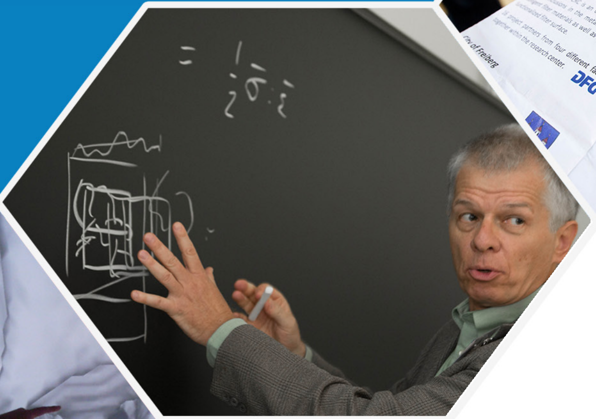
SFB 920

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

NEWSLETTER 5 (2/2013)

DFG Deutsche Forschungsgemeinschaft

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG



DEAR READERS,

Developing novel materials requires the collaboration between scientists from different academic disciplines, which enables the integration of knowledge from several scientific fields. Holding a “Workshop on the mechanical modeling of random open cell foams,“ the CRC 920 offered a unique opportunity for intensive dialogue between experts on structural mechanics and stochastic geometry that gave fresh impetus to the development of innovative filter materials and filter systems based on foam structures.

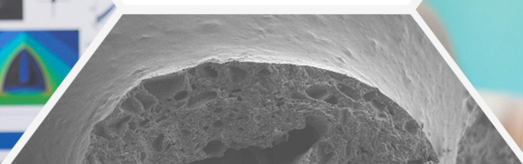
This workshop as well as other activities of the Integrated Graduate Program aimed at supporting young scientists in materials science and engineering with regard to contents and methods and to empower them to participate in interdisciplinary dialogue. Details on these and other activities, results and next steps 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



RICH OPPORTUNITIES FOR TRAINING AND QUALIFICATION

The Integrated Graduate Program embedded in the CRC 920 puts strong efforts on a comprehensive training and qualification of its doctoral students. The ultimate goal is to ensure an excellent education and an accelerated graduation of young researchers. To this end, various lectures and workshops with guest from academia and industry were offered that addressed both professional knowledge as well as individual capabilities with great importance for a successful graduation.

On the occasion of the 7th Doctoral Meeting in June 2013 the CRC 920 welcomed **Prof. Charles E. Semler**, Fellow and former Vice President and Chairman of the Refractories Division of the American Ceramic Society. He gave a talk on basic facts and advances in steelmaking refractories.

Photo (from left to right): Prof. Charles E. Semler, Prof. Christos G. Aneziris, Prof. Subhashis Ray, Eric Werzner

Moreover, doctoral students were invited to join two guest lectures organized by the CRC 799 "TRIP-Matrix-Composite." Prof. Masao Sakane from Ritsumeikan University Kyoto, presented research results on the fatigue behavior of metallic materials.

Dr. Peter Nold from Maschinenfabrik Gustav Eirich GmbH & Co. KG in Hardheim provided a workshop on fundamentals of ceramic materials preparation, entitled "Mixing, granulating, coating, plasticizing and slurrying in the ceramic industry." Referring on technological and economic requirements of preparation processes, he demonstrated the impact of mixing tools, power and speed on the mixed product and, hence, on relevant properties of a material.

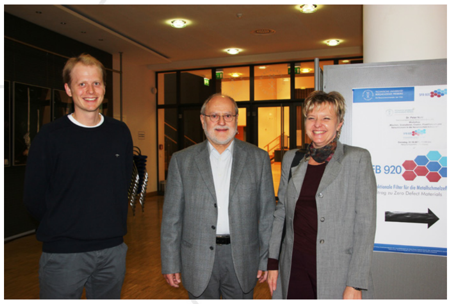


Photo: Dr. Peter Nold (middle) with Dominik Krewerth (left) and Christiane Biermann (right)

Also, a workshop on „Rules of good scientific practice" was offered to the CRC doctoral students. **Prof. Broder Merkel**, Liaison Officer of the German Research Foundation DFG at TU Bergakademie Freiberg, discussed guidelines on safeguarding good scientific practice, which are intended to prevent scientific misconduct. ■

SCHOLARS VISITING THE CRC 920

Photo: CRC research assistant Steffen Dudczig (middle) with PhD scholars Ashish Pokhrel (left) and Enrico Storti (right)

Holding scholarships from the CRC 920 and the German Academic Exchange Service DAAD, doctoral and master students from four countries are joining CRC research teams. During a 12-month visit, until spring 2014, **Enrico Storti from Italy** and **Ashish Pokhrel from Nepal** are being involved in the subprojects A01 and A02. Recently, Dig Vijay (India) and Jorge René Gavidia Alas (Canada), who participated in subproject B03, have successfully finished their visit in Freiberg.

