Alkali corrosion testing setup of SiC refractory linings in thermal waste incineration systems

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Abstract

SiC samples from the combustion chamber of a waste incinerating plant are compared by SEM Micrographs with samples of the same material exposed to a corrosive environment of sodium and potassium chloride (1000°C for 5 days) in a lab experimental design. The lab corrosion tests show comparable results as the material of the waste incinerating plant after several months.

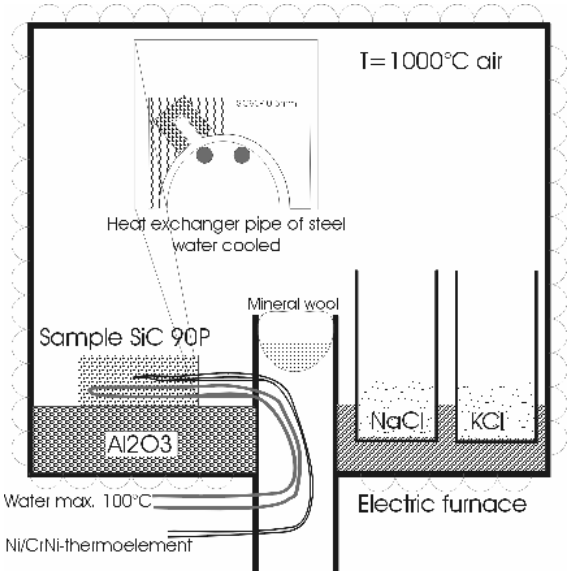

Fig. 1: Schematic of the corrosion experiment

The aim of this work is the experimental comparisim of alkali-corrosion applied to SiC90 after several months in use and the simulation of alkali corrosion in a lab experimental design. The lab experiment had to be equivalent to the environment in waste incineration plants especially in respect to temperature and the type of corrosion. It differs in scale of time of exposition and in the less complex chemical composition of the corrosive media.

Examined Material:

SiC90; chemical composition: Al_2O_3 1.5%; SiO_2 8%, Fe_2O_3 0.3%, SiC 88,0%. All data in wt.%; chemical binder: Monoalumina Phosphate. Heat exchanger tube: Original part of the waste incinerating plant with steel-pin of the quality 1.4827

Preparation:

The SiC- mass was prepared according to the instructions of the manufactors datasheet. It was put on an original part of the steel heat exchange pipes used in the waste incinerating plant. The sample was dried for 24 h at ambient temperature, afterwards dried for 12 h at 120°C and then heated up to 300°C (15°/h, dwell time 10 h) and finally up to 1000°C (30°/h, dwell time 5 days). During heating and dwelling the backward side of the sample prepared on the steel pipe was cooled with water by using a steel cooling pipe of 3 mm inner diameter.

Technical Equipment

After heating the SiC-steel sample was put in a cubic box made of 3 mm steel plates and placed into an all-side heated electric furnace (see: Figure 1). The box itself was not hermetically sealed due to a ventilation pipe with a diameter of 40 mm that led through the bottom of the furnace for gas exchange. In order to avoid thermal convection a piece of mineral wool was placed on top of the ventilation pipe. For thermal insulation, the bottom of the box was filled with layers of spinel and alumina powder. The SiC-steel sample was placed at one edge of the box, connected on the bottom with cooling water pipes. The water flow was set to 1 l/min. A capsuled Ni/CrNi thermocouple was placed at the surface of the sample. At the opposite edge of the box, four alumina crucibles, two filled with 80 g NaCl p.a. each and two filled with KCl p.a. each, were placed.

The idea was to establish a system of vaporizing corrosive salts and a sample as cooling trap with a thermal gradient in the range from cooling water temperature to the maximum furnace temperature. Time of exposure of the sample in the corrosive salt atmosphere was 130 h at

1000°C ± 5°C. Afterwards the furnace was cooled down to room temperature with 50°/h.

Results:

Method of observation: Prepared polished sections of the test sample, examination with SEM Jeol 6400F with EDX System Noran Voyager .

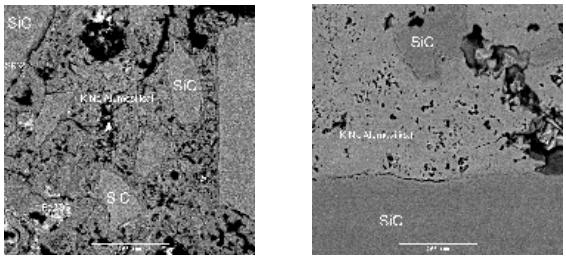

Fig. 2,3: Left side: SE-Micrographs of the original sample from the waste incineration plant near the fire side. Right side: Sample of Lab experiment with alkali chloride vapor corrosion for 5 days, 1000°C

The SEM-Micrographs of the corrosion test samples and the samples taken from the waste incineration plant show comparable results in matrix corrosion type. Alumo-silicates are formed in both samples by the corroding cationes.

Due to the longer time of exposition of the original sample in the waste incineration plant, a thin band of SiO_2 around the SiC grains is observable (see Figure 2 upper left grain). The matrix is more differentiated showing a higher porosity than the sample of the lab-experiment. This is caused by changes in temperature while typical operation of the system and the additional chemical corrosion of Mg and Ca as sulfat.

In both cases the results of window measurement in the matrix by EDX show an alcali alumo-silicate composition.

	Original Sample		Lab Sample	
wt%	Matrix1	Matrix2	Matrix1	Matrix2
Al_2O_3	10	15	15	12
SiO_2	60	64	60	70
K_2O	3	2	12	8
Na_2O	6	7	13	10
CaO	9	4	-	-
MgO	4	5	-	-
SO_3	8	3	-	-

Tab. 1: EDX Window measurements in Matrix

A critical point in the parameters of this experiment is the way of thermal treatment of the sample. There is no way to realize the thermal ramp-parameters as demanded in the data-sheet because of the necessity of backward cooling the material. In the real system the complete combustion chamber will be shut down in a short time because the of a lack of additional heaters. The result are cracks and microcrack by tensile stress.

In future work we will compare material of different manufacturers. There will also be experiments with different thermal treatments (variation of cooling ramps) for getting information about the influence of thermal shock on the chemical resistivity of SiC linings. Additional to structure micrographs as shown in this article, tests in hot abrasion (based on ASTM C 704-88: abrasion resistance) before and after simultaneous corrosion tests on different samples will be described. The amount of eroded material of the samples can be regarded as an indicator for resistivity against wear. On this way a qualifying parameter can be formulated which can be important as additional information for the estimation of the time of revision intervals in the waste incinerating plants.