS

To reproduce a representative urban atmospheric aerosol distribution, it is necessary to implement a suitable technique for generating nanoparticles at high concentrations. Apart from this, the technology to be used needs to fulfill several requirements in order to be effectively standardized for laboratory air filter ageing. Firstly, the PM generation technique must be able to match the sub-micron urban aerosol mass PSD within an adequate tolerance. This is essential to ensure a realistic representation of the real environmental conditions to which the HVAC filters are exposed during their service life. Secondly, the PM generation method must be capable of delivering high mass output rates for PM below 1 µm, in order to produce an accelerated air filter clogging in just a few hours.

Another important requirement is the cost of the equipment for generating the nano-aerosols, as well as the operational and maintenance expenses. Moreover, it must be a reliable technique, capable of producing consistent and reproducible results. Also, because of the very large concentrations of nanoparticles needed, the nano-aerosol should be produced in a way that minimizes the aggregation or growth of the smaller particles, to respect the target PSD throughout the test duct. For instance, a negligible hygroscopic growth would be desirable. Finally, the ability to modulate the PSD of the aerosol obtained with the PM generation technique would be an important feature for performing suitable tests.

There are several existing technologies for generating nano-particles in a laboratory. The least expensive ones could be the atomization method and the nano-powder dispersion. The atomization process consists in generating particles by injecting a high-pressure air jet against a low-pressure liquid bulk material, which breaks into small droplets and disperse in the flow stream. Figure 7 shows an explanatory diagram.

The nano-powder dispersion, instead, consists in discharging a pressurized air jet through a nozzle into a low-pressure chamber in which a fine powder is loaded from a funnel. The high-pressure flow generates particle-to-particle and particle-wall collisions, resulting in a de-aggregation of the powder material, which is dispersed in the air stream towards the test duct. A schematic illustration of the process can be seen in Figure 8.

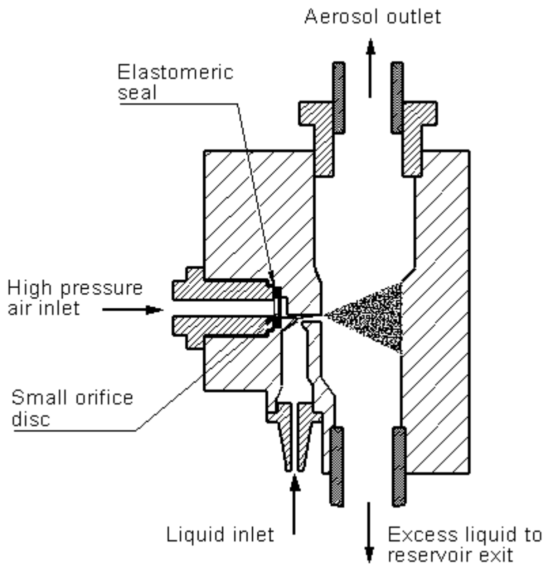

Figure 7 Atomization process.