Funded by the ERASMUS program "Lifelong Learning Programme: Erasmus Student Mobility for Placements 2012/2013," the master student **Francesco Sponza from the Università di Padova (Italy)** is visiting the CRC. Until the end of November, he will be conducting field studies which are an integral part of his master thesis.

Scholarships for students and doctoral students are of great importance to the CRC 920 because they support the integration of young scientists from abroad into local research activities. Moreover, these scholarships enable CRC doctoral students to establish and extend their working relationships with colleagues and experts around the world. ■

ENHANCING INTERDISCIPLINARY RESEARCH

Developing novel materials requires the collaboration of scientists across scientific disciplines. For the first time, a CRC 920 workshop brought together experts in the fields of structural mechanics and stochastic geometry. Discussions centered on new ways for analyzing and modeling foam structures.

Their paths do not often cross: experts in the fields of structural mechanics, who focus on modeling structures under mechanical load, and experts who study random spatial patterns based on mathematical approaches. Yet, the development of new materials may greatly benefit from the combination of knowledge gained in both fields.

Against this background, the CRC 920 and the Institute of Mechanics and Fluid Dynamics at the TU Bergakademie Freiberg initiated an international "Workshop on the mechanical modeling of random open cell foams." Following an invitation to Freiberg, five internationally leading experts took part in this workshop: **Prof. Martin Ostoja-Starzewski** (University of Illinois/USA), **Prof. Andrew Kraynik** (currently COFUND Senior Research Fellow at Durham University/UK), **Prof. Stelios Kyriakides** (University of Texas at Austin/USA), **Prof. Claudia Redenbach** (TU Kaiserslautern, Germany) as well as **Prof. Dietrich Stoyan** (TU Bergakademie Freiberg).

The presentations focused on approaches for modeling open-cell foam structures as well as ways to describe geometric properties of such structures. Investigations of foam structures play a crucial role for the CRC: The CRC researchers aim at developing smart ceramic foam macro structures which improve the purity of metal melts by efficiently reducing non-metallic inclusions. To accomplish this goal, researchers seek to better understand the relations between geometric properties and the behavior of ceramic foam structures under thermal or mechanical load. In order to develop a proper design modeling and, hence, predicting effects of structures on relevant properties is an important issue for the development of the new filter materials and systems.

The workshop and also the panel discussion, which took place after the presentations, are first steps towards the integration of research results from different academic disciplines that may provide fresh impetus to research activities of the CRC. Consequently, this interdisciplinary dialogue will be continued in the future. ■


Photo: Speakers and participants of the CRC workshop (from left to right): Torsten Sieber, Prof. Kraynik, Prof. Redenbach, Dr. Abendroth, Prof. Ostoja-Starzewski, Prof. Kyriakides, Johannes Storm


Photo: Prof. Dietrich Stoyan, discussion with presenters


Photo: Speakers and participants of the CRC workshop, joining the panel discussion

What was your motivation to attend this workshop?

Prof. Kraynik: We all came with expertise and some aspects on modeling mechanical properties in foam structures, to exchange what we know with the group here.

Which challenges do you see pertaining to the development of novel filter materials?

Prof. Kyriakides: The development of ceramic filters is an extremely interdisciplinary issue which involves many aspects of engineering and science. I think we touched several aspects of that issue during the meeting here. We have also seen the importance of an effective communication within multi-disciplinary teams.

Prof. Ostoja-Starzewski: Additionally, tremendous developments in computer technology will play an increasing role in understanding relationships between foam structures and properties.

Which impressions did you receive from the CRC 920?

