SFB 920

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

NEWSLETTER 2 (1/2012)

DFG Deutsche Forschungsgemeinschaft

Bergakademie Technische Universität Freiberg

DEAR READERS,

Approaches to effectively filter metal melts is a vital prerequisite for controlling the fatigue behavior of metal components and, thus, for preventing the failure of these components. Therefore, insights into appropriate micro and macro structures of filter materials, of methods suitable to detect inclusions and to study the impacts of inclusions on materials properties and performance are requested. Moreover, a deeper understanding of interrelations between materials and process-related parameters in metallurgic processes is needed.

To provide this knowlegde to its Ph.D. students, the CRC 920 offered a doctoral colloquium with internationally distinguished experts on high-temperature processes. The guest speakers from France, UK and the US took actively part in the discussion on research approaches and methodes and they provided valuable comments on further research activities.

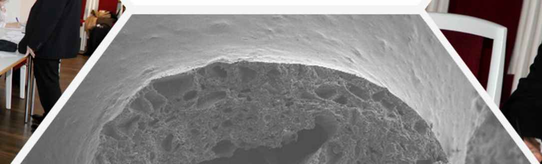
The latest activities, results and events of the CRC 920 are illustrated in this issue of our newsletter. More information is also available on our website on http://sfb920.tu-freiberg.de. We hope you‘ll enjoy the newsletter.

Yours sincerely,

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

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

CONTENT



INNOVATIVE RESEARCH STRATEGY TO FOSTER CLIMATE-FRIENDLY TECHNOLOGIES

Worldwide, there is a growing demand for knowledge on effective metal melt filtration and on methods taking into account economic and environmental requirements. To date, however, only few research groups are focusing on the entire innovation chain leading from the material to the product. Employing a methodological, interdisciplinary and integrated view, the CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials" claims an international key position.

Figure: Flow control in high-temperature processes

Foamed ceramic filters are increasingly deployed for eliminating non-metallic inclusions from metal melts and, thus, to enhance strength, ductility, and fatigue resistance of components such as security elements. To date, filter materials and filter systems often appear as passive, non-functionalized items. The innovative approach the CRC 920 is pursuing refers to the functionalization of filter surfaces based on active, ceramic coatings. Combined with tailored pressure conditions within porous functional cavities, an improved segregation of inclusions on the filter surface will be enhanced.

Currently, metal melt filtration is realized by using about 70 % foamed ceramic filters. In 2002 in Europe approximately 140 million units of filter products have been supplied for iron casting, 20 million units for aluminum casting, and 2 million units for steel casting, satisfying two thirds of the demand for filter products in iron casting, one half of the demand in aluminum casting, and one third of the demand in steel casting. The annual growing rate exceeds 5 %, including about 400 million units of pressed and extruded filters in Europe.

Foamed ceramic filters effectively eliminate non-metallic inclusions from metal melts, thus gaining considerable strength improvements. In fact, foamed ceramic filters show the highest filtration efficiency concerning non-metallic inclusions, specifically oxides and sulfides. The higher filter efficiency stems from the fact that while melt flows through the interconnected pores, particles settle in the pores. Noteworthy, inclusion accretion depends on the interrelation between particles and the melt. Moreover, interactions between the filter wall and the melt as well as forces occurring between inclusions and the filter wall affect the filter efficiency. Due to a high surface tension, the contact of the steel melt with the ceramic filter material leads to a rejection of non-metallic inclusions. On the filter surface, particles can build up to clusters, clinging on the filter and, hence, serving as flow barriers. This happens when wettability of both the inclusions and the filter wall with metal melt is low.

The CRC 920 is pursuing several approaches for designing filters and filter systems according to different metal melts, inclusions and foundry technologies. With regard to mould casting filter systems will be developed which permit both an agglomeration of fine particles in functional cavities and separation caused by wetting and adhesion on the active filter wall of the functional cavity. For continuous casting filter systems will be generated that engender agglomeration and separation along the manufacturing process.

Advanced methods for a theoretical and experimental design of active and reactive filter materials and filter systems as well as the investigation of filter efficiency will contribute to a better way of removing impurities from metal melts, to an increased quality of materials and components and, last but not least, to the accommodation of economic and ecologic aspects such as saving energy by reducing energy consumption for mechanical finishing. The CRC 920 thus promotes internationally important competitive advantages Germany is possessing in research and technology. ■

Figure: "Spaghetti" ceramic as basic structure for filter macro structures

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INTERNATIONAL EXPERTS FOR HIGH-TEMPERATURE PROCESSES VISITING THE CRC 920

In March, three internationally distinguished experts for ceramic and refractory materials visited the CRC 920. The aim of their visit was to provide lectures for CRC Ph.D. students. Participants, in turn, gained the opportunity to discuss research approaches and results with the scholars from the US, France, and UK.

Three international experts on ceramic and refactory materials visited the Freiberg University to present their research and to exchange ideas with participants of this colloquium about the CRC's current research results: Professor **Jeffrey D. Smith**, Missouri University of Science and Technology/ USA, Professor **Jacques Poirier**, Université Orléans/France, and Professor **Jon Binner**, Loughborough University, UK.

