SFB 920

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

NEWSLETTER 18 (1/2020)

DFG Deutsche Forschungsgemeinschaft

TECHNISCHE UNIVERSITÄT BERGAKADEMIE FREIBERG
Die Ressourcenuniversität. Seit 1765.

DEAR READERS,

Material-based innovations result from scientists‘ work along the process chain of basic research from materials to components. Intensive cooperation and networking across disciplines is of utmost importance. Recently, results of the CRC‘s interdisciplinary, cross-project work have been published in a special issue, which presents selected findings along the process chain of metal melt filtration - ranging from the research of the filter materials, the understanding of filtration mechanisms and kinetics, the contribution of the gas phase up to the mechanical properties of the end metallic components in means of ductility, strength and fatigue.

Despite constraints caused by COVID-19, subprojects and working groups continue their joint research efforts, using, for instance, virtual rooms and online meeting formats. The new issue of our newsletter keeps you informed about recent publications, patents, research results and further information about the CRC 920. Further information is provided at http://tu-freiberg.de/forschung/sfb920.

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

TRANSFORMING MATERIALS INTO COMPONENTS: OUTSTANDING RESEARCH ALONG THE PROCESS CHAIN OF METAL MELT FILTRATION

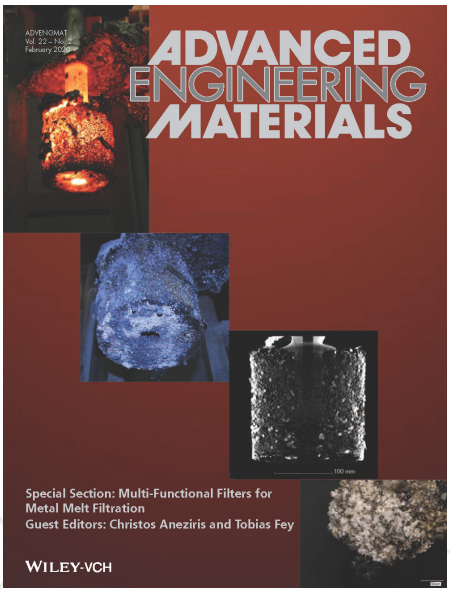
Since 2011, researchers involved in the Collaborative Research Center CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials" work on smart filter materials and filter systems, capable to significantly reduce anorganic, non-metallic inclusions in the metal matrix. In a special issue, "Advanced Engineering Materials" presents research results across subprojects and along the process chain of metal melt filtration.

Especially in the third period a **new generation of combined refining filter systems** will be the focus. Employing at least two ceramic filter materials with different coatings permits reducing various impurities and non-metallic inclusions from metal melts, for the sake of reliable and resistant founded components. This implies reducing scrap rates for users and converters as well as new opportunities for metal recycling, which is relevant for foundries and the metalworking industry.

Such hybrid filter systems consist of at least two porous ceramic filter materials, that have been functionalized with different coatings. Active coatings can be applied, for instance, through flame-spraying, electrophoresis, or electro-spinning technology. When joining the single ceramic filter components, inside the hybrid filter systems a characteristic is generated that differs from that on the external surface.

The metal melt comes first in contact with a reactive filter which generates gas bubbles in the melt as well as activates gas bubbles on the surface of the inclusions. As a result a kind of flotation of the inclusions towards the slag on the surface of the melt takes place. Further the high reactivity as well as the gas bubbles contribute to the agglomeration of the fine inclusions to big clusters which flow due to buoyancy forces to the surface of the melt or are filtrated on the surface of active filters, which do not form gas bubbles but provide on their functionalized surfaces the same chemistry as the inclusions for a sufficient adhesion and as a result for a sufficient filtration of the inclusions. With this approach a purification higher than 95 % can be achieved. The procedure for developing novel hybrid filter systems has been recently patented **(patent no. 10 2018 201 577)**.

In the CRC 920, modelling is focusing mainly on the several contributions of the gas bubbles and on the in situ formed reactive layers on the surface of the reactive filters as well as they generate codes with respect to the thermomechanical and functional properties of the filters for a 3D-printing of filter structures.



Current research results are presented in a **special issue of "Advanced Engineering Materials"**. The February issue compiles selected findings of previous research. It contains ten articles based on the work of 19 scientific projects with more than 30 funded researchers are working together by bridging different disciplines. Noteworthy, the special issue contains also publications from doctoral students in CRC 920. Comprising contributions across subprojects, this special issue covers the entire process chain of metal melt filtration, including research and development of the filter materials, the understanding of filtration mechanisms and kinetics, the contribution of the gas phase up to the mechanical properties of the end metallic components in means of ductility, strength and fatigue. Hence, the CRC 920 contributes to a better understanding of the process chain from materials to components and to the creation of material-based innovations.

Converting materials with relevant properties into innovative components is also a **main purpose of a new transfer project** funded by the German Research Foundation DFG. In cooperation with a regional industry partner, this transfer projects aims at **applicating the novel filter system for metal melt filtration in aluminum dead-mold casting**.

"The new transfer project T05 combines intelligent filter materials and filter systems, developed in the CRC 920, with ceramic fibers," says CRC cordinator Prof. Christos G. Aneziris. The CRC will collaborate with the Hoffmann GmbH AL-EXPERT in Dresden and adapt the filter systems developed for an effective purification of metal melts to conditions prevalent in aluminum dead-mold casting. The filter systems will be employed in an industrial setting and for complex founding systems.

