SFB 920

Multifunktionale Filter für die Metallschmelzefiltration – ein Beitrag zu Zero Defect Materials

NEWSLETTER 11 (2/2016)

DFG Deutsche Forschungsgemeinschaft

Bergakademie Freiberg Technische Universität

DEAR READERS,

Research and science are embedded in an international environment. Worldwide collaborations, joint research projects or shared research facilities are of increasing importance.

Tied in a worldwide network, researchers of the CRC 920 “Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials“ are actively contributing to an international exchange of knowledge and experiences - by attending conferences, involving visiting researchers and scholars from all over the world, by establishing links to other research institutions for initiating academic collaborations as well as for promoting young researchers. Also, approximately 100 mostly international publications and currently 15 patents and patent applications are contributing to an international awareness for the CRC‘s research.

Details on these and other activities are available in our latest issue of this newsletter. Further information is provided at http://sfb920.tu-freiberg.de. We hope you‘ll enjoy the newsletter.

Yours sincerely,

Prof. Dr.-Ing. habil. Christos G. Aneziris
CRC 920 Coordinator

Prof. Dr.-Ing. habil. Horst Biermann
CRC 920 Vice Coordinator

CONTENT

INTERNATIONAL ATTENTION CALLED TO CRC's EXCELLENT RESEARCH RESULTS

The CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials" repeatedly demonstrated visibility and competitiveness on an international scope. Cooperating with internationally renowned research institutions and collaborating with experts worldwide strengthen the international reputation of researchers from TU Freiberg and their international networks.

Research activities and results provided by the CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials" became a central topic of the **7th International Symposium on Refractories ISR 2016 in Xi´an/China**. Prof. Christos Aneziris, coordinator of the CRC 920, presented in his keynote speech findings on "Clean steel technologies based on interactions of refractory filtering materials with steel melt." Moreover, Dipl.-Ing. Jens Fruhstorfer and Dr.-Ing. Stefan Schafföner (both with the Institute of Ceramics, Glass and Construction Materials IKGB) presented research results obtained from projects in the Priority Program 1418 "Refractory - Initiative to Reduce Emissions - FIRE."

The ISR conference, held every four years, is an international plattform for researchers, producers, customers and suppliers to evaluate results and advancements made in the field of refractory materials, to identify and assess new developments in refractory research, production and application and to foster exchange and cooperation worldwide.

This year, discussions centered on mechanisms at interfaces between ceramics and metal melts, but also on filter geometries for large metal melt capacities. In this regard, opportunities for utilizing nanotechnology were of vital interest. A panel discussion was committed to the application of regenerative methods for light-weight constructions using more complex component geometries for metal melt filters.

The ISR 2016 was organized by the Chinese Society for Metals, the Chinese Ceramic Society, and the Sinosteel Luoyang Institute of Refractories Research Co., Ltd. China is among the world's largest producers and consumers of refractories mainly for steel production. Moreover, China is the largest manufacturer and supplier of refractory raw materials such as magnesia or bauxite.

This year's **CELLMAT 2016 in Dresden** will include a **special session held by the CRC 920 on "Multifunctional carbon-bonded filters for metal melt filtration."** The session will contain 13 presentations from the CRC as well as an overview of concepts and activities the CRC applies for scientific communication purposes. Attending the CELLMAT 2016 provides the CRC researchers a valuable opportunity to present their research results to a wider scientific audience.

On September 26 and 27, the **"International Autumn School of UFSCar São Carlos and CRC 920"** invited doctoral students, researchers and project teams and members of the CRC 920 to a two-day session on "Functional porous ceramic materials and more in high temperature applications." Invited by the CRC 920, a group of researchers from the Departamento de Engenharia de Materiais der Universidade Federal de São Carlos/ Brasil, headed by Prof. Victor Carlos Pandolfelli, joined the meeting. Prof. Victor Carlos Pandolfelli is an expert, among others, on porous functional ceramics, refractory materials and related high-temperature applications.

Photo (from left to right): Prof. Christos C. Aneziris (Coordinator of the CRC 920), Prof. Victor Carlos Pandolfelli as well as Dr. Vania Regina Salvini, Dr. Ana Paula Luz, and Dr. Mariana de Albuquerque Lima Braulio (all with UFSCar).

The German Research Council DFG supports various forms of collaboration between researchers from German and Latin America. Running a local office in São Paulo, DFG aids and accompanies institutional cooperation with partner organizations, including joint and co-funded research projects in all scientific areas. ■

MORE NEWS

GUEST RESEARCHERS & SCHOLARS

Several international guests followed an invitation offered by Prof. Rüdiger Schwarze (subproject B06N) to spend some time as a guest researcher at TU Bergakademie Freiberg. Among them, **Prof. Kinnor Chattopadhyay, University of Toronto/Canada,** visited the university in summer 2016 for three months, funded by the CRC 799 " TRIP-MATRIX-Composite" and the CRC 920 "Multi-functional filter materials." He coordinates the research group "Process Metallurgy and Modelling" at the Department of Material Science and Engineering at Toronto University.

During his visit, Prof. Chattopadhyay was involved with multi-phase flows in metallurgic vessels such as the tundish. Documentations and publications of research results aim at the preparation of a German-Canadian International Research Training Group, funded by German Research Council DFG. Moreover, in June 2016 Lei Gao, doctoral student and member of the working group of Prof. Chattopadhyay, visited TU Freiberg for one month to deal with the simulation of flow processes in electromagnetic levitation. His work aims at building a computational fluid dynamics model (CFD model) which will be continuosly advanced as part of joint research projects in the field of numeric flow mechanics. Project partners include the working group coordinated by Prof. Schwarze as well as researchers from Helmholtz-Zentrum Dresden-Rossendorf.