Jeffrey Smith introduced latest insights gained from laboratory tests considering the accretion of nozzles (clogging). As he showed, deposits during the foundry process not only wear out refractories. Moreover, they limit the quality of metal melts and the reliability of related aggregates. By simulating industrial foundry processes, the influence of several parameters in steelmaking, including temperature, oxygen content, chemical properties of the melt as well as the properties of refractory materials, on the evolution and on impacts of deposits has been investigated.

Professor Poirier pointed to interactions between refractories and metal melts in several metallurgical processes. Referring to prior research revealing the impacts of metallic and non-metallic impurities and inclusions on properties and materials behavior of steels, he emphasized how refractory materials, component design, for instance the design of nozzles, and control of the steel-making process may prevent inclusions and, hence, increase steel cleanliness. Aspects he identified as critical to enhance clean steel technologies, encompassing a simultaneous control of refractory composition, porosity, permeability and reactivity, appear as valuable connection between his research and the CRC's work.

After their presentations, referees responded to questions from the audience, especially regarding experimental approaches, designs, materials, and procedures used to investigate relevant phenomena. Beside an extended training, the doctoral colloquium provided an excellent opportunity to present and discuss current research results. Interactions between the subprojects exchanging ideas and concepts across disciplines are inevitable in order to accomplish the CRC's aims and goals.

"I like this research program a lot," Jeffrey Smith said. "It is a pleasure to see how the students interact and how subprojects actively collaborate. The CRC is addressing central issues in materials science. Especially innovative high-temperature materials and a smart management of metallurgic processes are vital to increase energy efficiency, to reduce heat loss, and to enhance efficient manufacturing processes."

All guest speakers demonstrated their interest in future collaborations with the CRC 920. Special emphasis has been given to the upcoming UNITECR 2013, taking place in Canada. Serving as the president of the North American UNITECR Committee, Jeffrey Smith invited the CRC Ph.D. students to submit their research to this conference acknowledged as the internationally leading assembly of experts on materials and technologies for high-temperature processes. ■

Photo: Attendees of the CRC doctoral colloquium on March 14th/15th, 2012 at the TU Bergakademie Freiberg

Photo (left to right): Professor Jeffrey Smith (Missouri State University of Science and Technology, USA), Professor Jacques Poirier (Université Orléans, France)

Photo (left to right): Professor Jon Binner (Loughborough University, UK), Professor Christos G. Aneziris (TU Bergakademie Freiberg)

WORKING GROUPS' REPORT

Research teams in the CRC 920 are connected in four working groups, thus ensuring targeted activities, close collaborations between subprojects, and intense 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. Claudia Voigt)

Working group 1 aims at designing ceramic filters in terms of materials, surface, and structure. Studies focus on the impact of filter materials, interfaces between filter and metal, and possible reactions occuring between chemical compounds involved in the process. Current studies include:

- the generation of filter materials with varying filter surfaces (A01, A03), the characterization of these filters considering cold compression strength and porosity, XRD analyses for studying interfaces and for evaluating the effectiveness of surface functionalization (A05),
- test of methods to introduce inclusions in steel and aluminum (for instance, using impurified filters, micro alloying, particle-filled metal wires or adding nano-structures alumina) (S03, B04, A01, A02),
- detecting inclusions employing light-microscopical analyses of polished and etched microsections (S01),
- casting of steel and alumium using newly developed filters (S03), CT analyses of casted and non-casted filters (S01),
- dipping tests using the metal cast simulator to determine the impact of reactive surfaces on steel melt, development of nozzles for clogging tests employing the metal cast simulator (C01),
- calculation of phase equilibria between filter materials and the melt, based on thermodynamic functions gained from the CALPHAD method (A03),
- generation of interfaces between filter surfaces and metal under controlled conditions (heat-up rate 900 K/min), using Spark Plasma Sintering, and characterization of the surfaces (A06), utilizing sample crucibles made of Al_2O_3-C and Al_2O_3 prepared by subprojects C01 and A03.

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

Working group 2 discusses the modeling and dimensioning of filter geometries. Subprojects involved in this group develop filtration models and processes suitable to illustrate heat and mass transport, agglomeration, deposition and adhesion of particles to the filter wall. Currently, the working group is focusing on:

- preliminary investigations to find suitable material combinations (a model filter and a model fluid), which are able to reproduce a similar wetting behavior to that of the metal melt flow through the ceramic foam filter (B01),
- development of a numerical tool for simulation of the molten metal flow within the filter including particle tracking (B02),
- final construction of test rig facilities to investigate thermo-physical properties of ceramic foam filters at very high temperatures (up to 1.650 °C) (B03),
- preliminary experiments to evaluate the van-der-Walls force between particle and wall as well as preliminary tests with the liquid-cell for the atomic force microscope to evaluate other adhesive forces in liquids, development of an approach to model particle distributions as a fundamental step to simulate the filtration process (B04),
- development of a numerical tool for the generation of ceramic foam filter geometry models that are able to reproduce the main properties of real filters, comparison with real data from CT analyses (B05),
- development of novel data compression and visualization methods supporting an interactive analysis of very-large-scale computer simulations of filtration processes (in-situ data compression) (S02).