The industry partner will be in charge for tests for conditioning the aluminum melt and the subsequent safe metal melt filtration. The Institute of Mechanical Process Engineering and Mineral Processing (MVTAT), headed by Prof. Urs A. Peuker, will take responsibility for the development of a filter system for aluminum melts. To this end, a small-industry filter plant for room-temperature models, developed in the CRC 920, will be employed. ■

MORE NEWS

FIELD TRIP AND WORKSHOP

In November 2019, the CRC 920 “Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials” and the CRC 799 “TRIP Matrix Composite“ invited their **female research assistants** to an excursion to the **thyssenkrupp Steel Europe AG** in Duisburg. The field trip included a guided tour through manufacturing facilities and a panel discussion with female executive staff members.

Dr. Arnd Köfler, Chief Technology Officer (CTO) at thyssenkrupp Steel Europe AG, gave a talk on current corporate projects and responded to questions from the audience. According to own information, thyssenkrupp Steel Europa AG belongs to the worldwide leading suppliers of quality flat steel. An annual production output of approximately 12 million tons of crude steel makes the company the biggest producer of flat steel in Germany.

The field trip was organized by both CRC as an activity to foster gender equity in research and academia. The German Research Foundation DFG provides financial resources to coordinated projects such as a CRC in order to support **equal opportunities for (young) female researchers** as well as compatibility of job-related career and family life. ■

Photo: Participants of the field trip to the thyssenkrupp Steel Europe AG Duisburg.

SCHOLARSHIP HOLDERS VISITING THE CRC 920

Supported by the German Research Foundation DFG the CRC invites regularly talented young researchers to join the CRC team as visiting scholars. Scholarship holders receive financial support, which allows them to pursue their own dissertation project, embedded in the CRC‘s Integrated Research Training Group (MGK) and based on the Doctorate Regulations valid at TU Bergakademie Freiberg.

Currently, **M. Sc. Gökhan Günay from the Gebze Technical University Kacaeli/Turkey**, is visiting the CRC 920. From November 2019 to October 2020 he will join the subprojects C02 and C04 and contribute to the **research project on “Acoustic Emission Analysis during High-Temperature Deformation of Carbon-bonded Alumina“**, supervised by **Prof. Horst Biermann** and **PD Dr. habil. Anja Weidner**. Subproject C02 investigates the high-temperature strength and form stability of carbon-bonded filter materials. Subproject C04 analyzes experimentally and stochastically the impact of inclusions on the fatigue life of metallic components. ■

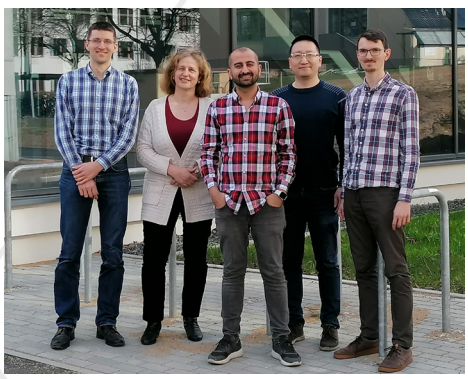


Photo (from left to right): Dr.-Ing. S. Henschel, PD Dr. habil. A. Weidner, M. Sc. G. Günay, Dr. X. Wu., Dipl.-Ing. R. Wagner.

CRC 920 GOES DIGITAL

Although the current pandemic situation limits significantly various investigations and experiments, the CRC 920 continues its research activities. **Researchers involved keep contact using digital communication channels,** in order to exchange research results across all subprojects.

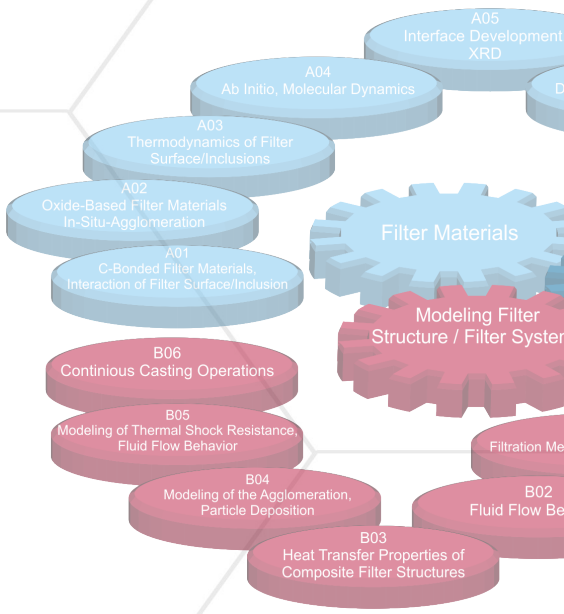
The four working groups arrange meetings in **virtual rooms**, to align upcoming tasks and work steps. Doctoral students work together online to finalize journal articles and presentations for submission to **international online conferences**. Subproject coordinators provide their permanent advice and support electronically. To this end, the technical infrastructure and tools offered by TU Bergakademie Freiberg, including online meeting platforms, webinars, and online conferences are of great value to all CRC members. ■

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.