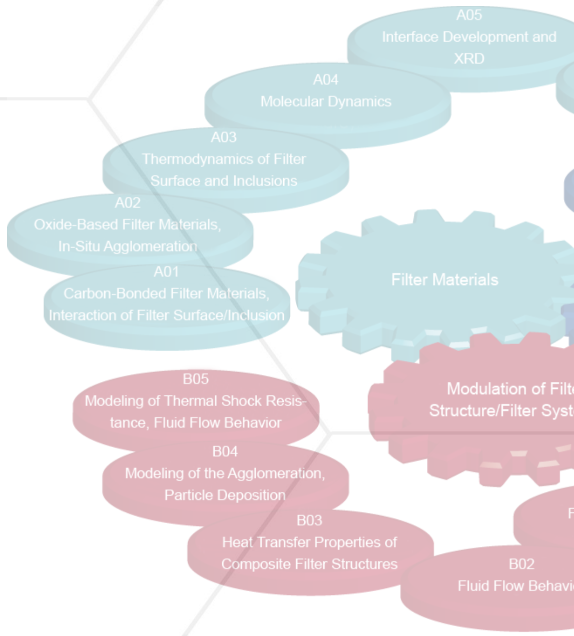
Prof. Kraynik: The aim the CRC is pursuing is ambitious. I would like to encourage the people in this group, although the problem they tackle is very hard. It is really refreshing to see how people are trying to do something together.

Prof. Kyriakides: I think this is a nice group and I like the way how the group handles its research tasks.

Prof. Ostoja-Starzewski: My experience here is quite unique. Discussing research problems with the entire group was very interesting.

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.

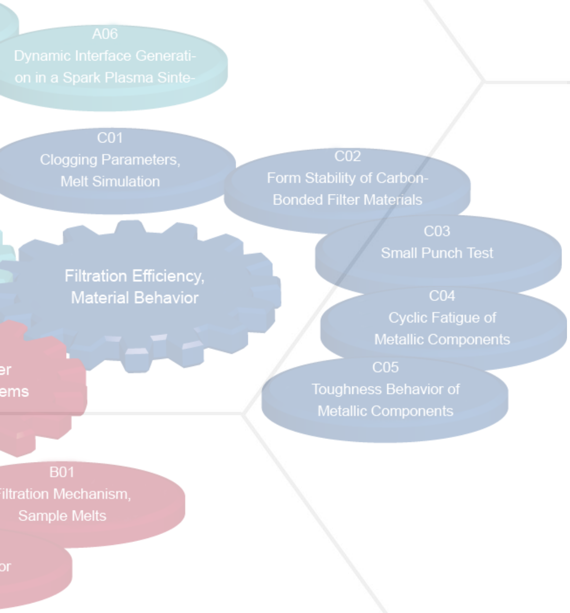


Working Group 1: "Metal melt/inclusions, active/reactive filter materials, boundary surface design" (Coordination: Dipl.-Ing. Tilo Zienert)

- Experiments employing the metal casting simulator (C01), testing uncoated filters and 100% carbon filter materials; successful test of a new method for controlling the oxygen content of a melt in order to generate endogenous inclusions,
- Analysis of spatial distribution of ceramic inclusions in steel, using samples from industrial casting experiments (A01), in order to determine the filtration efficiency,
- Determination of thermal shock properties of filters with active coating and test of these filters in both a laboratory and an industrial field casting test (S03, A02),
- REM analyses for characterizing casted filters (A02); analysis of casted aluminum with the PREFIL method (S03, A02),
- Generation of specific filter geometries with pore sizes ranging between 30 and 40 ppi for further field casting tests (A02, S03),
- Matching between calculated thermal capacities in the Al-Fe-Si system (A04) and experimental data (A03); initiation of further calculations applying the DFT method to the Al-Fe system (A04); completion of thermal capacity measurements of intermetallic phases in the AL-Fe system (A03),
- Analysis of SPS-generated interfaces between the alloy A365 and coatings based on Al_2O_3, SiO_2 and TiO_2 (A06),
- Structure analyses of several carbon-based materials including black, graphite, carbores, and resin after coking (A05).

Working Group 2: "Modeling and designing of the filter geometry" (Coordination: Miguel Mendes, Ph.D.)

- Analysis of the influence of process conditions as well as wetting behavior of particles and filter surface on filtration efficiency (B01),
- 3D fluid flow and particle tracking simulations for prediction of filtration efficiency, using both detailed and simplified approaches for unsteady flow fluctuations (B02),
- Evaluation of effective thermal conductivity of ceramic filters at ambient and high temperatures (B02, B03),
- Experimental evaluation of convective heat transfer coefficient of filter foams; measurement of bulk material properties of filter foams (B03),
- Validation of stochastic model for shape distribution of primary particles and agglomerates using measurements from QUI-PIC experiments. Atomic force microscope measurements of agglomerates stability (B04),
- Investigation of effective thermal conductivity as well as elastic and inelastic behaviour of representative volume element of filter structure (B05),
- Analysis of geometrical parameters of filter foam structures. Measurement and numerical prediction of effective properties of filter foams using different approaches for foam geometry generation (B02, B03, B05).