Also, **international scholars** contribute to the CRC's research efforts. Subproject S03 receives support from Maria Raczek, Natalia Mrowka, and Michal Smolka (all from Poland). Omar Alomar (Iraq) is involved in subproject B02, Mariia Ilatovskaia (Russia) in subproject A03. Alexander Szwaykowski (USA) joined the research team in subproject B03, funded by a RISE scholarship. Dipl.-Ing. Pitt Götze serves as his supervisor. Two scholars who joined the CRC 920 - **Dig Vijay (2013) and Omar Alomar (2016)** - meanwhile **successfully defended their Ph.D. theses**. ■

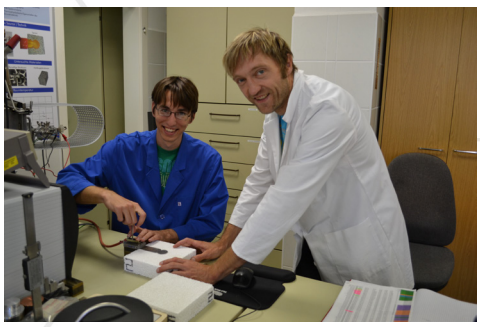


Photo above (from left to right): Prof. Rüdiger Schwarze, Prof. Kinnor Chattopadhyay and Amjad Asad M.Sc.

Photo below (from left to right): RISE-Scholar Alexander Szwaykowski and his supervisor Dipl.-Ing. Pitt Götze.

SECOND TRANSFER PROJECT APPROVED

In September 2016, CRC 920 received approval from the German Research Council DFG for a **second transfer project**. From October on, TU Bergakademie and an industrial partner will be jointly investigating high-cycle fatigue properties of steel alloys. Inclusions caused by materials- or manufacturing-related factors, pores, microshrinkages or second phases constrain the strength of existing steel alloys. Subproject T02, **coordinated by Prof. Horst Biermann and Dr. Anja Weidner**, investigates how creep fatigue and high temperatures effect the damage behavior of industrial steel alloys. In particular, analyses will be focusing on the effect of non-metallic inclusions on the lifetime, with specific regard to the critical defect size and damage accumulation. Additionally, manufacturing conditions, chemical composition, and the microstructure of steel alloys is of great importance. "This transfer project contributes significantly to the exploration of damage mechanisms in steel alloys under higher temperatures," said Prof. Christos Aneziris, coordinator of the CRC 920. ■

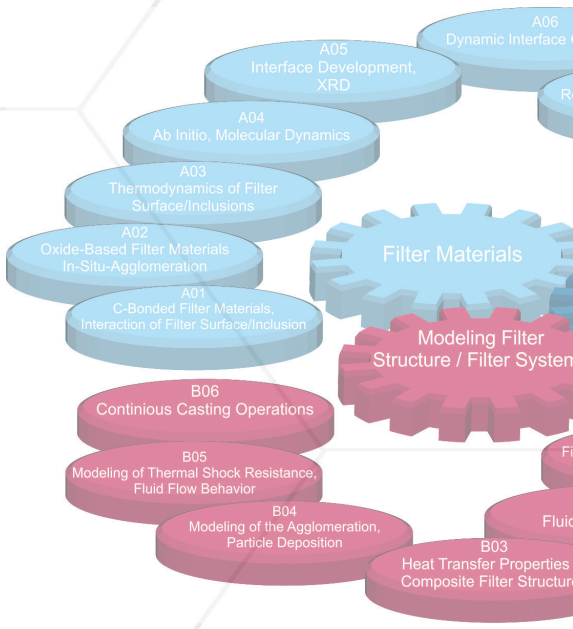
Photos: Prof. Horst Biermann (left), Dr. Anja Weidner (right).

WORKING GROUPS' REPORT

Research teams in the CRC 920 are connected in four working groups, thus ensuring targeted activities, close collaborations between subprojects, and intensive exchanges between all researchers involved. Young scientists are taking responsibility for coordinating these working groups - a measure the CRC has taken to support young scientists already in early career stages to promote their capabilities to work independently as well as in teams and to strengthen their management skills.

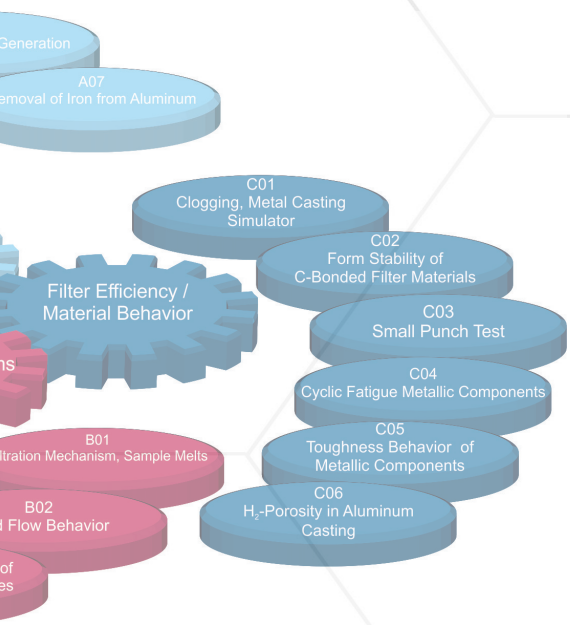
Working Group 1: "Metal melt/inclusions, active/reactive filter materials, boundary surface design" (Coordination: Dipl.-Ing. Tilo Zienert)

