Success Story
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K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development
Programm: COMET - Competence Centers for Excellent Technologies
Programmlinie: K1-Zentren
Project 2.4 - Analysis of refractory wear aiming to improve lining life time
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Development of a setup to perform creep tests on carbon containing refractories

Mechanical testing of carbon containing refractories at high temperatures requires measures to protect the sample from oxidation. Therefore, a special setup for tensile and compressive creep testing was developed, which prevents the oxidation of carbon in the sample. The developments allow the quantification of the tensile and compressive creep behaviour of MgO-C materials at temperatures up to 1500 °C.

Motivation

Magnesia carbon bricks (MgO-C) are used as refractory lining, for example in the LD converter, casting and treatment ladles and electrical furnaces. In service, temperature is more than 1500 °C. Thermomechanical stresses can occur inducing a creep of the refractory lining. Creep is defined as time and temperature dependent irreversible deformation under constant load. For a better understanding of the creep behaviour of the material, uniaxial compressive and tensile creep tests were carried out in the laboratory. Due to the carbon content of the MgO-C brick and the high affinity from oxygen to carbon, a standard creep test in oxidizing condition cannot be performed. For this reason, an experimental setup was developed to protect the sample from oxidation during a high temperature creep experiment.

Standard compressive and tensile creep experiments

In the compressive creep experiment, a sample with a diameter of 35 mm and a height of 70 mm is inserted in a universal testing device. The sample is heated up with 5 K/min to the defined target temperature. The holding time is 1 hour for temperature homogenisation. Thereafter, the force is applied with 0.3 mm/min to the desired load. At the same time, the displacement is measured by means of corundum extensometers at the front and on the rear side. The end of the experiment is reached with the sample fracture. The sample diameter for tensile creep experiments is 30 mm and the length of the sample is 230 mm. The testing procedure is equivalent to the compressive creep test.

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Developed setup to perform compressive and tensile creep experiments

To perform creep tests on carbon containing refractories at high temperature, reducing conditions must be established. The utilization of coke breeze ensures that a reducing atmosphere is established within the probe area. Figure 1 shows the experimental setup for compressive creep test in detail.

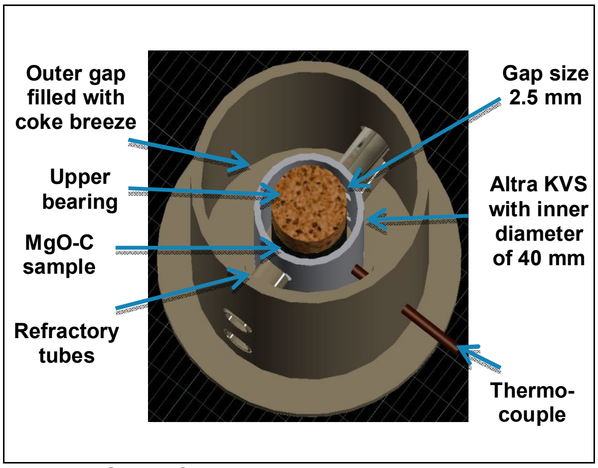

Abb. 1: Setup for compressive creep experiments.

To protect the carbon in the sample, the outer ring visible in Fig. 1 is filled with coke breeze. The basic idea is that the used coke oxidizes the oxygen from the ambient atmosphere to avoid a reaction with the carbon in the sample. To prevent a mechanical influence of the sample, the direct contact between coke breeze and sample is prevented by a highly porous tube.

Additional installed corundum tubes avoid the contact of the extensometer fingers with the coke breeze. This configuration enables a displacement measurement with the extensometers. The setup for the tensile creep measurements is shown in Figure 2.

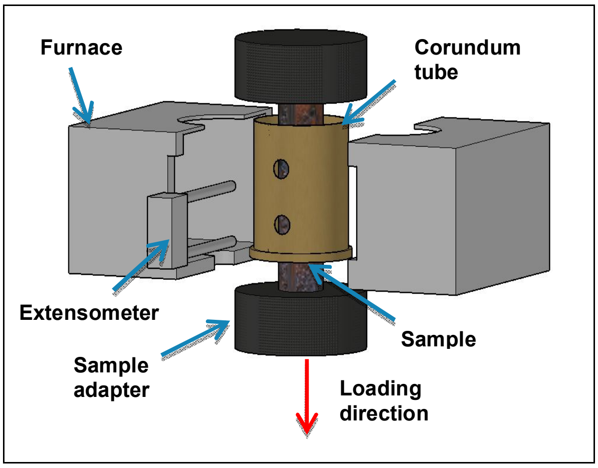

Abb. 2: Setup for tensile creep experiments.

Impact and effects

The newly developed experimental setups enable the characterization of carbon containing refractories regarding creep at high temperatures. Based on the obtained data from the laboratory experiments, creep parameters can be determined and implemented in Finite Element (FE) simulations. This enables, for example, the simulation of thermomechanical stresses occurring in refractory linings during service.

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