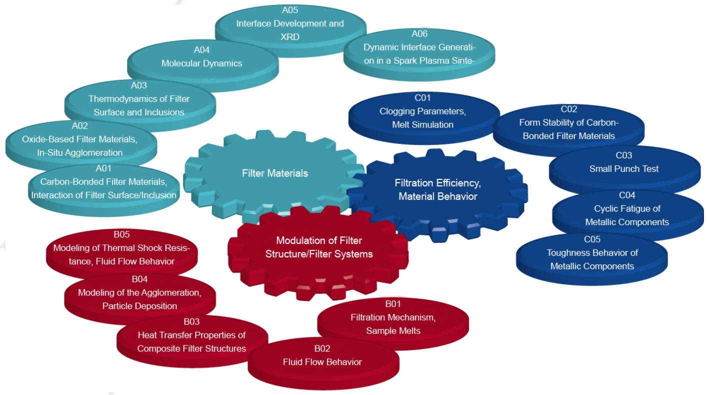

Figure: CRC project structure

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

In working group 3, thermo-mechanical properties of filter materials and structures, in particular their resistance against thermal shock, mechanical stress caused by the metal melt, and - for at least 30 seconds - against softening under load are discussed. Further issues are methods to prevent chemical reaction between the filters and the metal melt. In order to address these issues, the working group has taken the following steps:

- experimental analysis of heat transport properties of carbon-bonded and carbon-free materials and visualization of heat conductivity (B03),
- geometry modeling of foams useful for subsequent simulations of thermo-mechanical stresses during metal melt infiltration (B05),
- preliminary experiments to generate compact Al_2O_3-C specimen as subjects to test for softening under load, cold compression strength, cold bending strength, density and porosity (C02),
- fracture-mechanical tests of compact materials that can be transferred to real carrier materials for filters (C03),
- development of active and reactive filter materials based on Al_2O_3-C and MgO-C, in order to use them for steel melt infiltration and the execution of impingement tests (A01),
- development of Al_2O_3 filters for aluminum melt infiltration (A02).

Working Group 4: "Mechanical properties, metallic materials, critical inclusions" (Coordination: Dr.-Ing. Sebastian Henkel)

Working group 4 focuses on mechanical properties and metallic materials. To this end, non-metallic inclusions are added to model melts and removed partially by filter technology. Filter efficiency can be determined based on investigations of polished and etched microsections. Moreover, studies aim at revealing the impact of added non-metallic inclusions on the specific life performance and toughness behavior of cast materials. Current activities the working group is pursuing include:

- determination of appropriate model melts, dipping procedures, and heat treatment parameters (C04, S01),
- definition of sample taking and steps to generate samples for metallographic and mechanical analyses (S01, S03, C04),
- X-ray investigations to evaluate sample quality and to advance the quality of cast material samples (C04, C05).

Moreover: CRC 920 involved in the development of a BDG guideline "Foamed ceramic filters"

In 2011, a working group of the Federal Association of the German Foundry Industry (BDG) has been installed to develop a guideline for foamed ceramic filters. Representatives of well-known manufacturers of foamed ceramic filters and of foundry companies, in particular from the area of iron, steel and stainless steel casting, are among the group members. The purpose of this guideline is to provide information on dimensions, tolerances, and sizes appropriate to characterize foamed ceramic filters.

In January 2012, researchers of the CRC 920 joined this group. Marcus Emmel (subproject A01) and Claudia Voigt (subproject A02) took an opportunity to present the CRC 920 to members of this working group. In April, Claudia Voigt presented results of a study on influences of test settings in cold compression tests of foamed ceramic filters.

FIELD TRIP AND TRAINING COURSE FOR CRC 920 DOCTORAL STUDENTS

In March 2012, CRC doctoral students visited both manufacturers and customers of foamed ceramic filters. This field trip was intended to develop a deeper understanding of processes and parameters of filter production and of customer needs considering functionality and filter efficiency. Representing an important and valuable element of a high-quality doctoral program, these field trips ensure an application-oriented education of young scientists.

Photo: Participants of the field trip organized by the CRC

The first stop of this field trip was the **Drache Umwelttechnik GmbH** in Diez, a supplier of foamed ceramic filters for continuous and mould casting, offering pore sizes between 10 and 60 ppi and dimensions ranging from 40 to 650 mm. Depending on specific applications, customers have the choice between alumina, zirconia, silicon carbide, and fused silica filters.

Together with the CRC manager Dr.-Ing. Undine Fischer, participants visited the firm's filter production facilities, including slip preparation, preparation of the PU foam, impregnation, drying, quality test and packaging. The visiting tour was followed by a presentation given by Jochen Schnelle, director for the application technology division of the Drache Umwelttechnik GmbH. He illustrated industrial applications of filters, filter usage in foundries, advantages and disadvantages of different filters and approaches for determining filter efficiencies. Moreover, he pointed to limitations of currently used filters and filter systems and strengthened needs for further innovations. For instance regarding pressure casting, centrifugal casting, or ingot casting appropriate filter solutions are still lacking.