- Investigation of reactions between MgO-particle with liquid steel within confocal laser scanning microscop. Reaction layer were found on the surface of these particles which are under further investigations. First experiments to coat Al_2O_3-C filters with fibers via electro spinning (A01),
- Development of a model/algorithm for calculation and prediction of heat capacity of crystaline materials. Experimental investigation of the phase relations in the system ZrO_2-TiO_2-Al_2O_3 for a thermodynamic description of the system (A03),
- Structural investigations of intermediary aluminium oxides accompanying the thermally induced continuous transition from boehmite to corundum by XRD, with special regard to their thermal stability. A three dimensional defect network was found by XRD, TEM investigations in combination with simulations (A05),
- Investigation of the influence of carbon amount on reactions between liquid steel and Al_2O_3-C filter systems by experiments and thermodynamic calculations (A01, A03 and A06),
- Analysis of the formation of secondary corundum during the contact of graded filter structures on the basis of carbon-bonded corundum with molten steel 42CrMo4 and determination of the influence of the carbon content on the kinetics of formation. Detection of the formation of $MgTiO_3$ and α-Al_2O_3 with defined orientation relationships towards TiO_2 (Rutile) after the contact of TiO_2-coated, corundum-based filters with molten AlSi7Mg0.6 and pure Al, respectively (A06),
- It is planned to precise conditionate Al-melts before casting by alloying with Cr and Mn. First experiments and thermodynamic calculations were done. Investigation of the order/disorder reactions in Fe_2Al_5 by XRD and TEM (A07),
- Investigations of the influence of TiO_2 in contact with liquid steel by LM, SEM, EBSD, ASPEX (filter material: carbon-bonded alumina filters (2,5 % TiO_2) with coating based on CNTs). Investigation of influence of heating rate/atmosphere on fibers (alkoxide system for $Mg_2B_2O_5$) produced via electrospinning by LM, SEM, XRD, BET (E. Storti),
- Commissioning of the new HT-AFM, first tests under high vacuum and at 630 °C on a Si-wafer. Preparation of a suitable Al_2O_3 substrate for the HT-AFM by ALD, evaluation at HV and at elevated temperatures planned (B01),
- For a better judgement of the nonmetallic inclusions, the surrounding steel matrix was dissolved, which made it possible to reveal the threedimensional morphology of nometallic inclusions by SEM (C04),
- Evaluation of crucible experiments showed that hydrogen reacts with spodumene at a temperature of 700 °C. Verification of increased hydrogen amount in spodumene samples and spodumene coated filters by SNMS after annealing under H2 atmospere (C06).



Working Group 3: „Thermo-mechanical characteristics of filter materials and structures" (Coordination: M. Sc. Henry Zielke)

- Comparison of real and artificially generated (virtual) foams based on foam structure properties (B05),
- Derivation of visco-plastic material properties from experimental data of C02 and application to artificially generated foams to model high-temperature foam compression tests (B05)
- Fracture mechanical experiments with notched load beams made of Al_2O_3-C at temperatures up to 1500°C (C02),
- In situ determination of Poisson's ratio using SEM as well as 4 strain gauges (2 crosswise, 2 lengthwise) (C02),
- Proceeding investigation acoustical emission as well as manufacturing of operating waveguides (C02),
- Analysis of the experimental data (C03) and micrograph structure (A01) of the miniaturized specimens for the Ball-On-Three-Balls-Test to assess the impact of the manufacturing method,
- Development and start of operation of a test set-up with miniaturized and Chevron-notched bending beam (CNB) (C03).



Working Group 2: „Modeling and designing of the filter geometry“ (Coordination: Dipl.-Ing. Eric Werzner)

- Analysis of the influence of roughness on adhesive forces in the model system on samples from sub-projects A01 and A02; measurements concerning nanobubble stability on smooth and rough coated Al_2O_3 surfaces using a RT-AFM (B01),
- Measurements of the kinetic of agglomeration of hydrophobic alumina particles at room temperature in an aqueous phase; the appropriate interaction forces are increased due to surface nanobubbles, which are produced via the solvent exchange method (B04),
- Commissioning of a semi-industrial water-based deep bed filtration pilot plant as well as development of a filter cloth based-separation device for determination of filtration efficiency (B01),
- Experimental investigation of infiltration and flow behaviour of filter samples whose surface was silanized for an increased contact angle (B03, B01),
- Setup of an experiment to investigate the behaviour of the flow and non-metallic inclusions in the induction furnace (B06),
- Verification of the TPS meter for determination of the effective thermal conductivity of the filters up to 25 W/(mK) through reference measurements of solid samples at temperatures of up to 750 °C (B03),
- Generation of artificial foams and comparison with real samples based on foam structure properties (B05),
- Extension of the pore-scale filtration model by taking into account the viscosity-temperature dependence of the liquid melt and the effect of viscous damping at particle impact (B02, B01),
- Determination of the agglomeration probability for small inclusions inside the filter during steel filtration on the basis of turbulence statistics obtained for a Kelvin cell (B02, B04),
- Extension of the macro-scale model to consider coagulation and agglomeration of the non-metallic inclusions (B06),
- In-situ creation of compressed data structure with index function during the pore-scale simulation for the realization of database-like queries as post-processing tool (S02, B02).