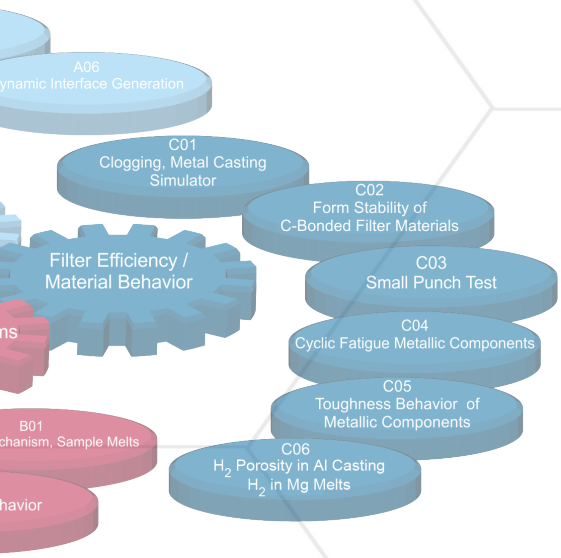
Working Group 1: "Metal melt/inclusions, active/reactive filter material, boundary surface design" (Coordination: Dr.-Ing. Hanka Becker)

- Preparation of carbon-bonded alumina filters coated with CA2 in combination with carbon (C01),
- Al_2O_3-C extrusion mixes for functional filter components in continuous casting of steel and development of 3D-printed filter replica templates for bottom-teeming steel ingot casting (T04),
- Additive manufactured filter templates coated by flame-spraying and their impact on steel melt filtration (A01),
- Electron backscatter diffraction (EBSD) before and after thermal treatment of non-metallic inclusions in 42CrMo4 from filtration experiments with a carbon-bonded and Al_2O_3-flame-sprayed AC filter (A05, C04),
- Pressure drop measurements of ceramic foam filters (CFF) with different filter surface roughness at the NTNU Trondheim, Norway (A02),
- Theoretical and experimental Raman spectroscopic investigations of pure lactose, pure tannin (gallic acid, ellagic acid, tannic acid), and filters containing lactose/tannin in order to determining the size of sp^2-carbon clusters at various temperatures (A04),
- Synthesis of pure hercynite ($FeAl_2O_4$) and partially Mg-substituted hercynite ($(Mg_xFe_{1-x})Al_2O_4$) using Spark-Plasma-Sintering for the analysis of the interplay of the generated phases with molten steel and with aluminium alloy melts (A06),
- Immersion tests in an AZ91 alloy using uncoated as well as Al_2O_3-coated carbon-bonded alumina filter samples with different immersion times for evaluation of the durability of the filters (C06),
- Synthesis of MgAlON and sessile drop measurements to determine the wetting behavior and interactions of Al and Mg alloys with MgAlON (C06),
- Reactivity of TiO_2- and C-containing filter materials with Al-Si-alloys (C06),
- Experimental investigation of the miscibility gap in the liquid in the Al_2O_3-TiO_2-SiO_2 system and its thermodynamic assessment (A03),
- Effect of typical alloying and accompanying elements on the formation of Fe-containing intermetallic phases in secondary Al-Si alloys (A07),
- Formation of Fe-containing intermetallic phases in an Al-Si casting alloys using thermal analysis and their application for molten metal filtration (T03),
- Potential filter materials with regard to the separation of grain-refining particles in aluminum and cast iron materials (S03),
- Particle and agglomerate separation on CFF struts in particular in dependence of angle based surface area from CT data (B01).



Working Group 2: "Modelling and designing of the filter geometry" (Coordination: Dipl.-Ing. Eric Werzner)

- Determination of the static and dynamic contact angle by means of optical methods and 3D µCT scans as well as the snap in / adhesion force using the drop probe AFM for small droplets of liquid metal (mercury) and investigation of the influence of the roughness (B01),
- AFM measurements of particle-bubble interactions with hydrophobic and hydrophilic colloidal probe particles (B01, B04),
- Nanoindentation experiments to scale MD-potentials for experimentally inaccessible high temperature processes like sintering (B01, B04),
- Experimental investigation of the interaction between particles and a rising bubble (B06),
- Evaluation of the temperature time series obtained from ceramic encased thermocouples after immersion into steel and aluminum melts for the determination of the response time and to correct dynamic error (B03),
- Commissioning and first measurements with the FTIR microscope for the characterization of reflection, transmission and ATR in the near and mid wavelength infrared range (B03),
- Further development of the hybrid material model to describe the inelastic deformation of 3D foams using neural networks for anisotropic material behavior and geometry as well as determination of the optimal strategy for the generation of data for the training of neural networks (B05),
- Development of a strategy for coupling FE simulations with CALPHAD using neural networks (B05),
- Investigations towards the determination of geometry characteristics of open-cell foams from the probability distribution of the Euclidean distance field for a quick estimation of effective properties (B02),
- Numerical simulation aiming to investigate the combined effect of the reactive cleaning and of the active filtration on the melt cleanliness (B06),
- Development of a toolchain consisting of codes for the parametrized generation of random foams, the determination of their filtration characteristics from pore-scale simulations and an automated creation of reports for immediate evaluation (S02, B02, B05).