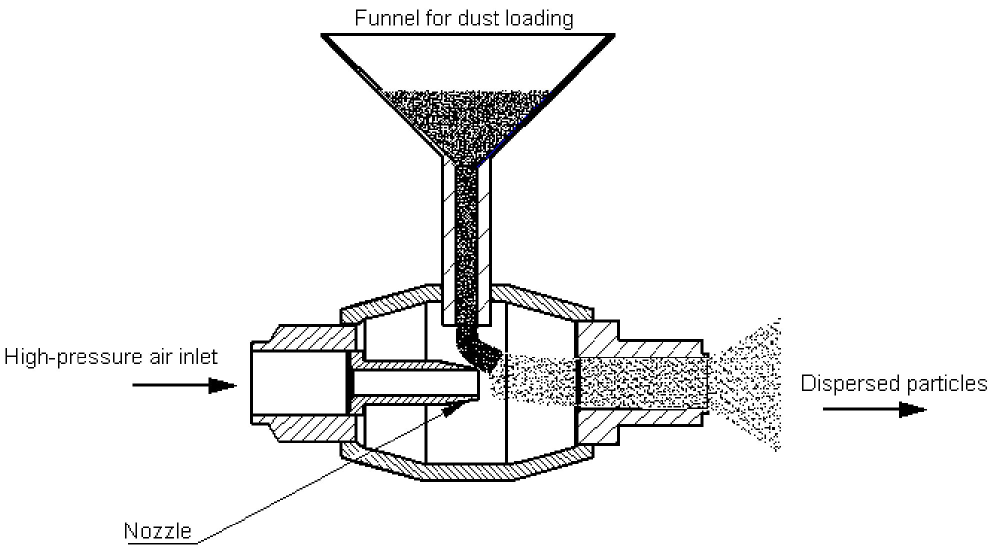

Figure 8 Nano-powder dispersion.

Although these are relatively cost-effective techniques, there are some drawbacks for each one. The atomization method can produce aerosols with realistic chemical compositions, but its mass output rate is low, which makes it inadequate for loading an HVAC air filter. In the case of the nano-powder dispersion method, it would produce PM that is not really found in the atmosphere.

Another relatively inexpensive method is to generate nanoparticles by evaporating and condensing a test substance using a tube furnace, but also this process yields low mass output rates.

There are more sophisticated methods for generating nanoparticles that are successfully used in other applications. One of these is the glowing wire generation (GWG) technique, which condensates a supersaturated vapor to produce nanoparticles. The GWG is used to evaporate a metallic material (for instance, zirconium or neodymium) with a resistively heated wire suspended in an inert gas stream. The vapor is then drastically cooled by mixing it with the gas, obtaining a supersaturation condition that is followed by a rapid condensation of nanoparticles [7]. Figure 9 shows the GWG device. This technique allows to produce highly concentrated (up to 10^6 cm^{-3}), nearly monodisperse aerosols, with particle sizes down to 2.5 nm in diameter, according to the results from previous studies [7].

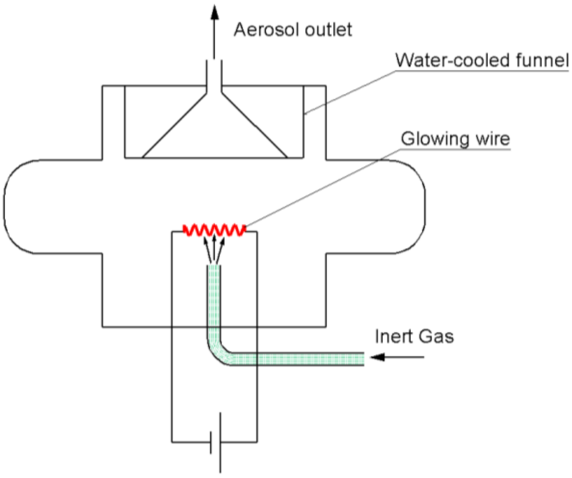

Figure 9 Glowing wire generator.

A similar technique for generating nanoparticles is the spark discharge method, illustrated in Figure 10. The spark discharge generator (SDG) consists of two opposing electrodes separated by a gap, with a high voltage applied across it in order to generate a spark. This causes the evaporation material from the electrodes, originating an aerosol that is transported by a carrier gas [8]. The generated particles are initially small (up to 9nm) but then coagulate or agglomerate with each other due to the very high concentrations. The resulting PSD can be modulated by modifying some parameters, such as the aerosol cooling rate and the ambient temperature. [8].

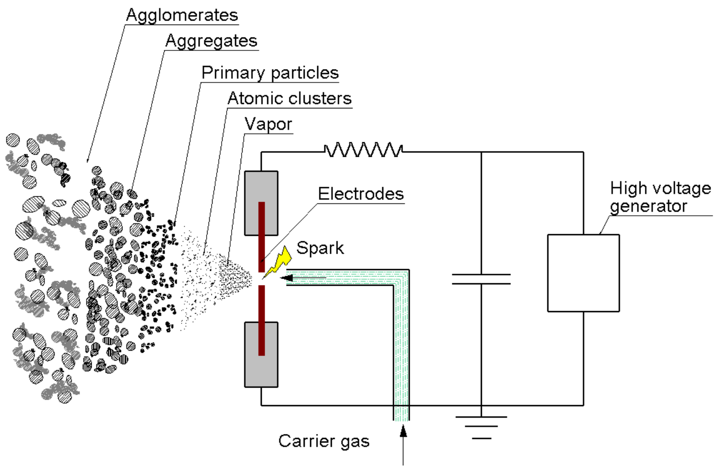

Figure 10 Spark discharge method for generating nanoparticles.