The second destination for this field trip was the **Aleris Aluminium Koblenz GmbH**, representing a customer of foamed ceramic filters. The company produces customized aluminum plates, sheets, and bands made with various alloys. Approximately 60 % of its products comply with the aviation standard. Among others, foamed ceramic filters from Drache Umwelttechnik GmbH are employed in the firm's manufacturing processes.

Aleris' plant in Koblenz is equipped with two 40 t melting furnaces and two 45 t holding furnaces to melt aluminum by horizontal heat treatment, using gas burners. After adding relevant alloy elements and additives, the material is casted straight from the holding furnace and with support of a laser-controlled stopper system. In a next step, the melt is drilled using a chlorine-argon mix before it flows into a filter box equipped with two 17" 30 ppi filters. Subsequently, the pre-cleaned melt flows to water-cooled moulds, where textile filters are installed to clean the melt again before the melt is distributed to the moulds.

When the moulds with a height of about 30 cm are filled the alumina cooles off and solidifies. Now the bottom of the mould descends 36 to 45 mm per minute. Thereby, with every cast several bars with dimensions from 30 mm x 1220 mm up to 510 mm x 2500 mm width and up to 7 m height can be produced simultaneously. After casting, which takes about 1.5 hours depending on their dimensions, bars are tempered according to customer specifications. To this end, one of the seven furnaces and temperatures up to 630 °C are employed.

To comply with special customer demands, the bars are milled and plated. More precisely, the bars are coated with another aluminum alloy. For the process of hot-rolling the bars are heated to a temperature between 420 and 460 °C and rolled to a thickness of 8 mm, using for instance a 160 inch hot-rolling scaffold. In order to test the quality of rolled plates, ultrasonic tests are applied that permit detecting defects of a size of at least 1.2 mm. ■

JOINT COLLOQUIUM OF THE CRC 920 AND 799

At a joint colloquium with 35 doctoral students and scientists Dr.-Ing. Undine Fischer, manager of the CRC 920, and Dr.-Ing. Peter Michel, manager of the CRC 799, presented aims and current results both research programs have achieved so far. In a subsequent part, Professor Bernd Steinbach and Michael von Wenckstern, both with the Institute of Computer Science at the TU Bergakademie Freiberg, introduced a database that has been developed for the CRC 799 to ensure a long-term storage of research results.

According to the standards of the German Research Foundation (DFG), research results that have been gained in a CRC have to be stored in a secure, reproducible, and re-usable manner up to ten years after a research program's end. To comply with these standards, a database has been developed that can be utilized in both CRC. The development of this database has been supported by the university's IT department, the Institute of Computer Science and two student assistants. ■

INTERNATIONAL GRADUATE SCHOOL INVITES CRC DOCTORAL STUDENTS

Marcus Emmel and Jörn Werner, doctoral students of the CRC 920, attended a one-week training course at the Federal University of São Carlos (UFSCar), Brasil. In sum, 130 doctoral students from 24 countries joined this course with presentations about today's challenges in materials science given by internationally renowned professors.

Between March 25th and March 31st, the Federal University of São Carlos (UFSCar) invited to the first São Carlos Advanced School on Materials Science & Engineering (SanCAS-MSE). This course aimed at providing young scientists an overview on today's scientific and technological developments in materials science and technology, in particular regarding processes, properties and applications of ceramic materials, glasses, metals, polymers and composite materials.

Nine internationally distinguished professors presented their research, among them Professor William E. Lee (Imperial College of Science and Technology London, UK), Professor Terence G. Langdon (University of Southhampton, UK) and Professor Victor C. Pandolfelli (Federal University of São Carlos, Brasil). Moreover, the program involved several poster sessions dedicated to the presentation of research projects participants of the course are currently involved with. Marcus Emmel and Jörn Werner contributed to this poster session with presentations of projects they are focusing on under the supervision of the CRC coordinator Professor Aneziris.

The São Carlos Advanced School on Materials Science & Engineering is addressing graduates worldwide who seek a master degree or a Ph.D. in materials science and technology. The training course was funded by São Paulo Research Foundation - FAPESP. The TU Bergakademie Freiberg was the only university that was allowed to delegate three participants. Along with Marcus Emmel and Jörn Werner, also Stefan Schafföner attended this event. He is a doctoral student involved in another research project that is hosted at the Institute of ceramics, glass and construction technology. ■

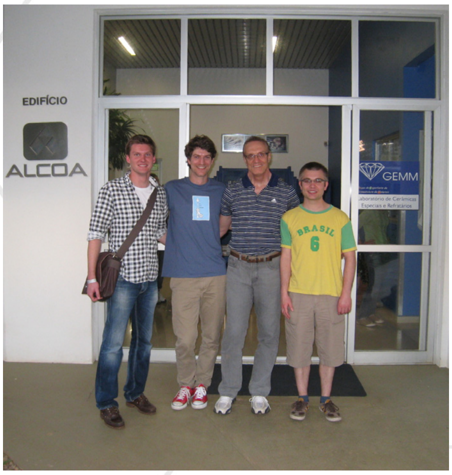

Photo: Professor Victor Pandolfelli (second from right) and attendees of the São Carlos Advanced School on Materials Science & Engineering (SanCAS-MSE): Marcus Emmel (first from left), Jörn Werner (second from left), and Stefan Schafföner (first from right), all with TU Bergakademie Freiberg

