



Experimental and numerical investigation of a two-stage porous combustion system regarding burner topology augmentation by replica method.

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Applications requiring a higher temperature and fuel conservation have found porous combustion to be a helpful concept. Superadiabatic combustion, in which the preheated mixture leads to higher adiabatic temperatures, causes enhancement in the efficiency and operating range of the burner. A numerical study of two stage porous combustion is done with experimental validation. Results are obtained experimentally, and extensive numerical modelling approaches are employed. The combustion chemistry and emissions were accurately predicted by a 1D model and the flow regimes inside the preheater were studied by using volume averaged approach in a 3D model. In addition to the momentum equation, gas-solid energy equations, and material-specific properties we have employed radiation model, which is discretised using the finite volume method in the 1D model. We are using the Fluent software's pre-existing models for 3D simulation. The 1D numerical simulations help in understanding the chemistry dependence of burner performance, whereas flow inside the porous matrix needs to be studied in flow-specific model such as volume averaged Navier Stokes in a 3D environment. We experiment with an in-house fabricated novel preheating arrangement using a different material composition. By altering materials, we are improving the thermal conductivity of the preheater region. As we increase thermal conductivity, we are increasing the temperature in the preheating region. Though theoretically, it will cause flashbacks, a proper mixing regime and our novel preheater design can allow the flame to be stable even at a higher temperature in the preheat region. These numerical observations state that the new preheater design fabricated using replica method provides better preheating of the incoming mixture which is implied by higher heat release rate, thus reducing the chances of flashback as more heat is transported to the mixture. Experimentally we used this design in a cookstove, and the efficiency of the burner improved by 7- 8% compared to conventional burners used in cooking applications. NO_x emissions reduced by 8-9 ppm, and CO_2 are reduced by 20-25%. CO emissions also reduce by 1-2%. The overall temperature of the burner is reduced, as the new design allows the heat to be transported towards the point of application. Observations from the 3D numerical investigation reveal that our innovative preheater design produces better mixing than conventional preheater designs employed in research.