Both the GWG and the SDG can generate high concentrations of very fine PM but in general they produce low mass output rates. Moreover, these techniques have the additional drawback of generating metal particles, which have very different properties from the atmospheric PM.

An alternative technique for producing PM is the generation of soot by using a diffusion flame. However, this method is very expensive and requires several units to be able to clog an HVAC filter in about 8 hours.

Since the low mass output rate seems to be the most common drawback for the ultrafine generation techniques, we would like to use an alternate form of the least expensive ones, that overcomes the limitation of unsuitable output rates. This is the case of the so-called thermal generation, which is a variation of the previously mentioned evaporation-condensation method. This technique consists in burning a salt stick with an oxy-propane flame from an annular burner, generating large amounts of salt vapor, which condense in an air stream and form a mixture of ultrafine particles. Figure 11 shows a schematic diagram of a thermal generation device.

The thermal generation of nano-particles is a relatively inexpensive technology that was developed in the early ‘70s and ever since has been used for in-place testing of large filter installations. It is a rather simple and consolidated technique and we consider it a reliable solution for generating ultrafine particles at a controlled and constant rate. Other advantages include the possibility to modulate the PSD of the generated aerosol, and the ability to produce PM naturally found outdoors, even if in small amounts (e.g. NaCl).

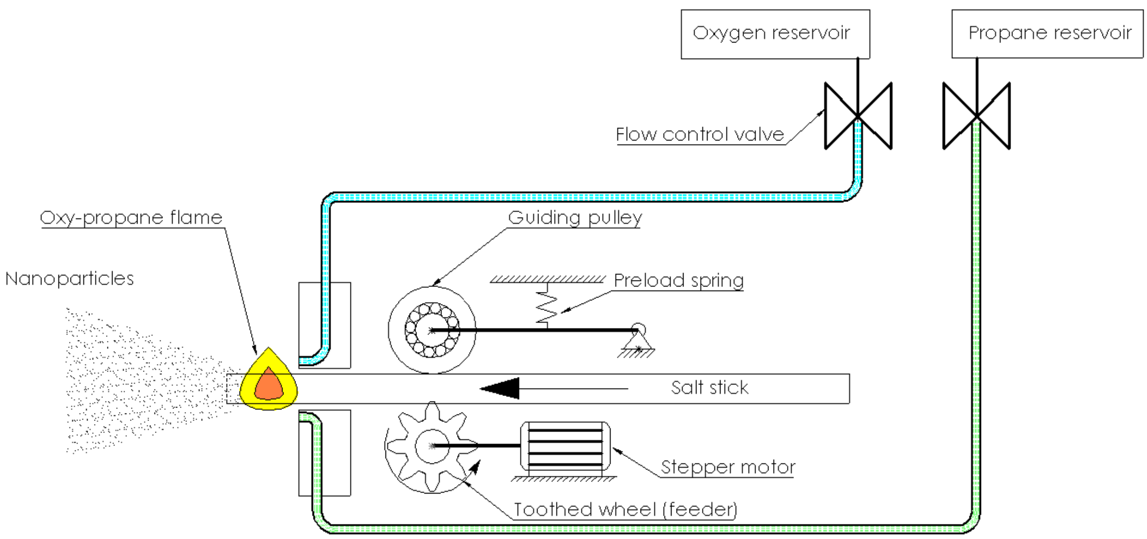

Figure 11 Thermal generation device.

5. NANO-AEROSOL THERMAL GENERATOR

Given the desirable characteristics of the thermal generation technique, we decided to use this technology to study the generation of nano-aerosols for accelerated air filter loading. Figure 12 shows the device while in operation.