DOCTORAL STUDENTS' DELEGATES ELECTED

Dipl.-Ing. Tilo Zienert (Institute of Materials Science) has been elected as speaker of the doctoral students of the CRC 920. **Dipl.-Ing. Pitt Götze** (Institute of Thermal Engineering and Thermodynamics) has been elected as vice speaker. Both candidates are representing the interests of the doctoral students involved in the CRC. In particular, as the doctoral students' representative Tilo Zienert will join the CRC managing board as advisory member and participate in the CRC member meetings where results and tasks of the CRC are discussed.

From 2005 to 2011, Tilo Zienert studied materials science and technology with focus on inorganic, non-metallic materials. Since August 2011, he has been involved as research assistant in subproject A03, dealing with thermodynamic modeling and calculations of phase equilibria and chemical reactions between applied ceramic filter materials and metal melts. His dissertation is dedicated to the thermodynamic optimization of describing the oxide systems Al_2O_3-MgO-Fe_2O_3-SiO_2-Mn_2O_3 and to the description of higher-component metal systems such as Al-Si-Mg-Fe.

After his apprenticeship as industrial technologist/mechatronic engineer and after his professional career at Infineon Technologies Gmbh & Co. OhG Dresden, Pitt Götze studied environmental technology at the TU Bergakademie Freiberg. Since 2011, he has been working as research assistant in subproject B03, focusing on thermophysical properties (such as heat conductivity and heat transfer) of open-porous foam ceramics. ■

Photo (left to right): Dipl.-Ing. Tilo Zienert, Dipl.-Ing. Pitt Götze

DETERMINATION OF DAMAGE-RELEVANT NON-METALLIC INCLUSIONS USING ULTRASONIC FATIGUE TESTING

Dr.-Ing. Anja Weidner
Subproject C04

Safety structural components are often exposed to cyclic mechanical stress, resulting in damage accumulation and fatigue failure. Ultrasonic fatigue testing is a suitable method for detecting critical non-metallic inclusions and for investigating materials fatigue behavior under high numbers of cycles.

The vision of the Collaborative Research Centre (CRC) 920 is the reduction of non-metallic inclusions in casting components by the application of the innovative melt filtration with active and reactive filters. Therewith, the CRC 920 accomplishes to the improvement of the quality of safety structural components with regard to so-called "zero defect materials".

Quite often, safety structural components are exposed in their practical application cyclic loading regimes which are accompanied by damage accumulation. Mostly, low loading amplitudes lead to fatigue failure after very high number of cycles. Often, non-metallic inclusions were identified on the fracture surface as the origin of fatigue failure. Therefore, cyclic loading experiments on casted specimens with and without the application of active and reactive filters can be used in order to determine the efficiency of filtration. Moreover, the largest, non filtrated non-metallic inclusion can be identified by the cyclic loading regime.

The ultrasonic fatigue testing is the most suitable method for testing materials in the range of very high number of cycles (10^7 to 10^{10}). Fatigue tests up to 10^{10} number of cycles are time and cost saving due to an applicable test frequency up to 20 kHz.

Since December 2011, an ultrasonic fatigue testing device is installed at the Institute of Materials Engineering, which is a development of the Institute of Physics and Material Science of the University of Agriculture in Vienna. Figure 1 provides a detailed view of the main parts of the testing machine: (i) the ultrasonic converter, (ii) the titanium horn, (iii) the induction/vibration sensor and (iv) the air cooling system.

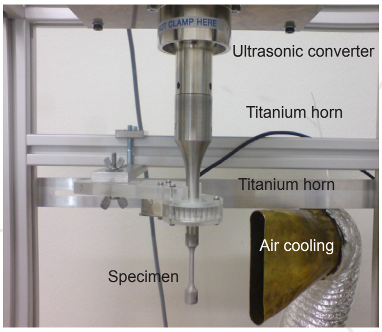

Figure 1: Detailed view on the main components of ultrasonic fatigue testing machine.

The ultrasonic converter realizes the transformation of an electric sinusoidal voltage in mechanical vibrations by the inverse piezoelectric effect. The amplitude of these mechanical vibrations will be enlarged by the titanium-horn and its tapering geometry. The enlarged mechanical vibrations will be transferred to the specimen. An induction/vibration sensor is located at the coupling area between titanium-horn and specimen in order to measure the vibration amplitude with an accuracy of 1%. A pulse-pause mode and/or additional air cooling is applied in order to avoid increasing temperature of the specimen during ultrasonic fatigue tests due to damping in the material.

Casted steel specimens G 42 CrMo4 which were quenched and tempered up to an ultimate tensile strength of 1300 MPa were tested applying ultrasonic fatigue tests at different loading amplitudes. Figure 2a) shows a corresponding Wöhler-plot, where the stress amplitude is plotted versus the number of cycles to failure. Figure 2b) shows a fracture surface with a so-called fish-eye fracture which is typically obtained at low stress amplitudes and very number of cycles.