Working Group 4: „Mechanical properties, metallic materials, critical inclusions“ (Coordination: Dipl.-Ing. Tim Lippmann)

- Investigation of the influence of crucible material on mechanical properties of steel 18CrNiMo7-6 (steel cast simulator) under static and cyclic loading conditions, which promotes the development of new crucible coatings (C01, C04, C05, S01),
- Investigation of contact time and surface chemistry of carbon-bonded Al_2O_3 filter structures using finger tests in the steel cast simulator contributing to the clarification of the effect of Al_2O_3-C filters on the mechanical properties of 42CrMo4 steel under static and cyclic loading conditions (A01, C01, C04, C05, S01),
- Analysis of nonmetallic inclusions and their spatial distribution within the steel matrix by revealing the erstwhile casting microstructure (C04, S01),
- Preparation of the crack-initiating nonmetallic inclusions or inclusion clusters and subsequent investigation plus characterization at the SEM (C04),
- Prearrangement of aluminum cast experiments in collaboration with Hydro Aluminum (Bonn),
- December 2016: Performance of preliminary tests of aluminum melt filters at a special test rig including LiMCA and PoDFA analysis for the investigation of the influence of the type of filter material as well as of the filter surface roughness on the kinetics of the formation of non-metallic inclusions (metallographic investigations both on the filters itself as well as on cast states with small dimensions),
- Spring 2017: Cast experiments using selected filters based on the results obtained during preliminary tests for providing cast materials states for the investigations of mechanical properties under static and cyclic loading conditions (A02, C04, C05, S01, S03),
- Transfer project with company Federal Mogul started at 1st of October 2016. The aim is the investigation of cyclic properties of 42CrMo4 cast steel at elevated temperatures (200 °C – 500 °C), focused on chanced damage mechanisms.

EFFECTIVE THERMAL CONDUCTIVITY OF OPEN-CELL FOAM STRUCTURES

Authors: Pitt Götze, Rhena Wulf
(Subproject B03)

Subproject B03 deals with heat transportation in filter structures. One of the critical tasks is the measurement of effective thermal conductivity as a function of temperature. Within the framework of SFB 920, a measuring device TPS 2500s has been implemented for this purpose, which fulfills the necessary criteria desired for the particular structural design of the ceramic filters.

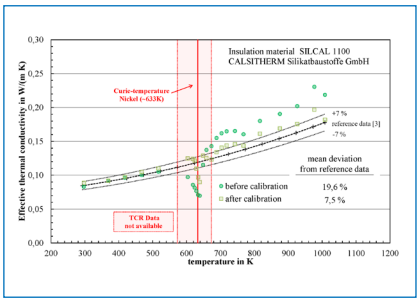


Fig. 1: Effective thermal conductivity of insulation material Silcal 1100 before and after calibration. Reference data are results of an intercomparison of thermal conductivity measurements with various laboratories and methods [3].

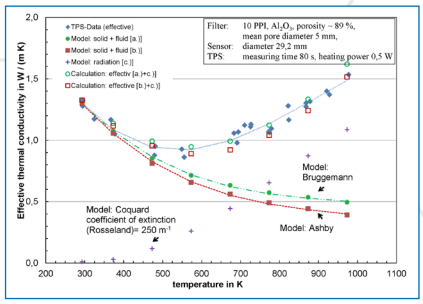


Fig. 2: Temperature dependent effective thermal conductivity of an Al_2O_3 filter, measured by Hot Disk TPS 2500s.

Measuring range	from	to
Thermal conductivity*	0.005 W/mK	1800 W/mK
Thermal diffusivity*	0.1 $mm^2/(s)$	1200 $mm^2/(s)$
Vol. heat capacity*		5 MJ / (m^3 K)
Temperature*	-253 °C	1000 °C
Sensor radius*	0.5 mm	29.5 mm
Sensor insulations	Kapton (up to 300 °C)	Mica (above 250 °C)
Furnace temperature	Room temperature (~ 20 °C)	~ 750 °C
		* Herstellerangaben

Tab. 1: Specification of Hot Disk System TPS 2500s: measuring range, sensors and furnace .

Ceramic filters for molten metal filtration are characterized by high porosity and large pores, whereas, the foam matrix is being thin-walled, brittle and difficult to machine. Standard measuring methods used in case of building and insulating materials, such as stationary hot plate apparatus or the hot-wire apparatus, have limited applicability in case of ceramic foams. A better alternative is the non-stationary measuring methods equipped with custom-built sensors. The measuring system TPS 2500s operates according to ISO 22007-2 is equipped with a circular sensor, which is embedded between the two sample halves. It consists of a nickel-coated double spiral, which simultaneously acts as a heating element and a temperature sensor. For a given heating time and intensity, the thermal conductivity, thermal diffusivity and specific heat capacity can be determined through the temperature rise of the sensor. The specification of the measuring instrument (manufacturer's data) is given in Table 1.

First measurements on ceramic foams were focused on the reproducibility of the measuring conditions and defining important measuring parameters at room temperature (Kapton sensors). It was shown that processing the sample by grinding is as vital as the adherence towards reasonable combinations of pore size, sensor diameter and sample dimensions [1]. Mica-coated sensors were used for the temperatures above 250 °C, which require a furnace with an inert gas atmosphere due to their inclination towards delamination. Numerical simulations have shown that the resulting inhomogeneous but stationary temperature field through the sample does not have a significant influence on the measurement results. The problem was found in test measurements on reference samples at high temperatures. On the one hand, in the temperature range of 300 – 400 °C nickel undergoes a phase transformation, as a result, no evaluation of the measurements is provided for this range in the original software. On the other hand, there is a clear deviation of the measured data from the reference values above 400 °C. After consultation with the manufacturer of the measuring device, a complex recalibration of the so-called TCR values (temperature coefficient of the resistance of nickel) was carried out. Consequently, a significant improvement and a good approximation of the reference curves could be achieved for materials having broader range of thermal conductivity. The already mentioned „gap" in the measuring range could also be clearly identified. (Fig.1, [2])