The nano-aerosol thermal generator is relatively small and compact, measuring less than 1 m and weighting 3.2 kg. Moreover, it is simple to operate and to install in a convenient position within an existing test duct. To control the particle concentration, the salt stick feed rate can vary between 1 and 25 mm/min and the diameter of the salt stick itself can be of 10 or 12 mm. Furthermore, the salt stick can be made of potassium or sodium chloride.

We are characterizing this instrument to determine whether it could be used for clogging the air filters in a more realistic way.

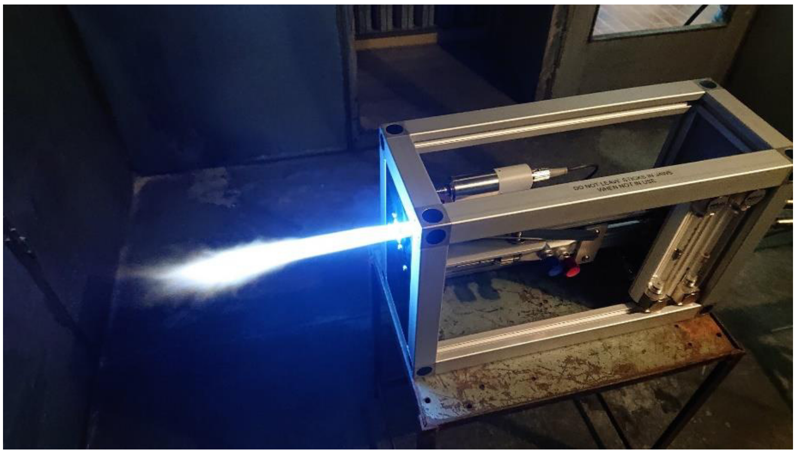

Figure 12 Nano-aerosol thermal generator in operation.

6. EXPERIMENTAL CHARACTERIZATION

To reduce the number of variables for characterizing thermal generator, we decided to perform the measurements only with KCl sticks because it is less affected by relative humidity changes and it is less corrosive than NaCl.

To study the impact of salt stick feed rate, we selected five different feed rates in the available range (3, 5, 10, 18 and 25 mm/min) and performed the measurements with both 10- and 12-mm stick diameter.

All the tests were performed in a standardized ISO 16890 test duct operated at 3400 m^3/h. We used a TSI NanoScan SMPS 3910 nanoparticle sizer in *scan mode* to measure the particle size distributions. The thermal generator injected the nano-aerosol in the same position where the synthetic dust is usually fed to clog air filters in the standardized test. The temperature and relative humidity of the test air were between 20.6 - 34.6 °C and 33- 55%, respectively.

The preliminary results presented in Figure 13 and Figure 14 show that the thermal generator produces a nano-aerosol representing well the accumulation mode of a typical urban atmosphere. The higher stick feed rate, the higher particle concentration of generated aerosol, as expected.

Furthermore, when increasing the stick feed rate, the peaks of PSDs shift to larger particles. This could allow obtaining nuclei and accumulation modes closer to the urban aerosol PSD used in ISO 16890:2016. We chose to align the higher peak of the typical urban aerosol PSD of ISO 16890 with the height of the PSD obtained at 25mm/min stick feed rate.

