# IMPACT OF PHASE TRANSFORMATION PROCESSES ON THE FACTURE AND BRITTLENESS REDUCTION OF FUSED SILICA BRICKS FOR COKE OVEN IN SERVICE

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Fused silica bricks in amorphous state are mainly used for maintenance of supporting walls of coke ovens, to replace the traditional silica bricks made of quartz raw materials. Fused silica bricks are also potential in building entire walls instead of traditional silica bricks, due to their rather low thermal expansions. With this regard, it is of importance to understand the mechanical behaviour of fused silica bricks under different operation conditions involving phase transformation.The presentproject focuses on the impact of phase transformation from silica glass to high temperature cristobalite on the fracture behaviour of fused silica bricks, e.g. notched tensile strength, fracture energy, brittleness, at different temperatures. Additionally, the specimens only containing the matrix shall be fabricated and the influence of phase transformation in matrix on fracture behaviour and Young's modulus also will be studied.

CoC (Institut Chair of Ceramics) will host and supervise a Chinese exchange student to perform the high temperature wedge splitting tests in the laboratory. The research activities in CoC are as follows:

1. Preparing specimens into required dimensions for high temperature wedge splitting testing and impulse excitation testing.
2. Performing the impulse excitation tests and analysing the frequencies and damping of specimens under thermal cycles.
3. Performing the wedge splitting test for specimens from silica bricks at 1050 °C, 1200 °C and 1400 °C after 2 hours soaking, respectively.
4. Performing the wedge splitting test for specimens only containing silica matrix at 1050 °C, 1200 °C and 1400 °C after 2 hours soaking, respectively.
5. Performing the wedge splitting test before and after the low-/high- temperature transformation after heating at 1400°C for 2 hours.
6. Analysing the fracture behaviour including nominal tensile strength and fracture energy.

WUST (Wuhan University of Science and Technology) will offer the raw materials and prepare the products for research. The research activities in WUST are as follows:

1. Grinding the fused silica blocks into different size of aggregates and fines;
2. Mixing the mixtures of aggregates and fines, and casting them into bricks;
3. Kneading and granulating the fines, and pressing them into bricks;
4. Drying the bricks at 110°C.

Silica refractories contain more than 93 wt% silica and possess remarkable refractoriness and good chemical resistance to acidic components. They are specially used for constructing coke ovens, glass melter roof, nonferrous metallurgical furnaces [1,2] In service, they undergo high temperature, thermal shock, mechanical stress, corrosion and erosion. The thermomechanical stress induced failure is one of the predominant factors limiting longevity of refractory linings. Two principal types of silica refractories are commercially available for the users: one is the conventional silica refractory produced from quartz raw materials and mainly consisting of cristobalite and tridymite; the other is the fused-silica based refractory [3, 4, 5]. The latter one is amorphous and shows smaller thermal expansion compared to the crystalline silica refractories at least in the low temperature region, which is believed to cause better thermal shock resistance. Although the interest in its application has grown, the fracture behaviour of fused silica refractories was not studied yet.

The crystallization of cristobalite from amorphous silica will gradually take place during their service lifetime. The crystallization as well as the further possible phase transformation causes a critical effect on the thermo-mechanical performance of fused silica refractories. The strength of fused silica refractories reduces due to the devitrification of amorphous fused silica to cristobalite, and is attributed to microcracking of the cristobalite caused by the phase transformation between the high-temperature cubic cristobalite and low-temperature tetragonal cristobalite (about 2.8%-5% volume contraction in the temperature range 200-250 °C during cooling) [6, 7]. The strength of fused silica is dependent on cristobalite content [8]. Besides, by acoustic emission technology and fatigue test, Andreev et al. [4] have proven that the presence of initial microcracks in silica refractories reduces the brittleness and limits the severe damage. Dai et al. [9] investigated the temperature dependent Young's Modulus and dilatation as well as the fracture behaviour of fused silica refractories after heat treating at 1400°C. They concluded that the crystallization and phase transformation of low -/hightemperature cristobalite subpolymorphs occurring during the heat treatment cause microcracks especially in the matrix and at the grain boundary. This microcracking enables the development of sizable fracture process zone, which is responsible for the increase of specific fracture energy even with the decrease of strength. Still, two questions remain unclear. Will the brittleness be affected by sole transformation process of glass to high temperature christobite at high temperatures? Whether the anisotropy of the length change from low to high temperature christobite also plays a role? These considerations are of importance to understand the mechanical behaviour of fused bricks and for advanced fused silica bricks development.

Therefore, the present study will emphasis on the understanding the influences of individual phase transformation processes on the fracture behaviour and Young's modulus evolution of fused silica bricks in service with the wedge splitting test (WST) and impulse excitation technique (IET). The research content will be divided into two parts. The first one is the investigation of silica bricks containing aggregates and fines with WST and IET, of which the above first question will be unambiguously answered. The second is the investigation of silica bricks containing sole fines to clarify the influence of low-/hightemperature phase transformation. The results will increase the understanding of fused silica bricks in service and provide a sound thermomechanical fundamental for silica development.