Working Group 4: "Mechanical properties, metallic materials, critical inclusions" (Coordination: Dipl.-Ing. Dominik Krewerth)

- Fabrication of several casting plates of aluminum alloy and steel applying different filter materials including reference materials (A01, A02, S03),
- Sampling and execution of static and cyclic tests to analyze mechanical properties and fatigue behavior of the metallic materials (C04, C05),
- Definition of metallographic parameters required for simulations based on point estimation methods (S01, C04, C05),
- Stochastic analysis and simulation of particle distributions of different casted steel plates (S01, C04),
- Determination of filter efficiency-levels of different filter materials using metallographic and stochastic analyses of particle distributions within the gating system (S01, C04),
- Generation of i) sinter tablets and ii) non-melted sinter tablets and subsequent HIP treatment in order to validate alternative manufacturing routes (C04, C05),
- Successful HIP treatment of steel plates for reducing shrinkage porosity (C04),
- Contamination of aluminum model melts with oxidized flakes (S03),
- Application of the PREFIL procedure for aluminum in order to determine the total content of non-metallic inclusions (A02, S03),
- Contamination of aluminum model melts by adding recycled aluminum and by using a copper mold (S03, S01, C04).

Working Group 3: "Thermo-mechanical characteristics of filter materials and structures" (Coordination: Dipl.-Wirt.-Ing. Yvonne Klemm)

- Description of the size distribution of Al_2O_3 particles observable in exemplary filtrations in water (subject in B02) and during particle flow around barriers (column) (subject in B01) (B04),
- Utilization of approaches for simulating mechanical and thermomechanical behaviors of deterministic foam structures, in order to generate data for material modeling (strain relaxation, creep in compression); construction of a further small punch facility that enables conduct creeping tests (B05),
- Conducting first compression and bending tests at 1.500°C employing new vacuum material testing equipment, which requires optimizing sample geometries and temperature measurements (C02),
- Construction of a customized creep tester (C02, B05), HT small punch tests of Al_2O_3-C materials (20 vol.% carbores) at 800°C and later at 1.000°C (C03).

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DYNAMIC INTERFACE GENERATION USING SPARK PLASMA SINTERING

Author: Anton Salomon
(subproject A06)

For effective usage of ceramic filters, the interfacial reactions of metal melts with active and reactive filter ceramics have to be understood and controlled. In the subproject A06 of CRC 920, the so-called Spark Plasma Sintering (SPS) is employed to generate interfaces between a liquid metal and pre-sintered ceramics under convection-less conditions.

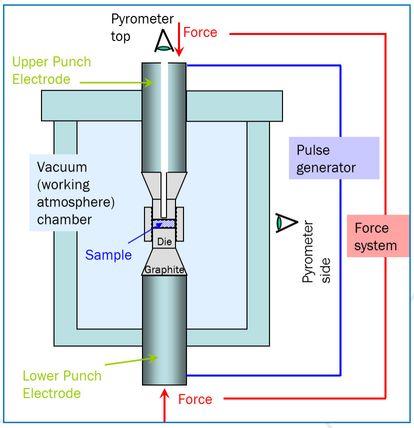

Fig. 1: Spark Plasma Sintering setup

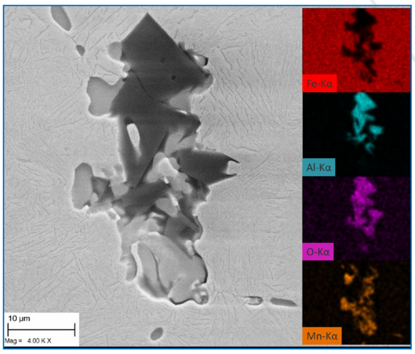

Fig. 2: SEM micrograph (SE contrast) of an Al_2O_3 cluster within steel with corresponding EDX elemental distribution maps for Fe, Al, O and Mn

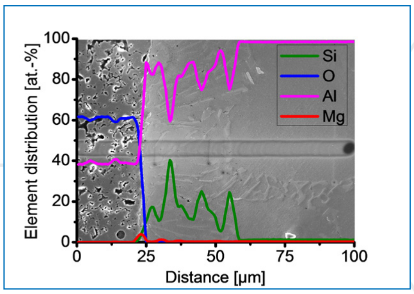

Fig. 3: Electron probe micro analysis elemental distribution measurement across the interface between Al_2O_3 and AlSi7Mg showing the enrichment of Mg with corresponding SEM micrograph (SE contrast)

The SPS process was developed as a powder metallurgical densification method. In recent years, it has become a sintering technique used for compaction of almost all kinds of materials. SPS simultaneously applies mechanical pressure and pulsed electric direct current that results in Joule heating of the sample (in the case of an electroconductive powder) and in heating of the sintering tools made typically from graphite (see Fig. 1).

