Numerical investigation of a single coal particle moving in a hot O2/CO2 atmosphere

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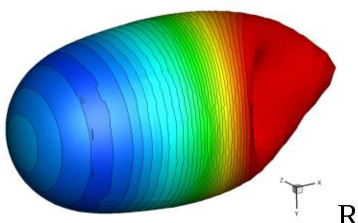
In this work the partial oxidation of a spherical coal particle (diameter 2 mm) moving in a hot environment consisting of O_2 and CO_2 is investigated numerically. The main goal of this work is to study the influence of particle velocity and surrounding gas temperature and its composition on the carbon consumption rates. The particle investigated is placed in a uniform oxygen-carbon dioxide mixture at different Reynolds numbers corresponding to the laminar flow regime. The ambient temperature was systematically varied in the range of 1500–3000 K, and the mass fraction of O_2 was varied between 12 and 36. To solve the Navier-Stokes equations for the flow field coupled with the energy and species conservation equations, a finite volume solver was applied. In addition to the solid carbon the model incorporates six gaseous chemical species (O_2, CO, CO_2, H_2, H_2O and N_2). The reaction mechanism is identically to the reduced one proposed in [1]. It includes the water gas shift reaction ($CO+H_2O \rightarrow CO_2+H_2$ [2]), two additional homogeneous reactions ($2CO+O_2+H_2O \rightarrow CO_2+H_2O$ [3], $CO_2+H_2 \rightarrow CO+H_2O$ [2]) and the three heterogeneous reactions $C+CO_2 \rightarrow 2CO$ [4], $2C+O_2 \rightarrow 2CO$ [5], $C+H_2O \rightarrow CO+H_2$ [4]. The ambient medium is assumed to be nearly dry (Y_{H_2O}=0.001). One of the findings is that the fluid flow past the reactive particle stays laminar for a larger range of Reynolds numbers in comparison to isothermal flows, that means Re_{krit} becomes larger than 270 (see Figure below). Additionally the influence of the O_2/CO_2 ratio on the carbon consumption and flame around the particle is analyzed.



Re=350, isosurface of Y_{CO_2}, colored by T=3300…3500 K

References

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