Measurements on pure and carbon-bounded Al_2O_3 foams show a clear influence of the solid matrix on the effective thermal conductivity up to ca. 250 °C. On the other hand, at high temperatures the radiative fraction dominates the effective thermal conductivity, which can be seen in the increment of the values of the effective thermal conductivity up to 700 °C. Only in the upper temperature range is the influence of pore size can be observed, since the small pores effectively suppress the radiative transport of heat (Fig. 2). With the help of the improved calibration data, further targeted measurements for the investigation of influencing parameters are now possible, which, for example, will provide the data for the validation of models developed in the frame work of subproject B02. ■

[1] Götze, P., Wulf, R., Gross, U.: The Effective Thermal Conductivity of Alumina Open-cell Foam Ceramics Measured by the Transient Plane Source Technique, Proc. 8th World Conf. on Exp. Heat Transfer, Fluid Mechanics and Thermodynamics (ExHFT-8), June 16-20 (2013), Lisbon, Portugal, P1.31, 1-8.
[2] P. Götze, S. Hummel, R. Wulf, U. Groß, T. Fieback: Simultane Bestimmung von Wärmeleitfähigkeit, Temperaturleitfähigkeit und Wärmekapazität bei Temperaturen bis 750°C. Thermodynamik-Kolloquium 2016, Kaiserslautern, Deutschland.
[3] H.P. Ebert et al.: Intercomparison of thermal conductivity measurements on a calcium silicate insulation material. International Journal of Thermal Sciences, 50 (2011) 1834 - 1844.

NEW FILTRATION PRINCIPLE FOR METAL MELTS IN INDUCTION FURNACES

Authors: Amjad Asad, Rüdiger Schwarze
(Subproject B06)

Subproject B06 investigates static and dynamic filtration in continuous casting. Moreover, the main task of B06 is to study the steel casting simulator by performing a numerical simulation. First results of B06 show the significant effect of the ceramic filter on the flow. Additionally, it is observed that the filter permeability has a considerable impact on the filter efficiency.

In subproject B06, a numerical model is developed to simulate the induction crucible furnace (ICF), which is a part of the steel casting simulator. In this model, the melt flow is solved on a fixed mesh, whereas the nonmetallic inclusions are tracked in a Lagrangian way by solving their equations of motion. Moreover, the Lorentz force, which drives the melt in the ICF, is included in the numerical model as a volumetric force. A ceramic filter is immersed in the ICF to capture the nonmetallic inclusions arising in the melt. To consider the presence of the filter in the flow field, Darcy's law is adopted to estimate the pressure drop because of in the filter. The numerical model is validated by using an experiment conducted by Baake et al. [1] The numerical results match well with the experimental data, quantitatively and qualitatively. [2]

The immersion of the filter in the melt leads to a reduction in the melt velocity in this region due to flow resistance. Figure 1 shows the time-averaged flow field in a vertical plane of ICF. It is clear that the flow is dominated by two toroidal vortices as expected for both considered filter permeabilities. Moreover, secondary vortices can be seen in the horizontal plane (see Figure 2). Filter permeability considerably influences the filter efficiency as can be seen in Figure 3. If the filter permeability is decreased, the filter efficiency will decrease as well. The reason for this is that there is a higher flow resistance in this case. This means lower mass flow rate of the melt through the filter. In the simulation, it was assumed that the inclusion has a separation probability of 50 % in the filter.

Figure 3 indicates the influence of inclusion diameter on filter efficiency. In the case of smaller inclusions, higher efficiency is obtained because the inclusions are able to follow the melt flow and then reach the filter. ■

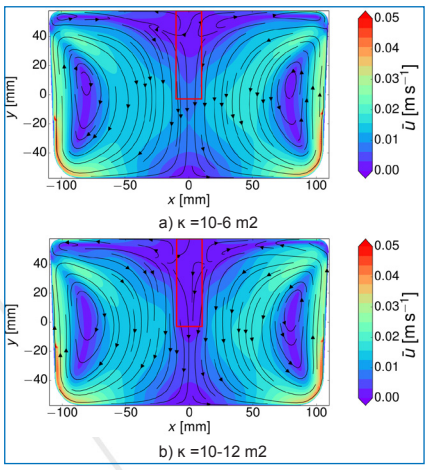


Fig. 1: Mean flow in a vertical middle plane for two different filter permeabilities; the red box represents the position of the filter.

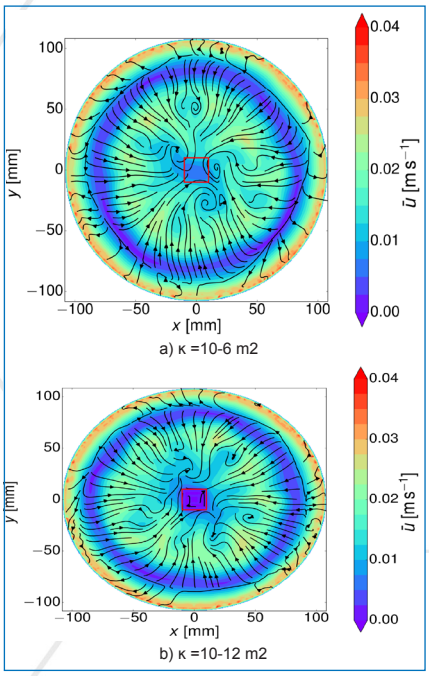


Fig. 2: Instantaneous snapshots of the flow in a horizontal plane for two different permeabilities; the red box represents the position of the filter.