The application of SPS for metal melting is a new approach that offers (i) extremely high heating rates of up to 1500 K•min^{-1} and fast cooling, (ii) melting in different atmospheres (vacuum or inert gases), (iii) precise temperature control, (iv) variable dwell times between seconds and hours. As a result, the SPS melting treatment can be designed to resemble actual filtering conditions.

In the first period, the CRC 920 is focused on two systems: 1. Liquid steel 42CrMo4 at a temperature of 1600 °C in contact with carbon bonded Al_2O_3 (Al_2O_3-C); 2. Aluminum alloy AlSi7Mg melt at 750 °C in contact with pure Al_2O_3. Since the first results had indicated that during SPS treatment no endogenous inclusions (due to reactions in the melts) are created, Al_2O_3 particles with sizes varying from several micrometres to millimetres were added to the metal powders that acted as exogenous inclusions. In this way, possible adherence of the particles to the ceramics is investigated.

The studies in the steel/Al_2O_3-C system revealed that the melt penetrates the porous ceramic, and a penetration layer with a thickness of approximately 40 µm is created despite no pressure acting on the liquid metal. However, the steel showed a bad wetting behaviour, did not adhere to the ceramic after solidification and no interfacial reactions were detected. The exogenous inclusions showed a tendency for agglomeration and acted as nucleation sites for the heterogeneous nucleation of manganese sulphide (MnS, see Fig. 2). Uncoated Al_2O_3-C could not be shown to attract the Al_2O_3 exogenous particles and promote adherence.

Also, the results obtained for the system AlSi7Mg/Al_2O_3 showed the tendency of the exogenous Al_2O_3 to agglomerate, although the size and appearance of these clusters were different. In comparison to the industrial tests, wetting and adherence of the metal to the ceramic are enhanced. After the SPS heat treatments for 30 min, the formation of spinel $MgAl_2O_4$ was shown to occur (see Fig. 3) at the metal/ceramic interface, which gives an explanation for the differing results. Without a coating, no significant interaction of the Al_2O_3 filter ceramic and Al_2O_3 inclusions was found.

Ongoing experiments in subproject A06 are concerned with the influence of and interactions between active and reactive coatings like rutile, silica, mullite, magnesia and spinel with the metal melts and the inclusions. ■

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MECHANICAL PROPERTIES OF BULK CARBON-BONDED AL_2O_3-C FILTER MATERIALS

The aim of subproject C02 is to provide physical and mechanical properties of carbon-bonded Al_2O_3-C materials at temperatures near to those in service. The influence of the amount of Carbores® P binder and the coking temperature was studied.

Author: Yvonne Klemm
(subproject C02)

First of all, compression and bending tests were performed at room temperature. Additionally the refractoriness under load was measured at a maximum of 1600 °C, a temperature close to the steel casting process which gives first information about the thermomechanical behavior of the filter material. The bulk samples were manufactured through a slurry route with a Carbores® P content from 5 to 20 wt. % and afterwards pressed uniaxially. The green samples were then coked at temperatures of 800 and 1400 °C.

Whereas the differences in the physical properties are obvious, the results of the compression and bending tests show no significant differences between the batches coked at different temperatures. The strength values increased with increasing binder content. The results of the refractoriness under load tests in Fig. 1 offer lower thermal expansion and earlier softening of the samples coked at 800 °C because further microstructural processes occur at temperatures up to 1400 °C. This can be proved by SEM showing lower grain sizes of the binder grain for specimens coked at 1400 °C (see Fig. 2). Thus, one can assume that a higher coking temperature tends to lower softening and higher stability at high temperatures.