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

- Analysis of the influence of melt conditioning and subsequent filtration of AlSi9Cu3 on the formation of iron-rich phases in the microstructure and their effect on fatigue life (S03, C04),
- Investigations by X-ray microtomography on crack propagation and the effect of intermetallic phases during ultrasonic fatigue testing of AlSi9Cu3 and evaluation by machine learning algorithms (C04),
- Further investigations on the morphology of Al_2O_3 inclusions after changed temperature control during oxidation and deoxidation of 42CrMo4 in the steel casting simulator using ultrasonic fatigue testing, fractography, automated scanning electron microscopy ASPEX and electrolytic extraction (C01, C04, C05),
- Extended fractographic analysis of fracture mechanics specimens that were tested under mixed-mode loading (C05),
- Study of the effect of the spatial inclusion distribution on those non-metallic inclusion that are found by metallographic investigation and on the fracture surface (C05),
- Development of a 3D Finite Element Model capturing the thermomechanics of 42CrMo4 in the VHCF regime; determination of the relevant sample geometry and definition of realistic boundary conditions based on different experimental setups and thermography data (C04),
- Modification of the steel casting simulator as well as test planning for combined cleaning systems trials consisting of metal melt treatment in the melting crucible, casting through a functionalized filter and solidification of the melt in the tundish. One aim is the supply of material (steel) for mechanical testing in subprojects C04 and C05 (C01).

Working Group 3: "Thermomechanical properties of the filter material and structures" (Coordination: Dipl.-Ing. Alexander Malik)

- Preparation of carbon-bonded alumina compact specimens with new slurry formulations via casting and pressing processes as well as mechanical and thermomechanical testing of the specimens (C02),
- Application of high temperature-B3B tests up to 1500 °C using the new load device (C03),
- Geometric standardization of miniaturized Brazilian Disk (BD) test to be applied on filter materials developed in subprojects A01 and A02 (C03),
- Numerical modeling of different loading cases to determine the loading parameters of the BD test (C03),
- Utilization of the ARAMIS system to investigate the development of the surface deformation field of the BD test specimen (C03),
- Development of an effective material law for foam structures to design ceramic filters. Required data for the filter material are provided by the subprojects A01, A02 and C01 (B05),
- Strength evaluation of the immersed filter in comparison to the experimental data from subproject T04 (B05),
- Mechanical, numerical and physical characterization of Al_2O_3-C foam filters produced by distinct routes (A01, T01, B05, S01).

FILTRATION OF MAGNESIUM MELTS USING CARBON-BONDED ALUMINA FILTERS

Author: Alina Schramm
(Subproject C06)

Subproject C06 investigates the effects of reactive filter materials on the filtration of aluminum alloys and the removal of hydrogen from said alloys by means of filtration. In particular, research focuses on interface reactions between magnesium melt and the filter surface, filtration efficiency, filter durability, reaction kinetics and the effect of various filter coatings on the melt cleanliness.

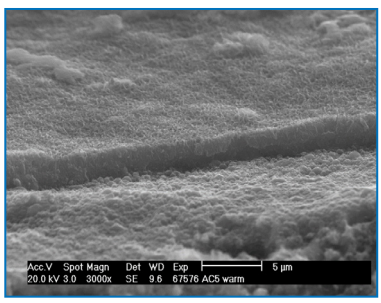


Fig. 1: In situ layer formed on the Al_2O_3-C filter surface after its contact with the AZ91 melt.

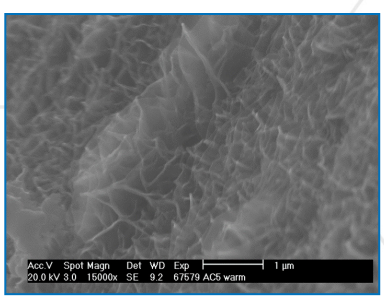


Fig. 2: Platelet-like structure of the in situ layer.

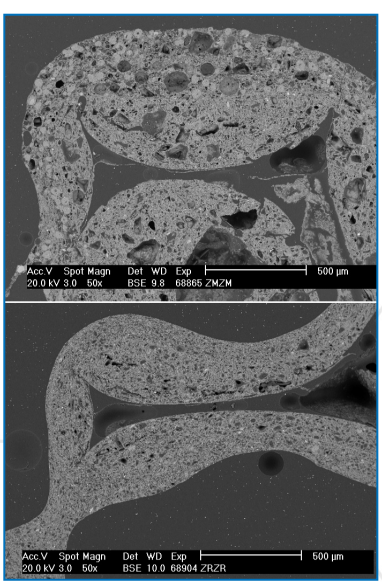


Fig. 3: Cross-section micrograph of filter struts manufactured by means of centrifugation using non milled (image above) or ball-milled slurries (image below).

Magnesium alloys show many advantageous properties, such as a low density, high specific strength, and good castability. Therefore, they are regarded as promising materials for light-weight applications, such as in the automotive industry. However, there are obstacles in the production process of magnesium that hinder a widespread commercial use. Magnesium melts are highly reactive, therefore, the content of oxidic inclusions as well as flux particles in the melt can be high, even more so, while remelting oxide-covered scrap. These inclusions lower the quality of the cast products, their mechanical properties, as well as their corrosion resistance.