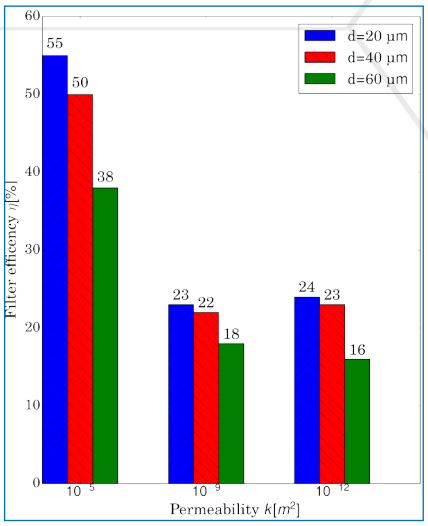


Fig. 3: Influence of the filter permeability κ and particle diameters d on the filtration efficiency.

[1] E. Baake, A. Mühlbauer, A. Jakowitsch, W. Andree, Extension of the k-ε model for the numerical simulation of the melt flow in induction crucible furnaces, Metallurgical and Materials Transactions B 26 (1995), 529–536.
[2] A. Asad, C. Kratzsch, S. Dudczig, C. G. Aneziris, R. Schwarze, Numerical study of particle filtration in an induction crucible furnace, International Journal of Heat and Fluid Flow (2006), DOI: 10.1016/j.ijheatfluidflow.2016.10.002.

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RECENT PUBLICATIONS (JUNE-NOVEMBER 2016)

Further information about the 96 publications from the second program period until November 2016 as well as about the currently 15 patents and patent applications can be found on http://tu-freiberg.de/forschung/sfb920".

Project area A - Filter materials

Subproject A01

Aneziris, C. G. (2016): Functionalised carbon bonded foam ceramics for advanced steel melt filtration. ICC6 - 6th International Congress on Ceramics, 21-25 August, 2016, Dresden, Germany, invited talk.

Aneziris, C. G., Storti, E., Dudczig, S., Berek, H., Schmidt, A., Hubalkova, J. (2016): Clean steel technologies based on interactions of refractory filtering materials with steel melt. 7th International Symposium on Refractories - ISR 2016, Xi'an, China on Sept. 20-22, 2016, (plenary lecture speaker), China's Refractories, Vol. 25, No. 3, 2016, pp. 1-10, ISSN 1004-4493 / CN 41-1183/TQ.

Schmidt, A., Gehre, P., Dudczig, S., Aneziris, C. G. (2016): Interaction of the carbon content of carbon-bonded alumina filters in contact with steel melt. ICC6 - 6th International Congress on Ceramics, 21-25 August, 2016, Dresden, Germany.

Schmidt, A., Storti, E., Dudczig, S., Aneziris, C. G. (2016): Experimental evaluation of the kinetics of inclusion deposition from a steel melt on Al_2O_3-C filters with functional coatings. 59th Internationale Colloquium on Refractories, 28.-29. September 2016, Aachen, Germany.

Storti, E., Dudczig, S., Colombo, P., Aneziris, C. G. (2016): MWCNTs-based coating on carbon-bonded alumina filters for steel melt filtration. ICC6 - 6th International Congress on Ceramics, 21-25 August, 2016, Dresden, Germany.

Storti, E., Dudczig, S., Emmel, M., Colombo, P., Aneziris, C. G. (2016): Functional Coatings on Carbon-Bonded Ceramic Foam Filters for Steel Melt Filtration. steel research international, Vol. 87, August 2016, Iss. 8, pp. 1030-1037, DOI 10.1002/srin.201500446.

Subproject A02

Liang, S., Li, Y., Liu, J., Sang, S., Chen, Y, Li, B., Aneziris, C. G. (2016): Fabrication of SiC reticulated porous ceramics with multi-layered struts for porous media combustion. Ceramics International, Vol. 42, Iss. 11, 15. August 2016, pp. 13091-13097, DOI 10.1016/j.ceramint.2016.05.093.

Voigt, C., Aneziris, C. G. (2016): Influence of the slurry rheology on the preparation of alumina foams via replica technique. ICC6 - 6th International Congress on Ceramics, 21-25 August, 2016, Dresden, Germany.

Subproject A03

Zienert, T., Amirkhanyan, L., Seidel, J., Wirnata, R., Weissbach, T., Gruber, T., Fabrichnaya, O., Kortus, J. (2016): Heat capacity of η-AlFe (Fe_2Al_5). Intermetallics, Vol. 77, October 2016, pp. 14-22, DOI 10.1016/j.intermet.2016.07.002.

Subproject A05

Rudolph, M., Zienert, T., Motylenkoa, M., Stöcker, H., Rafaja, D. (2016): Thermally Induced Formation of Transition Aluminas from Boehmite. European Powder Diffraction Conference - EPDIC15, June 12-15, 2016, Bari, Italy, Book of Abstracts, MS09-P10, ISBN 978888080203.7.

Rudolph, M., Zienert, T., Motylenke, M., Voigt, Claudia, Rafaja, D., Aneziris, C. G. (2016): Thermally Induced Formation of Transition Aluminas from Boehmite. ICC6 - 6th International Congress on Ceramics, 21-25 August, 2016, Dresden, Germany.

Subproject A06

Salomon, A., Rafaja, D. (2016): Generating $MgAl_2O_4$ whiskers using carbothermic reactions and SPS/FAST. Proceedings of Electric Field Assisted Sintering and Related Phenomena Far From Equilibrium conference, March 6-11, 2016, Tomar, Portugal, extendend ab-stract.