In future work stress-strain curves up to temperatures of 1500 °C will be studied in a vacuum testing machine (see Fig. 3). From this, constitutive equations for the filter materials will be determined and the mechanical behavior of filters can be simulated. ■

Fig. 3: Vacuum testing machine for high temperature bending and compression tests

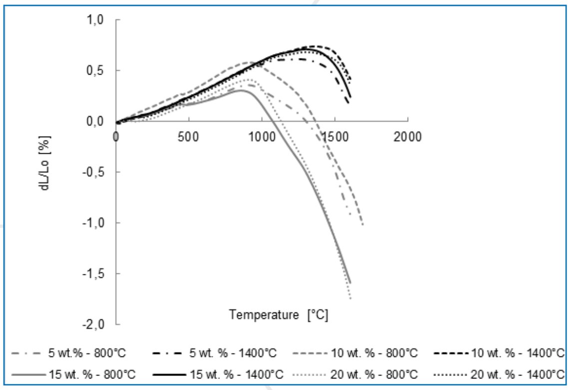

Fig. 1: Refractoriness under load (RUL) at different Carbores® P contents and coking temperatures

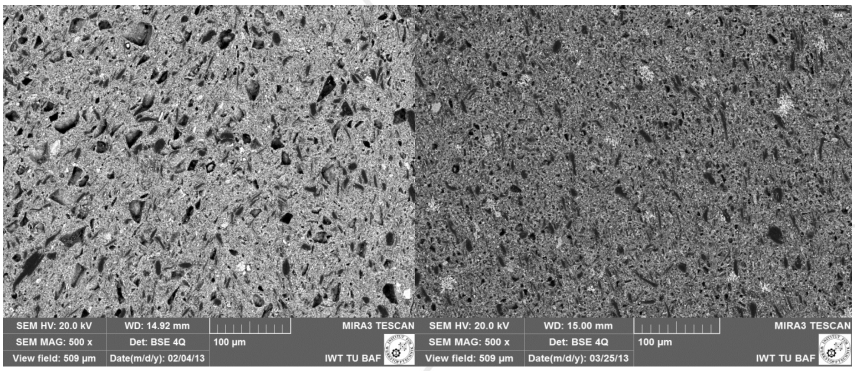

Fig. 2: SEM images of the microstructure of samples with 10 wt. % binder. Left: coked at 800 °C, right: coked at 1400 °C. Grains of the Carbores® P binder are visible in black, alumina agglomerates in bright grey.

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ANALYZING MATERIALS PROPERTIES USING THE SMALL PUNCH TEST (SPT)

Author: Stefan Soltysiak
(subproject C03)

Developing novel materials requires investigations of their mechanical properties, in order to predict their behavior under service conditions. In general, mechanical properties of ceramic materials show considerable variation. Hence, mechanical properties of filter materials are identified by employing the Small Punch Test (SPT).

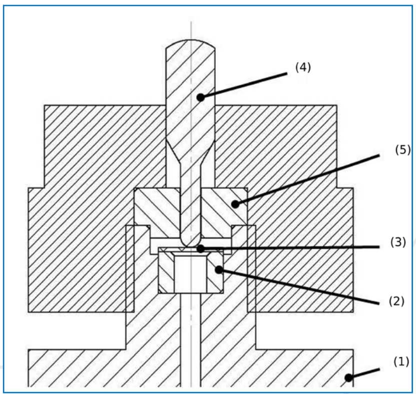

Fig. 1: Components of the SPT equipment: (1) adapter, (2) bearing, (3) specimen, (4) punch, (5) guide-way

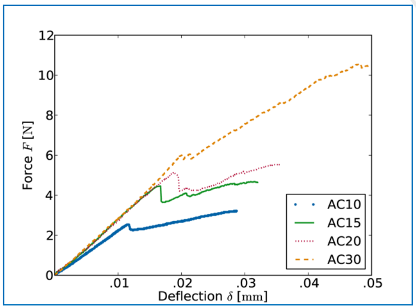

Fig. 2: Typical force-displacement curves of quasi-brittle materials

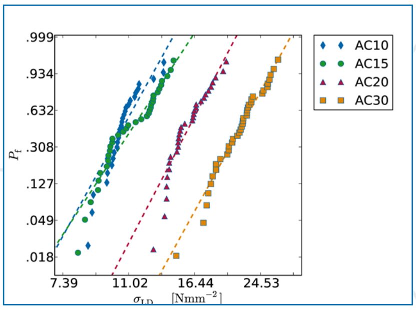

Fig. 3: WEIBULL diagram showing the fracture probability as a function of the fracture load

The SPT represents a small-scale plate bending test which requires only small material volumina (specimen diameter d=8mm, specimen thickness t=0.5mm). Hence, the SPT provides great advantages by permitting multiple tests. The evaluation of statistical distributed material properties is therefore possible. Since the specimen thickness is comparable to the diameter of filter struts the influence of size effects can be minimized.