Regarding the successful application of carbon-bonded or purely oxidic alumina filters in cleaning steel and aluminum melts, it is the task of the subproject C06 to explore the applicability of such filters for the filtration of magnesium as well. Therefore, preliminary immersion tests were conducted using variously coated, carbon-bonded alumina filters in an AZ91 magnesium melt [1]. Additionally to the uncoated Al_2O_3-C-substrate, filters coated in MgO-C, Al_2O_3, $MgAl_2O_4$ or Carbon Nano Tubes/Alumina Nano Sheets were tested. The AZ91 melt was held at 680 °C, protected by SF6 cover gas, the filter samples were immersed into this melt for 10 to 120 s. While all of the filter samples endured the tests, differences in the interface reactions could be seen. Filter surfaces that contained alumina or spinel showed a platelet-like in situ layer after being in contact with the AZ91 melt (see Fig. 1, 2), resulting from the reduction of alumina or spinel by the melt, leaving the formed layer of MgO on the filter surface. The MgO-C-coating showed no reaction besides partial surface flaking.

Further research will be based on these tests, the finely structured in situ layers are seen as potentially positive for future filtration efficiency, due to the possibility of attracting and binding oxidic inclusions from the magnesium melt that is to be filtered. Manufacturing and testing novel filter coatings will be another research goal.

Another contribution was published in cooperation with the subprojects A01 and A02, and describes the advantages of manufacturing carbon-bonded alumina filter samples by means of ball-milling slurries and applying them through centrifugation, achieving a fine microstructure with improved mechanical properties, compared to filters manufactured from non-milled slurries (see Fig. 3), [2]. The results can be readily applied in the future manufacturing of filter samples for the application in magnesium melt filtration. ■

[1] Schramm, A., Bock, B., Schmidt, A., Zienert, T., Ditze, A., Scharf, C., Aneziris, C. G.: Interface reactions of differently coated carbon-bonded alumina filters with an AZ91 magnesium alloy melt, Ceramics International, 44 (2018), 17415–17424.
[2] Schramm, A., Voigt, C., Hubálková, J., Scharf, C., Aneziris, C. G.: Influence of the Manufacturing Technique on the Macro- and Microstructure of Reticulated Carbon-Bonded Alumina Foams, Adv. Eng. Mater., 22 (2020), 1900525.

FATIGUE LIFE AND CRACK INITIATION OF STEEL ALLOYS AT ELEVATED TEMPERATURES

Author: Alexander Schmiedel
(Subproject T02)

Subproject T02 studies the fatigue behaviour of steel alloys at temperatures for an application area of up to 500 °C. Therefore, fatigue tests in the High- (HCF) and Very High Cycle Fatigue (VHCF) range were performed, and the mechanism of fatigue for each individual alloy was investigated by using optical and scanning electron microscopy.

Depending on operating conditions, steel alloy components for mobility applications are often subject to cyclic and thermal loading conditions. Fatigue tests in HCF range were performed by the project partner using conventional resonance testing machines. The fatigue tests in VHCF range were performed using ultrasonic fatigue testing machines. This ultrasonic technique is already known from previous research [1-3] in the subproject C04 of CRC 920. For heating, the ultrasonic fatigue testing system was coupled with an induction heating system (Fig. 1). Thus, the fatigue behaviours of the steel alloys were determined at defined temperatures up to 109 cycles to failure.

Fractographic investigations on all fatigued specimens were performed to determine the crack initiating defects. By scanning electron microscopy (MIRA 3 XMU, TESCAN, Czech Republic) using secondary electron (SE) contrast, backscattered electron (BSE) contrast and energy dispersive X-ray spectroscopy (EDX) the fracture surfaces of the failed specimens were observed to study the defects in detail. In addition, investigations using optical microscopy were performed mostly for the HCF specimens. Depending on the material condition, the following defects were identified as crack initiating: (i) alumina (globular) (Fig. 2a), (ii) alumina clusters (Fig. 2b), (iii) manganese sulphides (elongated) (Fig. 2c), (iv) microshrinkages (Fig. 2d) und (v) crack initiation from ferrite grains (Fig. 2e).

Further investigations of the VHCF fatigue data of the cast variant of the steel G42CrMo4 showed a significant change in the fatigue behaviour at a test temperature of 500 °C compared to the tests at room temperature (RT) and 200 °C [4]. Two different heat treatment states (HT1 and HT2) were compared in order to investigate the influence of the testing temperature as well as the matrix hardness on the fatigue strength. Fractographic investigations of the failed specimens showed clearly microshrinkages as crack initiating defects (Fig. 2d). The increase of matrix hardness of HT2 (420 HV10) compared to HT1 (320 HV10) has not resulted in an increase in fatigue strength. Thus, the SN-curves of material states HT1 and HT2 were comparable (compare Fig. 3a and b). The fatigue data at 500 °C show a significant increase of the SN-curve slope and a decrease in scatter compared to RT and 200 °C. A short crack growth model was applied to the fatigue data, which showed a good agreement between experimental and numerical values of cycles to failure but only at 500 °C. Therefore, crack growth was estimated as dominant fatigue mechanism at 500 °C and crack initiation was estimated as dominant fatigue mechanism at RT and 200 °C. The damaging effect of the microshrinkages is the reason why the hardness increase of material state HT2 has no influence on the fatigue strength. ■

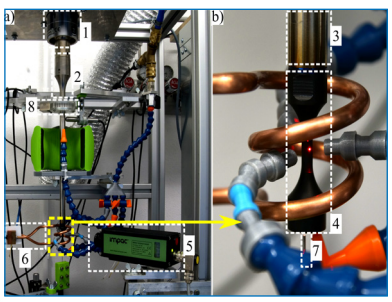


Fig. 1: Ultrasonic testing equipment for elevated temperatures. (a) Overview. (b) In detail: (1) ultrasonic transducer, (2) booster horn, (3) λ-rod, (4) specimen, (5) infrared pyrometer, (6) induction coil, (7) fibre optic sensor, (8) vibration sensor.