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Project area B - Modeling of filter structures/ filter systems

Subproject B02

Demuth, C., Werzner, E., Mendes, M.A.A., Trimis, D ., Ray, S.: Simulation of aluminium depth filtration. Filtech 2016, 11-13 October 2016, Köln, Germany, Session L12.

Mendes, M., Roessger, P., Gross, U., Wulf, R., Trimis, D., Ray, S., Goetze, P., Talukdar, P., Werzner, E., Demuth, C. (2016): Measurement and simplified numerical prediction of effective thermal conductivity of open-cell ceramic foams at high temperature. International Journal of Heat and Mass Transfer, Vol. 102, November 2016, pp. 396-406, DOI 10.1016/j.ijheatmasstransfer.2016.06.022.

Subproject B04

Fritzsche, J., Peuker, U.A. (2016): Modeling adhesive forces caused by nanobubble capillary bridging. Colloid and Surfaces A: Physicochem. Eng. Aspects, Vol. 509 (2016), pp. 457-466, DOI 10.1016/j.colsurfa.2016.09.051.

Subproject B05

Settgast, C., Abendroth, M., Kuna, M. (2016): Fracture mechanical analysis of open cell ceramic foams under thermal shock loading. 15th International Conference on Fracture and Damage Mechanics, 14-16 September, 2016, Alicante, Spain.

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Subproject B06

Asad, A., Kratzsch, Ch., Dudczig, S., Schwarze, R., Aneziris, C. G. (2016): Numerical study of particle ltration in an induction crucible furnace. International Journal of heat and fuid flow, accepted: 07.10.2016 DOI: 10.1016/j.ijheatfluidflow.2016.10.002.

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Project area C - Filter performance, materials properties

Subproject C02

Solarek, J., Bachmann, J., Klemm, Y., Biermann, H., Aneziris, C. G. (2016): High-temperature compression deformation behaviour of fine-grained carbon bonded alumina. Journal of the American Ceramic Society, Vol. 99, Iss. 4, April 2016, pp. 1390-1397, DOI 10.1111/jace.14070.

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... AND LATEST PATENTS AND PATENT APPLICATIONS

Subproject C03

Zielke, H., Abendroth, M., Kuna, M. (2016): Determination of fracture mechanical properties of carbon bonded alumina using miniaturized specimens. 15th International Conference on Fracture and Damage Mechanics, 14-16. September, 2016, Alicante, Spain.

Zielke, H., Abendroth, M., Kuna, M. (2016): Determination of fracture and damage mechanical properties of ceramic filter materials using miniaturized specimens. Key Engineering Materials, Vol. 713, 2016, pp. 70-73, DOI 10.4028/www.scientific.net/KEM.713.70.

Zielke, H., Abendroth, M., Kuna, M. (2016): Determining fracture mechanical properties for brittle materials using the ball on three balls test combined with numerical simulations. Theoretical and Applied Fracture Mechanics, Volume 86, Part A, December 2016, Pages 19-24, ISSN 0167-8442, DOI: http://dx.doi.org/10.1016/j.tafmec.2016.09.001.

Subproject C04

Lippmann, T., Weidner, A., Biermann, H. (2016): Influence of nitride layer on the fatigue behavior and crack initiation on 42CrMo4 cast steel in the VHCF regime. Materials Science and Engineering Conference - MSE, 27-29 September, 2016, Darmstadt, Germany.

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Weidner, A., Krewerth, D., Witschel, B., Emmel, M., Schmidt, A., Gleinig, J., Aneziris, C. G., Biermann, H. (2016): Microstructure of non-metallic inclusions identified in cast steel 42CrMo4 after metal melt filtration by novel foam filters. Steel Research International, Special Issue: 250 Years of TU Bergakademie Freiberg, accepted: 16.03.2016, DOI 10.1002/srin.201500462.

Subproject C05

Henschel, S., Krüger, L. (2016): Crack initiation at high loding rates applying the four-point bending split Hopkins pressure bar technique. International Journal of Fracture, Vol. 201 (October 2016) Iss. 2, pp. 235-248, DOI 10.1007/s10704-016-0127-5.

Henschel, S., Dudczig, S., Krüger, L., Aneziris, C. G. (2016): Effect of non-metallic inclusions and shrinkage cavities on the dynamic fracture toughness of a high-strength G42CrMo4 cast steel. Procedia Structural Integrity, Vol. 2, 2016, Pages 358–365, 21st European Conference on Fracture, ECF21, 20-24 June 2016, Catania, Italy, DOI 10.1016/j.prostr.2016.06.046.

Henschel, S, Schmidt, A., Krüger, L. Aneziris, C. G. (2016): Low-temperature crack resistance of a high-strength steel with non-metallic inclusions. The Arctic Region - Geo-resources and Economic & Political Developments, Conference, 09-10 June, 2016, TU Bergakademie Freiberg, Poster.

Settgast, C., Abendroth, M., Kuna, M.: Fracture Mechanical Analysis of Open Cell Ceramic Foams Under Thermal Shock Loading. Journal of Multiscale Modelling, Vol. 7, No. 4 (2016) 1640006. DOI: 10.1142/S1756973716400060

Complementary subprojects

Subproject S01

Berek, H., Hubalkova, J., Aneziris, C. G. (2016): Compressive deformation of Al_2O_3-foams as investigated by in situ X-ray computed tomography and thermal emission. ICC6 - 6th International Congress on Ceramics, 21-25 August, 2016, Dresden, Germany.