Fig. 1 shows the components of the Small Punch Test equipment. An adapter (1) is used to connect the equipment with an universal testing machine. The specimen (3) is placed on the bearing (2). A punch with a hemispherical tip (4) is used to deflect the specimen until final fracture. The concentric alignment of the punch with respect to the specimen is ensured by the guide-way (5).

The punch force and the deflection of the specimen are measured during the experiment. Fig. 2 shows force-deflection curves of carbon bonded alumina (Al_2O_3-C) which is developed in the CRC 920. These curves provide information about the force at fracture and the absolute deflection of the samples. The critical stress at fracture can be calculated based on this information using the following equation:

$$\sigma_{krit} = k \cdot \frac{F_{max}}{t^2}$$

In this equation σ_{krit} is the critical stress, F_{max} the load fracture, t the specimen thickness and k is the geometry factor of the equipment. The punch-tip diameter, inner bearing diameter, and specimen diameter are represented by k.

As it was mentioned before, measured values for the investigated quasi-brittle material disclose considerable variations. In order to quantify these variations, the WEIBULL distribution is used. This distribution function predicts the fracture probability of a material dependent on external stress. The WEIBULL diagram shown in Fig. 3 plots the fracture probability on a double-logarithmic axis versus the fracture load, illustrating the functional relationship between both parameters.

This WEIBULL diagram in Fig. 3 pertains to the (Al_2O_3-C) material. As one can see, under equal stress, the fracture probability decreases as the coal tar pitch content increases.

Using this method, mechanical properties of materials which have been developed in the subprojects A01 and A02 can be identified. Moreover, these tests deliver data which are requested by subproject B05 for simulating the mechanical behavior of foam structures. ■

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RECENT PUBLICATIONS

Project area A - Filter materials

Subproject A01

Aneziris, C. G., Schröder, C., Fischer, U., Berek, H., Emmel, M., Kortus, J., Amirkhanyan, L. G. Weißbach, T. (2013): Interactions between Exogenous Spinel Inclusions with Endogenous Inclusions in a Steel Melt. AEM. Special Issue 12/2013, DOI 10.1002/adem.201300155.

Emmel, M., Aneziris, C. G. (2013): Functionalization of carbon-bonded alumina filters through the applications of active oxide coatings for the steel melt filtration. Journal of Materials Research. Vol. 28, Iss. 17, pp. 2234-2242, DOI 10.1557/jmr.2013.56.

Emmel, M., Aneziris, C. G., Schmidt, G., Krewerth, D., Biermann, H. (2013): Influence of the chemistry of ceramic foam filters on the filtration of alumina based non-metallic inclusions. AEM. Special Issue 12/2013, DOI 10.1002/adem.201300118.

Subproject A02

Voigt, C., Jäckel, J., Aneziris, C.G., Hubálková, J. (2013): Spinel coating on alumina foam ceramics for aluminum filtration. AEM. Special Issue, 12/2013. DOI 10.1002/adem.201300111.

Voigt, C., Storm, J., Aneziris, C. G., Abendroth, M., Kuna, M., Hubalkova, J. (2013): The influence of the measurement parameters on the crushing strength of reticulated ceramic foams. Journal of Materials Research. Vol. 28, Iss. 17, pp. 2288-2299. DOI: 10.1557/jmr.2013.96.

Subproject A03

Zienert, T., Fabrichnaya, O. (2013): Thermodynamic Assessment and Experiments in the system MgO-Al2O3. CALPHAD, Vol. 40, March, pp. 1–9. DOI: 10.1016/j.calphad.2012.10.001.

Zienert, T., Fabrichnaya, O. (2013): Phase relations in the A356 alloy: experimental study and thermodynamic calculations. AEM. Special Issue, 12/2013. DOI 10.1002/adem.201300113.

Subproject A04

Amirkhanyan, L., Weißbach, T., Kortus, J., Aneziris, C. G. (2013): On the possibility of hercynite formation in a solid state reaction at the Al2O3-iron interface: A density-functional theory study. Ceramics International. DOI 10.1016/j.ceramint.2013.05.132.

Rödel, C., Weißbach, T., Kortus, J., Dudczig, S., Aneziris, C. G.: Raman spectroscopic characterization of novel carbon-bonded filter compositions for steel melt filtration. Journal of Raman Spectroscopy. Accepted: 08.11.2013.

