Volatilization of Refractory Silica in Hydrogen Water Vapour Gas Streams

by Greg Palmer BE PhD, Palmer Technologies Pty Ltd

PALMER TECHNOLOGIES

Palmer Technologies
PO Box 513
New Farm
QLD 4005
Australia

Tel: +61 7 3852 4448
Fax: +61 7 3852 4934

Introduction

The volatilization of silica (SiO2) from refractory concrete has been studied extensively and reaction thermodynamics are also well published.

Understanding the degradation of the refractory containing silica in hydrogen /steam gases at temperature is important when designing and selecting refractory linings for gasifiers or boilers particularly in low temperature processes such as ammonia plant transfer lines which operate in the temperature range of 700°C to 950°C.

The reduction of silica into SiO (g) not only accelerates refractory corrosion and strength loss but can also lead to downstream deposits of SiO2 (s) on boiler tubes which results in fouling and decreases in plant throughput. However, the majority of literature published is on silica volatilization at high temperatures, greater than 1200°C. Example, Wright and Wolff [1] have reported refractory degradation by silica volatilization occurs by CO and H2 at temperatures > 1349°C and Plibrico state that the volatilization reaction in hydrogen occurs at temperatures >1140°C. However, Day and Gac [22] have reported silica volatilization for refractory at 199°C. Given that there are a number of processes that operate at temperatures <1000°C understanding how refractories behave in low temperature hydrogen/steam environments is important for asset owners. Research [13] has found that silica volatilization at temperatures less than 980°C is dominated by the formation of Si(OH)4.

The opportunity to study silica volatilization from industry occurred when a refractory lined transfer line in an ammonia plant had inadvertently been lined with a standard alumina silica refractory castable hotface. The transfer line had been in operation for several years. In ammonia plants the process gas is a composition of H2, N2, CO, CO2, CH4 and H2O transfer lines operate at temperatures varying from 750°C to 950°C and at pressures of approximately 20 atmospheres.

This paper investigates silica volatilization under various reducing conditions, temperature and pressures and shows that it is possible to estimate the rates for silica volatilization from refractories. Validation of the methodology was possible by using data from two industrial samples. Good agreement was achieved between measured and predicted results. Using this method it is possible to predict the volatilization of silica species (SiO or Si(OH)4) from refractory under reducing conditions at various temperatures and pressures. It was further found that the silica lost from a refractory castable was from the aggregate and not the matrix which is in line with other research.