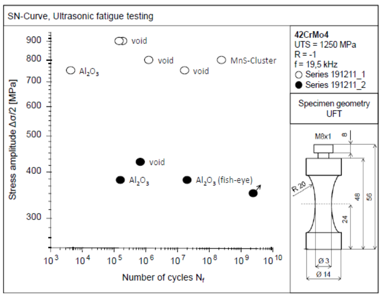

Figure 2a: Wöhler plot depicting results of ultrasonic fatigue tests on specimens of cast steel G 42CrMo4 (quenched and tempered up to ultimate tensile strength of 1300 MPa).

In this case, the origin of failure was an agglomerate of Al_2O_3 which was located about 200 µm beneath the specimen surface having a diameter of approximately 200 µm. Each individual fracture surface is investigated by SEM fractography and EDS measurements in order to determine the defect size, arrangement and chemical composition. ■

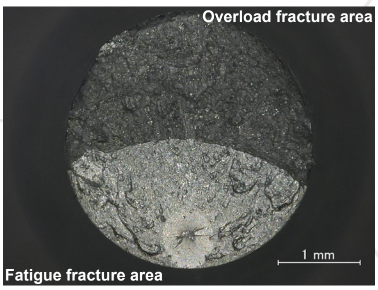

Figure 2b: Fracture surface with fish-eye fracture on an Al_2O_3 agglomerate of a specimen tested at 380 MPa and $N_f = 2 \times 10^7$.

MICROFOCUS X-RAY COMPUTED TOMOGRAPHY

Computed tomography (CT) is a non-destructive testing method permitting three-dimensional imaging of internal structures of materials and the identification of defects (pores, cracks, cavities, inclusions etc.). In the CRC, CT analyses are employed to investigate different states of the filter structures (after forming, after heat treating and after metal casting) from the subprojects A01 und A02 as well as submerged entry nozzle elements from subproject C01.

Dipl.-Ing. Jana Hubálková
Subproject S01

In contrast to medical tomographic scanners, the X-ray tube and detector are stationary in the micro-CT-systems, see Fig. 1. During the micro-CT measurement, the scanned material sample is rotated stepwise by 360° in the X-ray cone beam. A series of radioscopic projections in different angular positions are taken by means of a flat detector, see Fig. 2. A mathematical reconstruction algorithm is then used to reconstruct the three-dimensional structure of the sample. The reconstruction output is a sequence of 2D-slices (single layer cross sections free from superpositions) or volume rendering, see Fig. 3. The grey values of the discrete voxels (elementary volume element of a 3D data set) are dependent on the attenuation of the X-ray radiation caused by several structural constituents; the attenuation coefficient is proportional to the density and thickness of the material, the atomic numbers of the elements and the wave length of the X-rays.

The scanner CT ALPHA 225 of the company ProCon X-Ray GmbH Garbsen available at the Department of Ceramic, Glass and Construction Materials (Fig. 1) is a variable CT-system with two degrees of freedom: two X-ray tubes (directional-head tube up to 225 kV or transmission-head tube up to 160 kV) and two detectors (Hamamatsu-detector with a photodiode area of 120 x 120 mm^2 and pixel size of 50 µm or Perkin Elmer-detector with a total area of 409 x 409 mm^2 and pixel size of 200 µm) are available. The maximal sample size depends both on the active area of the used flat panel detector and on the radiolucency of the material. The limits of radiolucency at maximal voltage of 225 kV are approx. 30 mm for steel, approx. 120 mm for aluminium and approx. 250 mm for alumina-based ceramics. However, the greater the sample size the lower is the volume resolution of the CT-images.

At this point, results of the first preliminary aluminium casting test (performed by Eva Jäckel, subproject S03) with alumina based ceramic filters (made by Claudia Voigt, subproject A02) should be exemplary presented. The „dirty“ alumina filters with oxidic inclusions (corundum, spinel, mullite) casted in aluminium, were first completely scanned in CT (Fig. 4); the voxel size after reconstruction was (75.7 µm)^3 (5-fold magnification) at a sample size of 55 x 55 x 50 mm^3. Afterwards, the alumina filter was cut out and quarted. One of the four cut alumina filter samples was scanned in CT again (Fig. 5); the voxel size after reconstruction was (55.7 µm)^3 (7-fold magnification) at a sample size of 25 x 25 x 20 mm^3. Based on CT micrographs in Fig. 4 and 5, the precipitation processes and the agglomeration of the non-metallic inclusions on the filter wall as well as the wettability of alumina filters by aluminium can be evaluated.

For the first time, 3D-characterization of the clogging-layer inside of the submerged entry nozzle elements by means of micro-CT should be carried out soon (in cooperation with Steffen Dudczig, subproject C01). The micro-CT should thereby contribute to the clarification of the clogging texturing. ■

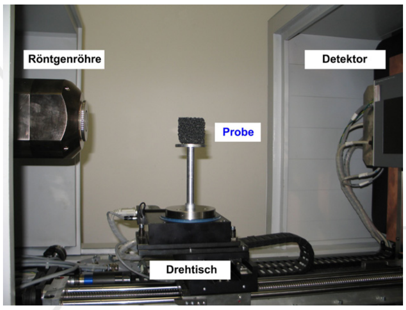

Figure 1: Configuration of the CT-ALPHA 225

The financial support received from the Dr.-Erich-Krüger Foundation for the CT-ALPHA 225 is gratefully acknowledged.