Subproject A04

Dopita, M., Rudolph, M., Emmel, M., Salomon, A., Aneziris, C. G., Rafaja, D. (2013): Simulations of X-ray scattering on two dimensional, graphitic and turbostratic carbon structures. AEM Special Issue, 12/2013. DOI 10.1002/adem.201300157.

Subproject A06

Salomon, A., Emmel, M., Dudczig, S., Rafaja, D., Aneziris, C. G. (2013): Dynamic, in situ generated interfaces between carbon-bonded alumina filters and steel during Spark Plasma Sintering/Field Assisted Sintering. AEM. Special Issue, 12/2013. DOI 10.1002/adem.201300119.

Salomon, A., Zienert, T., Voigt, C., Jäckel, E., Fabrichnaya, O., Rafaja, D., Aneziris, C. G. (2013): Comparison of interfacial reactions between AlSi7Mg and alumina filter after casting and Spark Plasma Sintering. AEM. Special Issue, 12/2013. DOI 10.1002/adem.201300114.

Project area B - Modeling of filter structures/ filter systems

Subproject B01

Heuzeroth, F., Peuker, U. A. (2013): Einfluss der Hydrophilie von dispergierten Feststoffpartikeln auf die Abscheidung an keramischen Tiefenfiltern. Jahrestreffen der Fachgruppe Mechanische Flüssigkeitsabtrennung, 6.-8.03.2013, Weimar.

Laitinen, O., Bauer, K., Niinimäki, J., Peuker, U. A. (2013): Validity of the Rumpf and the Rabinovich adhesion force models for alumina substrates with nanoscale roughness. Powder Technology 246, pp. 545–552. DOI: 10.1016/j.powtec.2013.05.051.

Subproject B02

Mendes, M. A. A., Ray, S., Trimis, D. (2013): A simple and efficient method for the evaluation of effective thermal conductivity of open-cell foam-like structures. Int. Journal of Heat and Mass Transfer. Volume 66, 2013, pp. 412-422. DOI 10.1016/j.ijheatmasstransfer.2013.07.032.

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Project area C - Filter performance, materials properties

Subproject C01

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Subproject C04

Krewerth, D., Weidner, A., Biermann, H. (2013): Investigation of the damage behaviour of cast steel 42CrMo4 during ultrasonic fatigue by combination of thermography and fractography. AEM. Special Issue, 12/2013. DOI 10.1002/adem.201300124.

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Subproject C05

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Complementary subprojects

Subproject S02

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Subproject Z

Aneziris, C. G. (2013): Multifunktionale Filter für die Metallschmelzefiltration – ein Beitrag zu Zero Defect Materials. Überblick. Plenarvortrag auf der Technikwissenschaftlichen Klasse, Sächsische Akademie der Wissenschaften, 14.06.2013, Leipzig (Veröffentlichung im Jahrbuch der SAW), http://www.saw-leipzig.de/plenum/plenarvortraege_2010_2019/copy2_of_plenarvortraege-2011/?searchterm=Aneziris#section-5.

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UPCOMING CRC EVENTS

Nov 13-14, 2013 - 8th Doctoral Meeting and Member Assembly of the CRC 920

Nov 27, 2013 - 4. Freiberg Forum on Refractories; workshop "Modulation of the Young Modules" held by Prof. Rodrigues (Brasil)

CONFERENCES AND CALLS FOR PAPERS

IREFCON - India International Refractories Congress, Jan 15-18, 2014, Kolkata/Indien: For further information please visit http://www.irmaindia.org/irefcon/.

DKG Annual Meeting and Symposium on Advanced Ceramics, Mar 24-26, 2014, Clausthal-Zellerfeld: For further information please visit http://www.dkg.de/veranstaltungen/konferenzen_und_tagungen/event/57.

18. Conference on Refractories and HITHERM, May 13-14, 2014, Prague/Czech Republic: Submission of Abstracts is due Jan 31, 2014; Submission of full papers is due Mar 30, 2014; for further information please visit http://www.silika.cz/index.php/en/.

71. World Foundry Congress WFC 2014, May 19-21, 2014, Bilbao/Spain: Submissions for oral and poster presentations are due Nov 29, 2013, notifications on acceptance will be provided until Jan 31, 2014; for further information please visit http://www.71stwfc.com/index.php/en/.

IMPRESSUM

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