Success Story
COMET

K1-MET
Competence Center for Excellent Technologies in Advanced Metallurgical and Environmental Process Development
Programme: COMET – Competence Centers for Excellent Technologies
Programme line: K1-Centres
COMET subproject, duration and type of project:
2.1 Wear of refractories, 07/2012 – 06/2015, multi-firm

Impact of creep on the thermomechanical behavior of refractory linings

Thermomechanical loads on a RH-degasser lower vessels refractory lining have been analysed by the FE-method according to a methodology developed in the K1 project. Special emphasis is put on the creep behaviour of the magnesia chromite wear lining. The results are giving a deep and novel insight in the thermomechanical behaviour and show a significant reduction of stresses especially close to the hot face where the temperatures are higher than 1100°C. The results exceed the state of the art with the consideration of the creep behaviour and allow for an optimisation of the refractory linings to increase the life time

RH-degasser

RH-degassers are wide spread in the steel industry secondary metallurgy to improve the purity of treated steel grades. The RH degasser comprises a refractory-lined upper and lower vessel with an inlet and outlet snorkel attached to the lower vessel (Fig.1). The inlet snorkel is equipped with tuyeres through which inert gas is injected. As a result of the applied technical vacuum in the vessels the steel rises approximately 1,4m and circulates due to gas injection. The vessels are lined with refractory bricks to protect the steel shell from the liquid metal. As for every metallurgical vessel closed joints between the bricks are important to avoid the penetration of liquid slag and metal, thus causing premature wear. FEM simulation helps to identify thermal and mechanical conditions during service and to understand possible failure modes. For the description of the refractories mechanical behaviour the creep is of special importance because it is a decisive factor for the stresses and strains at service temperatures up to 1580°C.

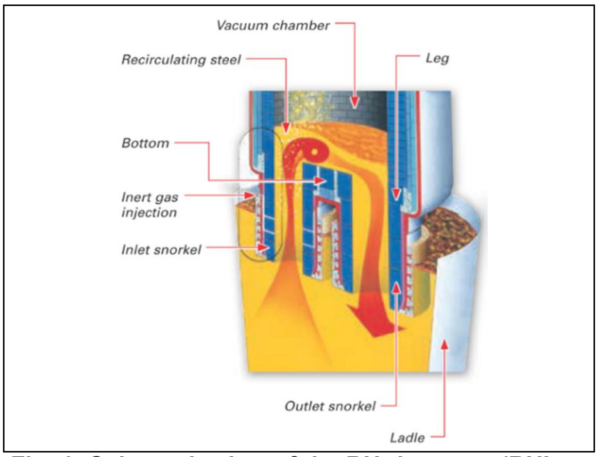

Fig. 1: Schematic view of the RH-degasser (RHI AG)

Simulation model

Due to the rotational symmetry of the RH-degasser lower vessel a unit cell model composed out of two symmetrical halves of the wear lining bricks including the joint in between and the corresponding permanent lining was set up (Fig. 2). The expansion allowance at room temperature is 0,4mm. A Norton-Bailey type creep model was applied for the wear lining.

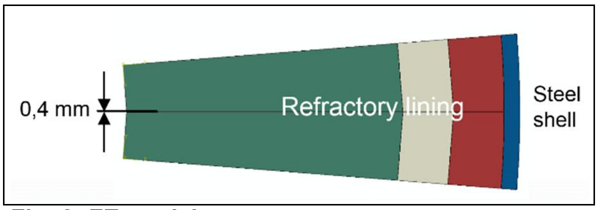

Fig. 2: FE-model

Simulation results

Figure 3 shows the temperature distribution in the lower vessel lining in the first heat.

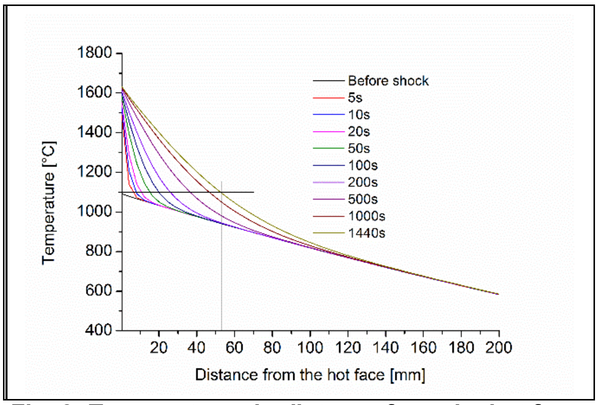

Fig. 3: Temperatures in distance from the hot face in the first heat

At the beginning of the first heat the maximum compressive stresses occur at the hot face (Fig. 4). With the course of time the maximum compression decreases and moves towards the cold end, i.e. a stress minimum in some distance from the hot face develops. This is caused by the heat flow from the liquid metal into the refractory and the creep of the applied materials for temperatures above 1100°C. The dashed and dotted lines indicate the stress and the temperature at the end of preheating before the first heat, respectively, the solid lines show the results at the end of the heat.

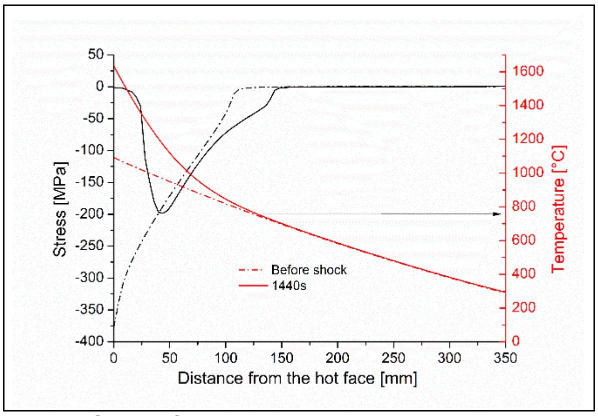

Fig. 4: Circumferential stresses and temperatures over the distance

Impact and effects

The results are giving an insight in the thermo-mechanical behaviour of the refractory lining of a RH-degasser. The presented model allows the calculation of a more justified expansion allowance to decrease the maximum compressive stresses and to increase the refractory lifetime. Finally it enables a decrease in refractory consumption.

Furthermore the methodology including materials testing and the application of material models in FE simulations is ready to use for further investigations.

Contact and information

K1-met/A2.1 Wear of refractories

Chair of Ceramics/Montanuniversitaet
Peter-Tunner Strasse 5, 8700 Leoben
T +433842 3213
E Dietmar.Gruber@mu-leoben.at, http://coc.unileoben.ac.at/

Project coordinator
Dr. Dietmar Gruber

Project partners

Organisation	Country
Chair of Ceramics, Montanuniversität	Austria
RHI AG	Austria
Voestalpine Stahl Linz	Austria
Voestalpine Donawitz	Austria
Primetals AG	Austria