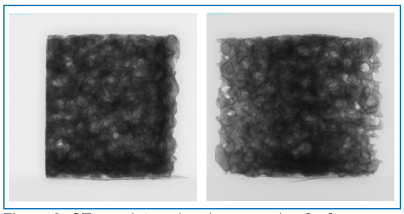

Figure 2: CT raw data using the example of a foam ceramic filter: Radiographs recorded in different angular positions - 0° (left) and 45° (right)

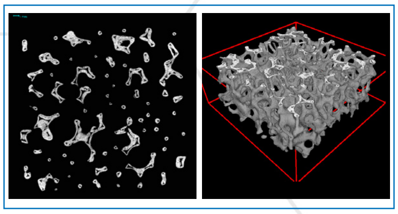

Figure 3: : CT results using the example of a foam ceramic filter: 2D slice (left) und volume rendering (right) reconstructed from the radiographs showed in Fig. 2

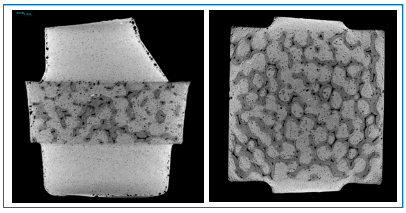

Figure 4: CT micrographs of an alumina filter (filter size: 50x50x25 mm^3) with inclusions casted in aluminium (fivefold magnification), 2D-slices perpendicular (left) and parallel (right) to the casting direction

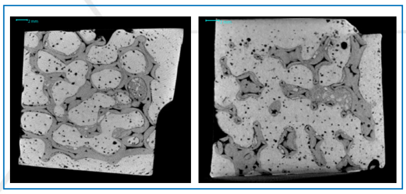

Figure 5: CT micrographs of an alumina filter (sample size: 25x25x25 mm^3) with inclusions casted in aluminium (sevenfold magnification), 2D-slices perpendicular (left) and parallel (right) to the casting direction

PUBLICATIONS

Project area A: Filter materials

Subproject A01

Emmel, M.; Aneziris, C. G. (2012): Development of novel carbon bonded filter compositions for advanced steel melt filtration. Ceramic International, Vol. 38, Iss. 6, August 2012, pp. 5165-5172, DOI: 10.1016/j.ceramint.2012.03.022.

Subproject A01/S03

Aneziris, C. G.; Emmel, M.; Stolle, A. (2012): Multifunctional carbon bonded filters for metal melt filtration. ICACC 2012, Januar 22-27, 2012, Daytona Beach, Florida; Accepted: 09.09.2011, control ID:1170223.

Emmel, M., Aneziris, C. G., Stolle, A. (2012): Multifunktionale kohlenstoffgebundene Filter für die Metallschmelzefiltration. 15. Werkstofftechnisches Kolloquium WTK, 20.-21. September 2012 in Chemnitz. Accepted: 14.05.2012.

Subproject A02

Voigt, C.; Aneziris, C. G. (2012): Optimierung der Herstellung von Schaumkeramikfiltern aus Al_2O_3. 15. Werkstofftechnisches Kolloquium WTK, 20.-21. September 2012 in Chemnitz. Accepted: 14.05.2012.

Subproject A06

Dopita, M., Chmelik, D., Salomon, A., Reichelt, B., Rafaja, D. (2012): FAST/SPS compaction of ultra-fine grained and nanocrystalline WC based hard metals. International Symposium on Ceramic Materials and Components for Energy and Environmental Applications CMCee, May 20-23, 2012 in Dresden. Accepted 25.04.2012.

Project area B: Modeling of filter structures/ filter systems

Subprojects B01/A01/B02

Peuker, U. A.; Aneziris, C. G.; Trimis, D. (2012): Liquid Metal Filtration – New Approaches. World Filtration Congress WFC11, April 16-20, 2012 in Graz (Austria). Accepted: 08.08.2011.

Subprojects B03/A01

Götze, P.; Skibina, V.; Wulf, R.; Emmel, M.; Groß, U.; Aneziris, C. G. (2012): Determination of effective thermal conductivity of open celled foam ceramics with the transient plane source technique. International Symposium on Ceramic Materials and Components for Energy and Environmental Applications CMCee, May 20-23, 2012 in Dresden. Accepted: 21.11.2011.

Subproject B05

Storm, J.; Abendroth, M.; Liedke, Th.; Sieber, T.; Emmel, M.; Voigt, C.; Ballaschk, U.; Kuna, M. (2012): Generating Foam Structures Using Implicit Functions. Materials Science and Engineering Conference 2012, September 25-27, 2012 in Darmstadt. Poster accepted: 25.04.2012.

