Zone modelling of underport firing of a simulated glass melting test furnace

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This paper describes the application of a model based on the zone method for analysing thermal radiation to predict the thermal performance and NOx emissions for a simulated glass melting test furnace. The model predictions were compared with experimental data gathered on the furnace which has a firing configuration which is representative of that found on underport fired glass melters. The furnace is fitted with two parallel, independently operated, electrical resistance heaters for preheating the combustion air. The furnace "load" consists of 6 different zones of partially covered water-cooled pipes running across the width of the refractory hearth to provide measurements of the variation in heat transfer along the length of the system. Consequently glass is not melted in this glass furnace simulator. During the tests the furnace was fitted with a pair of water-cooled, underport, double-impulse gas burners. The furnace was represented by a three-dimensional zone model comprising 336 volume zones and 285 surface zones and the necessary radiation exchange areas between these zones were determined using a Monte-Carlo technique. The energy balances for the zones also incorporate terms for enthalpy transport between adjacent zones and energy release by combustion in each zone. The data for these terms were calculated using an isothermal CFD simulation of the flows and methane and oxygen concentrations within the furnace chamber. Simultaneous solution of the system of zonal energy balances yielded the temperatures in each zone and the rate of heat transfer to the load. This information can then be employed using a series of rate equations to calculate NOx emissions from the furnace. This type of model in which the zone technique was coupled with an isothermal CFD simulation has the advantage of relatively short computing times so can be used to study a range of different operating scenarios. The model was found to provide reasonable representation of the furnace performance.