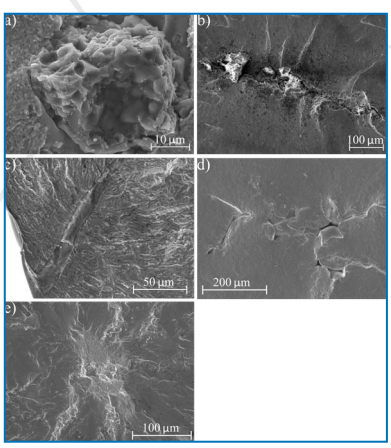


Fig. 2: SEM images of the crack initiating defects. (a) Alumina (globular). (b) Alumina cluster. (c) Manganese sulphide (elongated). (d) Microshrinkages. (e) Crack initiation from ferrite grain.

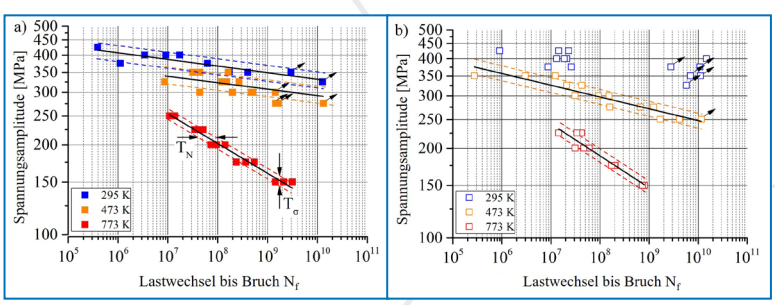


Fig. 3: SN curves of steel G42CrMo4 at RT (blue), 200 °C (orange) and 500 °C (red) including runouts (black arrows). (a) Material state HT1 including exemplary scatter TN (horizontal arrows) and Tσ (vertical arrows). (b) Material state HT2.

[1] Krewerth, D., Lippmann, T., Weidner, A., Biermann, H.: Application of full-surface view in situ thermography measurements during ultrasonic fatigue of cast steel G42CrMo4, International Journal of Fatigue, 80 (2015), 459-467.
[2] Krewerth, D., Weidner, A., Biermann, H.: A Comparative Study on Infrared Thermography during Ultrasonic Fatigue Testing of Cast Steel 42CrMo4 and Cast Aluminium Alloy AlSi7Mg, Key Engineering Materials, 592-593 (2013), 501-504.
[3] Krewerth, D., Weidner, A., Biermann, H.: Investigation of the Damage Behavior of Cast Steel 42CrMo4 During Ultrasonic Fatigue by Combination of Thermography and Fractography, Advanced Engineering Materials, 15 [12] (2013), 1251-1259.
[4] Schmiedel, A., Henkel, S., Kirste, T., Morgenstern, R., Weidner, A., Biermann, H.: Ultrasonic fatigue of AISI 4140 at elevated temperatures. Fatigue & Fracture of Engineering Materials & Structures 2020. (under review)

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CURRENT PUBLICATIONS (NOVEMBER 2019 - JUNE 2020)

Further information about the 66 publications that have been generated since the start of the third program period as well as about the currently 17 patents and patent applications are available at http://tu-freiberg.de/forschung/sfb920.

Projectarea A - Filter materials

Subproject A01

Bock, B., Gehre, P., Herdering, A., Aneziris, C. G. (2020): Ressourceneffizientes Hybridverfahren für die Fertigung von keramischen Filtern für die Stahlschmelzefiltration, DGM-Fachtagung Werkstoffe und Additive Fertigung, Potsdam, 13.-15.05.2020, web conference, oral presentation.

Gehre, P., Aneziris, C. G. (2019): Aktiver und reaktiver Filterkosmos für ressourcen- und energieeffiziente Technologien im Bereich der Metallurgie, Steuler Blockguss-Forum, 29.-30.10.2019, Herborn, oral presentation.

Jankovský, O., Lojka, M., Jirícková, A., Aneziris, C. G., Storti, E., Sedmidubsky, D. (2020): Carbon-bonded alumina filters coated by graphene oxide for water treatment, Materials, 2020, 13 (8), 2006, DOI 10.3390/ma13082006.

Schmidt, A., Fruhstorfer, J., Dudczig, S., Schmidt, G., Hubálková, J., Voigt, C., Aneziris, C. G. (2019): Interactions between carbon-bonded alumina filters and molten steel: Impact of a titania-doped filter coating, Advanced Engineering Materials, 1900647 (1-10), DOI 10.1002/adem.201900647.

Storti, E., Jankovský, O., Sedmidubsky, D., Dudczig, S., Aneziris, C. G. (2019): Filter coatings based on combination of nanomaterials for steel melt filtration, Advanced Engineering Materials, 1900457 (1-8), DOI 10.1016/adem.201900457.