Project area C: Filter performance, materials properties

Subproject C01

Aneziris, C. G.; Gehre, P.; Kratschmer, T.; Berek, H. (2011): Thermal shock behavior of flame-sprayed free-standing coatings based on Al_2O_3 with TiO_2- and ZrO_2-additions. International Journal of Applied Ceramic Technology, 8 (4), pp. 953-964.

Gehre, P., Aneziris, C. G. (2011): EBSD- and CT-analyses for phase evolution and crack investigations of thermal shocked flame sprayed alumina and alumina-rich structures. Ceramics International, 37 (6), pp. 1731-1737.

Kratschmer, T.; Aneziris, C. G. (2011): Amorphous zones in flame sprayed alumina-titania-zirconia compounds. Ceramics International, 37 (81), pp. 181-188.

Kratschmer, T.; Aneziris, C. G.; Gruner, P. (2011): Mechanical properties of flame sprayed free-standing coatings. Ceramics International, 37 (7), pp. 2727-2735.

Subproject C02

Klemm, Y., Hampel, M., Aneziris, C. G., Biermann, H. (2012): Variation in der Rohstoffzusammensetzung und deren Einfluss auf das Gefüge und die mechanischen Eigenschaften von kohlenstoffgebundenem Al_2O_3-C. 15. Werkstofftechnisches Kolloquium WTK, 20.-21. September 2012 in Chemnitz. Angenommen: 14.05.2012.

Klemm, Y., Hampel, M., Aneziris, C. G., Biermann, H. (2012): Variation in raw material composition and shaping route and its influence on the microstructure and mechanical properties of carbon-bonded Al_2O_3-C. Materials Science and Engineering Conference 2012, September 25-27, 2012 in Darmstadt. Poster accepted: 24.04.2012.

Subproject C04

Krewerth, D., Weidner, A., Biermann, H., Emmel, M., Aneziris, C. G., Stolle, A., Eigenfeld, K. (2012): Experimentelle Untersuchungen zum Einfluss verschiedener Gefügeinhomogenitäten auf das VHCF-Ermüdungsverhalten des Stahlgusses G 42CrMo4. 15. Werkstofftechnisches Kolloquium WTK, 20.-21. September 2012 in Chemnitz. Accpeted: 14.05.2012.

Subproject C05

Krüger, L., Henschel, S., Mandel, K., Radajewski, M. (2012): Studie zur Impulsformung an Split-Hopkinson-Aufbauten. 15. Werkstofftechnisches Kolloquium WTK, 20.-21. September 2012 in Chemnitz. Accepted: 14.05.2012.

Complementary subprojects

Subproject S02

Lehmann, H., Jung, B. (2012): In-Situ Data Compression for Flow Simulation in Porous Media. PDPTA‘12 - 18th International Conference on Parallel and Distributed Processing Techniques and Applications. Las Vegas, USA, July 16-19, 2012. Accepted 27.04.2012.

Subproject Z

Aneziris, C. G.; Fischer, U. (2012): Manche mögen es heiß: Keramische Filterwerkstoffe als „Hochtemperatur Fliegenfänger“ für die Metallschmelze-Filtration. In: Jahresmagazin Ingenieurwissenschaften, Fokus Werkstofftechnologie. Lampertheim, ISSN 1618-8357, S. 26-30.

Aneziris, C. G.; Fischer, U. (2012): Multifunktionale Filtersysteme für die Stahlschmelzefiltration. Keramische Zeitschrift 2012-2 (April 2012), pp. 124-128.

DATES

UPCOMING CRC EVENTS

29.05.2012
Guest lecture given by Prof. Ik Jin Kim, Hanseo University, South Korea: "Functional Porous Ceramics by Direct Forming"

01.06. - 15.07.2012
Visit of Prof. Prabal Talukdar, Indian Institute of Technology Delhi, focusing on "Modelling of Radiation Heat Transfer Inside Participating Media“

16./17.07.2012
4th Doctoral meeting

17.07.2012
5th Member meeting (jointly held with the 4th Doctoral meeting)

08./09.102012
5th Doctoral meeting and workshop

08.10.2012
Guest lecture given by Dr. Tassilo Moritz, IKTS Dresden on "Freeze-foams - Cellular Structures for Various Applications“

09.10.2012
Workshop on “Confocal Microscopy“, Dr. A. Nakano, RIKEN Discovery Research Institute, Japan

07.12.2012
3. Freiberg Refractory Forum

CONFERENCES AND CALLS FOR PAPERS

15. Werkstofftechnisches Kolloquium, September 20./ 21, 2012, Chemnitz: Submission deadline for abstracts: April 28, 2012, submission of full papers not later than May 25, 2012 (poster session registration until August, 24, 2012). More information on http://www.wtk.tu-chemnitz.de.

5th International Congress on the Science and Technology of Steelmaking ICS, October 1-3, 2012, Dresden: Submission of full papers not later than May 31, 2012. More information on http://www.ics2012.de.

MSE 2012, September 25-27, 2012, Darmstadt: Preliminary program (by May 2012), final program (by August 2012), and further information on www.mse-congress.de.

Cellular Materials - CELLMAT 2012, November 7-9, 2012, Dresden: Information on the program and details of the registration on http://www.conventus.de/cellmat.

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