Subproject S02

Lehmann, H., Werzner, E., Degenkolb, C., Ray, S., Jung, B. (2016): Optimizing In-Situ Data Compression for Large-Scale Scientific Simulations. 24th High Performance Computing Symposium, Spring Simulation Multi-Conference (HPC/Spring Sim 2016), April 3 - 6, 2016, Pasadena, CA, USA. Simulation Series Vol. 48, No. 4, pp. 32-39, ISBN 978-1-5108-2318-1.

Patents and patent applications

Subproject A01

Process for producing carbon-containing and/or carbon-bonded ceramic metal melt filters. Patent application No. 10 2011 109 682.9 (filed 08.08.2011).

Carbon-containing ceramic filters for the filtration of melt metal and process for filter production. Patent application No. 10 2012 008 526.5 (filed 02.05.2012).

Process for producing a flame-sprayed or plasma-sprayed thermal shock resistant and corrosion-resistant ceramic surface based on Al_2O_3-TiO_2-ZrO_2. Patent application No. 10 2009 006 778.7 (filed 01.02.2009), granted 19.08.2014.

Coated Filters and Methods of Production. Patent application No. EP16192346.1 (filed 05.10.2016).

Process for producing carbon-containing ceramic components. Patent application No. PCT/EP2016/076647 (filed 04.11.2016).

Subproject A02

Silica-based aluminum melt filters. Patent application No. 10 2016 011 566.1 (filed 26.09.2016).

Subprojects A01 / A02

Ceramic filters for metal melt filtration based on established metal melt filter geometries and processes for filter production. Patent application No. 10 2011 109 681.0 (filed 08.08.2011), granted 28.03.2014.

Ceramic reactive filters for metal melt filtration. Patent application No. 10 2011 109 684.5 (filed 08.08.2011), granted 04.03.2014.

Ceramic filters for filtrating melt metal and process for filter production. Patent application No. 10 2012 008 525.7 (filed 02.05.2012).

Subprojects A01 / C01

Process for producing carbon-containing ceramic components. Patent application No. 10 2015 221 853.8 (filed 06.11.2015).

Refractory material and its application. Patent application No. 10 2016 100810.9 (filed 20.01.2016).

Thermal shock and corrosion-resistant high-melting composite or refractory composite and process for their production. Patent application No. 10 2016 013 265.5 (filed 09.11.2016).

Subprojects B06 / C01

Process for purifying metal melt in an induction furnace. Patent application No. 10 2016 011 152.6 (filed 16.09.2016).

Subproject C02

Process for producing components with locally defined varying density and/or porosity. Patent application No. 10 2016 212 474.9 (filed 08.07.2016).

Subproject T01

Ceramic filters and filter systems for continous metal melt filtration. Patent application No. 10 2016 106 708.3 (filed 12.04.2016).

SUCCESSFUL PH.D. DEFENSE

Jörg Fritzsche, doctoral student in the CRC 920, defended his Ph.D. thesis on the measurement of adhesion forces between rough surfaces with excellent results. His research is part of the work delivered in subproject B04.

Different wetting properties, obtained from an variation of liquids and the utilization of coated surfaces, have been analyzed. In addition to the contact angle of the investigated systems, free surface and interface energy have been measured and correlated with the forces.

Results suggested that adhesion forces on rough surfaces are following distributions across several scales. Descriptions of the identified distributions were based on both statistical functions and, at least partially, a modelling approach developed in this thesis. Moreover, findings demonstrated that various adhesion mechanisms (capillary connections or VAN DER WAALS as well as polar interactions) can be distinguished. Capillary connections, caused by nano-scale bubbles on mostly poor-wetting surfaces, have been found to form the highest forces. ■

Photo: Dr.-Ing. Jörg Fritzsche (left) and Prof. Dr. Urs Peuker (right).

NEW RESEARCH DEVICE

A new high-temperature scanning force microscope High Vacuum 7500 SPM, produced by RHK Technology and acquired for research purposes of the CRC 920, has been installed at the Institute of Mechanical Process Engineering and Mineral Processing. "This high-temperature scanning force microscope allows us to run measures in atomic resolution under high vacuum and for sample temperatures up to 1800 K" said Prof. Urs Peuker, coordinator of project area B "Modeling of filter structures/filter systems."

Photo: The new high-temperature scanning force microscope.

The new device serves two purposes, namely, first, quantifying adhesion forces under vacuum and high temperatures and, second, verifying sinter effects between particles and filter materials during metal melt infiltration. Furthermore, capillary forces between particles and the metal melt shall be investigated. To this end, specific temperature-stable colloidal probe cantilever for measuring force-distance curves and a first ingot prototype for the aluminum melt has been developed in advance. ■

CONFERENCES AND CALLS FOR PAPERS

4th CellMat 2016 including a "Special Session CRC 920": Sep 07-09, 2016, Dresden. Further informationen at: http://cellmat.dgm.de/home.

7th Freiberger Feuerfestforum: Dec 14, 2016, Freiberg.

92th DKG Jahrestagung mit Symposium Hochleistungskeramik 2017: March 19-22, 2017, TU Berlin. Further information at www.dgk.de.

19th Conference on Modern Refractory Materials and Key Achievements in High-Temperature Technologies, REFRA 2017: May 30 June 1, 2017, Prague. Further informationen at www.silikaty.cz.

UNITECR 2017: Sep 26-29, 2017, Santiago de Chile. With a Special Session "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials." Further information at unitecr2017.org.

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PHOTOS
TU Bergakademie Freiberg, CRC "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials," Detlev Müller

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SFB 920
Multifunktionale Filter für die Metallschmelzefiltration – ein Beitrag zu Zero Defect Materials