Subproject A02

Voigt, C., Hubálková, J., Giesche, H., Aneziris, C. G. (2020): Intrusion and extrusion mercury porosimetry measurements at Al_2O_3-C - influence of measuring parameter, Microporous and Mesoporous Materials, Vol. 299, June 2020, 110125, DOI 10.1016/j.micromeso.2020.110125.

Subproject A03

Ilatovskaia, M., Fabrichnaya, O. (2020): Experimental investigation of the Al_2O_3-TiO_2-SiO_2 system, 34th Annual MSIT Meeting, 16.-21.02.2020, Schloss Ringberg, Kreuth, oral presentation.

Project area B - Modeling of filter structures/ filter systems

Subproject B01

Ditscherlein, L., Knüpfer, P., Peuker, U. A. (2019): The influence of nanobubbles on the interaction forces between alumina particles and ceramic foam filters, Powder Technology, Vol. 357, 1 December 2019, pp. 408-416. DOI 10.1016/j.powtec.2019.08.077.

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Project area C - Filter performance, materials properties

Subproject C01

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Transfer projects

Transfer project T01

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Transfer project T02

Schmiedel, A., Biermann, H., Weidner, A., Kirste, T.: Ultrasonic fatigue of AISI 4140 at elevated temperatures, FDMD 2020 - 4th International Symposium on Fatigue Design and Material Defects, Potsdam, 26.-28.05.2020, web conference, oral presentation.

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Complementary projects

Aneziris, C. G., Fischer, U. (2019): Aktiver und reaktiver Filterkosmos: Erforschung von ressourcen- und energieeffizienten Technologien im Bereich der Metallurgie auf Basis von multifunktionalen Filtersystemen für die Metallschmelzefiltration, in: Schriften zum Zentrum für effiziente Hochtemperatur-Stoffwandlung (ZeHS) an der Technischen Universität Bergakademie Freiberg, Hrsg.: Meyer, D. C., Lemser, T., Zentrum für effiziente Hochtemperatur-Stoffwandlung an der Technischen Universität Freiberg, Heft 2, S. 56-79, ISSN 2513-1192.

Buchholz, L. (2020): Glück auf - ein Gruß aus Freiberg, Keramische Zeitschrift, Jahrgang 72, Ausgabe 2, 2020, S. 18-21.

Faßauer, C. (2019): 9. Freiberger Feuerfestforum, Keramische Zeitschrift, Jahrgang 71, Ausgabe 3, 2019, S. 30-34.

Faßauer, C. (2020): 10. Freiberger Feuerfestforum, Keramische Zeitschrift, Jahrgang 72, Ausgabe 2, 2020, S. 27-31.

Patents and patent applications

Subproject A01

Procedure for manufacturing metal-melt hybrid filter and a ceramic metal-melt hybrid filter. Patent application no. 10 2017 000 979.1, patent application date: 2017-02-03, patent granted: 2020-02-06, publication date: 2020-02-06, published as DE102018201577B4, priority 03.02.2017 DE102017000979.1.

AWARDS FOR YOUNG RESEARCHERS

The **TU Bergakademie Freiberg Friends & Alumni Association ("Freunde und Förderer der TU Bergakademie Freiberg VFF e.V.")** assigned its **Bernhard von Cotta Award** to **Dr.-Ing. Hanka Becker**, recognizing her excellent dissertation entitled "Intermetallic phases and phase formation during solidification related to Fe-containing Al-Si alloys with Mg, Mn and Cr". The dissertation project was embedded in subproject TP 07 - "Removal of iron from secondary aluminum alloys by metal filtration" (subproject coordinator: Prof. Andreas Leineweber).

Photo: Among others, Dr.-Ing. Hanka Becker (3rd from the right) received the Bernhard von Cotta Award, offered by TU Bergakademie Freiberg Friends & Alumni Association ("Freunde und Förderer der TU Bergakademie Freiberg VFF e.V.").

The **Heinrich Schubert Award**, offered by the **Faculty of Mechanical, Process and Energy Engineering** was awarded to **Dipl.-Ing. Lisa Hille** for her diploma thesis. The faculty appreciated her work on the filtration behavior in a semi-industrial filtration plant and the exemplary description of measurements of the adhesive force on the atomic force microscope. The award is given in memory of the work and achievements of Prof. Dr. sc.techn. Dr. h.c. Heinrich Schubert, who has earned oustanding merit nationally and internationally in mechanical process engineering and preparation. The prize, including a certificate, the Heinrich Schubert medal, and a prize money, was presented by Prof. Tobias Fieback, dean of the faculty, on the occasion of the annual "Preparation and Recycling" conference.

Photo: Prof. Tobias Fieback (right), Dean of the Faculty of Mechanical, Process and Energy Engineering, presented the Heinrich Schubert Award to Dipl.-Ing. Lisa Hille.