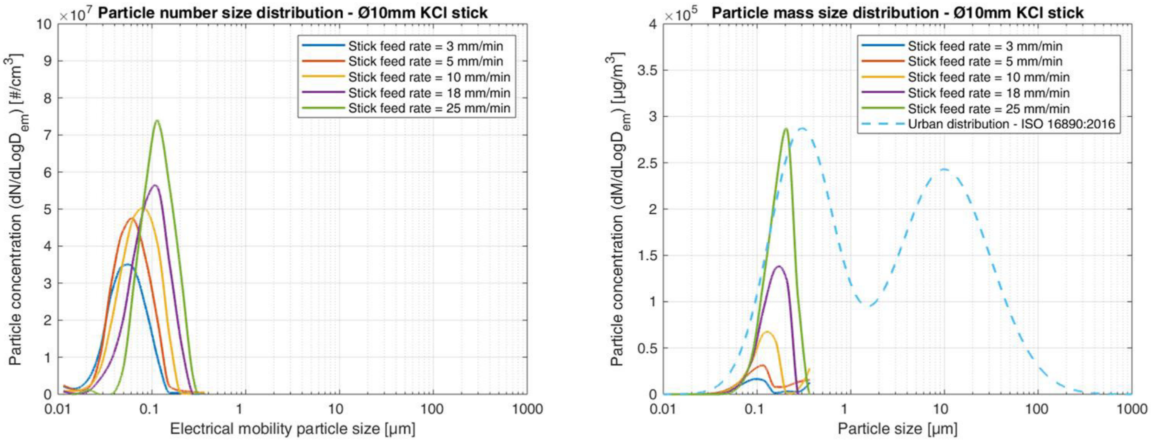

Figure 13 Comparison between the number and mass PSDs nano-aerosol obtained with the thermal generator using 10 mm diameter KCl stick with various feed rates and the urban atmospheric aerosol according to ISO 16890.

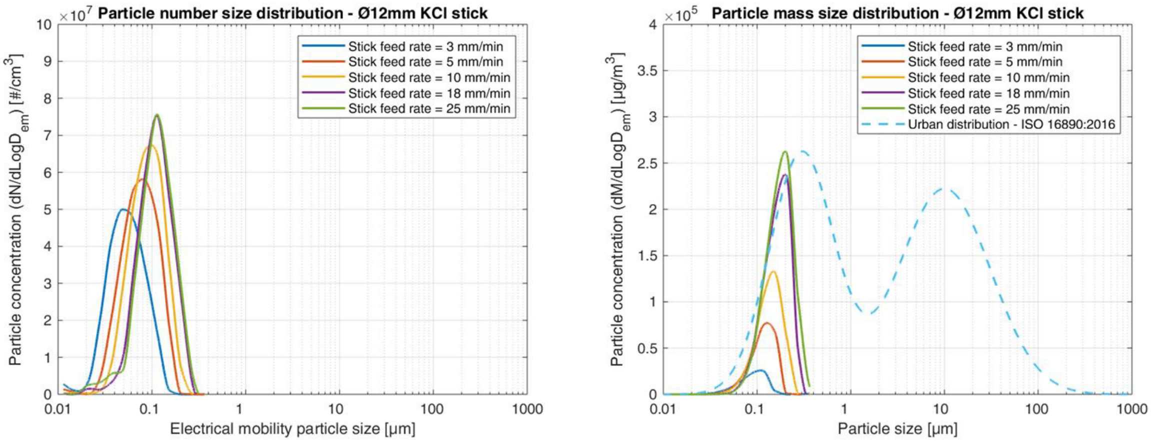

Figure 14 Comparison between the number and mass PSDs nano-aerosol obtained with the thermal generator using 12 mm diameter KCl stick with various feed rates and the urban atmospheric aerosol according to ISO 16890.

Following these positive preliminary results, we will further investigate its use with the aim of achieving a much more realistic accelerated ageing of HVAC filters. After having selected fixed operating parameters (salt stick feed rate and diameter), the next step will be to clog air filters with the proposed method to compare the loading curves with the ones obtained using synthetic dusts and with natural ageing.

7. CONCLUSIONS

Current artificial ageing methods provide data that is dramatically different from what really happens to air filters in HVAC systems. For a specific increase of airflow resistance, air filters clogged in real applications require a much lower captured particles mass compared to the synthetic dust fed in standardized laboratory tests.

These differences highlight the limited value of ageing filters with the current standardized tests. The remarkable differences between the particle size distribution of the aerosol challenging the air filter during its operation in a real air conditioning or ventilation system and the one of the synthetic dusts is the main problem.

Current laboratory methods prescribe clogging procedures governed by surface filtration while in real conditions the predominant process is deep filtration. Hence, it is necessary to simulate air filter ageing using a synthetic dust with much smaller particles in order to bring laboratory simulations closer to the reality.

After studying different methods to generate highly concentrated nano-aerosols, a combustion process seems to be the most appropriate option to generate large amounts of ultrafine particles fulfilling the requirements listed above.

The preliminary data obtained with the thermal generator provide a promising solution for the aforementioned problem.

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