

Launcher Design for Chemical Looping Combustion

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Abstract

Chemical looping combustion uses solid particles as an oxygen carrier for the combustion of coal. We are developing a Doppler sensing to measure the mass flow rate of the oxygen carrier particles in chemical looping combustion. A microwave launcher is a crucial part of Doppler flow sensing. The launcher must be designed to minimize the reflected power and tolerate the high temperature (~900 C) in the reactor at 10 GHz because the particles are transported at high temperature in an insulated duct. We use Electromagnetic Waves, Frequency Domain (emw) mode in Multiphysics COMSOL 4.3a. A 2.54 cm cylindrical alumina waveguide is attached to the flow region at an angle of 77 degrees. Simulation of electromagnetic field with this geometry is performed. First we consider launching a wave into the alumina cylinder directly from a coaxial input. Figure 1 shows one of the geometries that are simulated. A coaxial cable is attached to the end of the cylindrical alumina waveguide and a perfectly matched layer (PML) at the end of the waveguide is used to absorb the emitted electromagnetic wave. We obtain better results using a wave-coupling method with a special geometry showed in Figure 2. An input from a coaxial cable is first coupled to a rectangular alumina waveguide and is then followed by a tapered alumina section to make a transition to the circular cylinder waveguide. A PML is placed at the end of the circular launcher. We perform simulations with varying probing length (X_i) and distance to the back wall (d). From the S_{11} at the input port, we determine the best geometry. We also simulate the transition of the wave from the alumina cylinder into a half-sphere of air with 7 cm radius surrounded by a PML. Boundary mode analysis is performed first and a port boundary is defined at the end of the alumina cylinder to solve the field equations. The geometry with an end probe does not launch the desired TE₁₁ mode. Figure 1 shows the y component of the magnetic field and $S_{11} = -12.8$ dB for the optimal probe length $X_i = 9$ mm. A tapered launcher does effectively launch the TE₁₁ mode with a nearly planar wave front with uniform electric field. Figure 2 shows the z component of the electric field with the special geometry. A minimum value of $S_{11} = -29$ dB is obtained for the optimal values $X_i = 3$ mm and $d = 3$ mm. Figure 3 shows the contours of constant time-averaged energy density in the flow region. The microwave energy density is highest at an angle near 45 degrees as expected and $S_{11} = -12.5$ dB at the input port. We simulated a microwave launcher with varying parameters to find out the best geometry. We also explored the field distribution in the flow field. These simulation results will be used to optimize the launcher design. This work was performed in support of ongoing research on chemical looping combustion system at National Energy Technology Laboratory's Regional University Alliance (NETL-RUA), a collaborative initiative of the NETL, under the RES contract DE-FE0004000.

Figures used in the abstract

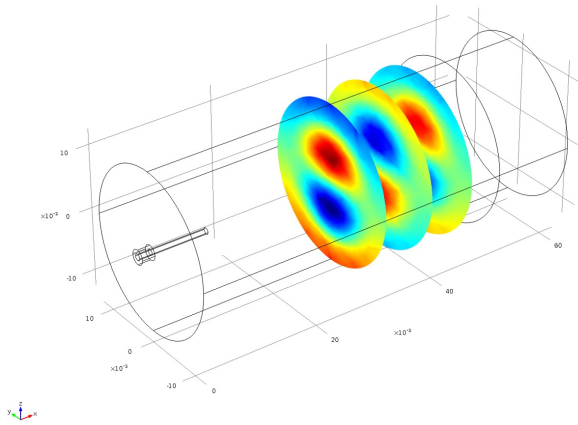


Figure 1

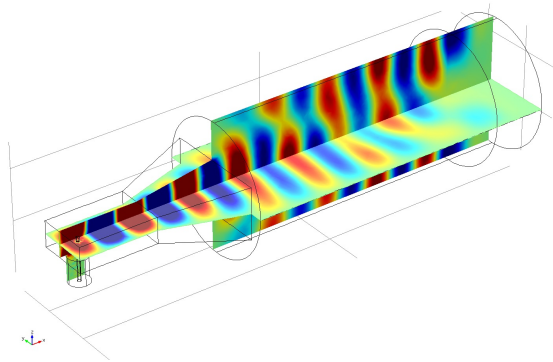


Figure 2

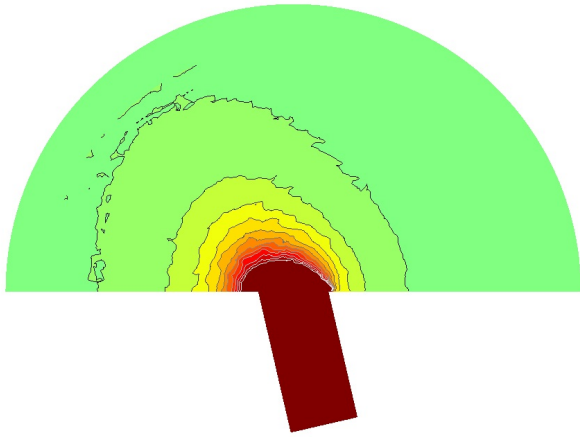


Figure 3