The 10th Freiberg Refractory Forum offered a suitable stage for presenting the **Theodor Haase Award**, offered by **Meeting of Refractory Experts Freiberg (MOREFreiberg)**, to **Dipl.-Ing. Dirk Endler** for his diploma thesis on "Surface structuring of Al_2O_3-C foams using electrophoresis". His work was part of the CRC 920's research program and investigates a novel filter for improved purity of aluminum melts. Electric fields aid applying a particular structure to the filters. "As this work demonstrates, students at TU Bergakademie Freiberg get actively involved in research. Quite early in their studies they take a direct part in developing innovative, functional refractory components," said the supervising professor, Prof. Christos G. Aneziris from TU Bergakademie Freiberg. ■

Photo (from left to right): Prof. P. Quirmbach (University Koblenz Landau), Dr. P. Gehre (TU Bergakademie Freiberg), Dr. C. Wöhrmeyer (Imerys Aluminates), Dipl.-Ing. D. Endler (TU Bergakademie Freiberg), Prof. C. G. Aneziris (TU Bergakademie Freiberg), Prof. H. Jansen (Refratechnik Steel).

HABILITATION AND DOCTORATE DEGREES

In February 2020, **PD Dr. Dr. habil. Olga Fabrichnaya** successfully completed her state doctorate (habilitation) at the Faculty of Materials Science and Materials Technology at TU Bergakademie Freiberg. **Her habilitation thesis was entitled "Experimental investigations and thermodynamic modelling of ceramic systems containing zirconia, rare earth oxides and alumina".**

Photo (from left to right): Prof. D. Rafaja, Prof. A. Leineweber, PD Dr. Dr. habil. O. Fabrichnaya, Prof. H.-J. Seifert (KIT), Prof. F. Mertens, Prof. J. Kortus, Prof. U. Prahl, Prof. G. Wolf.

Based on the habilitation thesis, a demonstration lesson and a research presentation, the habilitation committee assigned to her both the habilitation degree as well as the teaching approval ("venia legendi") for the subject of materials science. PD Dr. Dr. rer. nat. habil. Olga Fabrichnaya does not only coordinate subproject A03, but in addition heads the project area A "Filter materials".

In December 2019, **Dr.-Ing. Henry Zielke** successfully finished **his dissertation on "Fracture and damage mechanical properties of ceramic filter materials using miniaturized specimens"**. In his research, he focused on the investigation of alumina and carbon-bonded alumina using miniature test methods and applying a test temperature up to 1500 °C.

CONFERENCES AND MEETINGS

Challenges for refractory materials, recent research results, and application scenarios were discussed at the **10th Freiberg Refractory Forum**. About 110 representatives from research and industry joined the meeting. Among others, **Prof. Helge Jansen**, managing director of **Refratechnik Steel GmbH**, Duesseldorf, gave a talk on high-temperature insulating material made of renewable materials. **Dr. Dietmar Bramhoff** from **TRIMET Aluminium SE**, Essen, presented current refractory materials for aluminum melting furnaces. **Ph.D. Ondřej Jankovský**, Associate Professor at the **University of Chemistry and Technology Prague** and former Humboldt scholarship holder at TU Bergakademie Freiberg, presented results from his research on carbon-based high-temperature materials.

Dipl.-Ing. Tony Wetzig from the Institute of Ceramics, Glass and Construction Materials at **TU Bergakademie Freiberg** gave an overview of research activities of the CRC 920 concerning the development of ceramic filters for steel melt filtration. The meeting ended with a poster session, illustrating the CRC's achievements of the second program period, which had been successfully defended in 2019. ■

UPCOMING CONFERENCES AND CALLS FOR PAPERS

ICR 2020: 63rd International Colloquium on Refractories 2020, 16.-17.09.2020, Aachen, http://www.ic-refractories.eu.

CIMTEC 2020: 15th International Ceramics Congress, 21.-25.09.2020, Montecatini Terme, Italien, http://2020.cimtec-congress.org/.

MSE 2020: Material Science Engineering Congress, 22.-25.09.2020, Darmstadt, Germany, http://www.mse-congress.de/home/.

CellMAT 2020: 6th Cellular Materials Conference, 07.-09.10.2020, Erlangen, Germany, https://cellmat2020.dgm.de/home/.

Keramik 2020: 95. DKG-Jahrestagung 2020, 22.-25.11.2020, Forschungszentrum Jülich, http://www.2020.dkg.de/.

11. Freiberger Feuerfestforum: 09.12.2020, TU Bergakademie, Freiberg.

IMPRESSUM

EDITOR
Prof. Dr.-Ing. habil. Christos G. Aneziris
CRC 920 Coordinator
TU Bergakademie Freiberg
Institute of Ceramics, Glass and Construction Materials
Agricolastraße 17, 09599 Freiberg
Phone: +49 3731 39 2505
Fax: +49 3731 39 2419
E-mail: aneziris@ikgb.tu-freiberg.de

Dr.-Ing. Undine Fischer
CRC 920 Manager
TU Bergakademie Freiberg
Institute of Ceramics, Glass and Construction Materials
Agricolastraße 17, 09599 Freiberg
Phone: +49 3731 39 3324
Fax: +49 3731 39 2419
E-mail: undine.fischer@ikgb.tu-freiberg.de

EDITORIAL OFFICE
Prof. Dr. habil. Anja Geigenmüller
TU Ilmenau
Faculty of Economic Sciences and Media
Department of Marketing
Langewiesener Strasse 22, 98693 Ilmenau
Phone: +49 3677 69 4085
Fax: +49 3677 69 4223
E-mail: anja.geigenmueller@tu-ilmenau.de

PHOTOS
TU Bergakademie Freiberg, CRC 920 "Multi-Functional Filters for Metal Melt Filtration - A Contribution towards Zero Defect Materials"; Detlev Müller; pixabay.

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