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Development of real-fluid based three-feed stream flamelet model in OpenFOAM for sCO2 oxy-fuel combustion * Danh Nam Nguyen[1], 이재훈[1], 유춘상[1]; [1]울산과학기술원.

Supercritical direct-fired CO2 (sCO2) cycle has been developed over the past several years as an innovative affordable power generation technology that enables the world to meet its climate target without paying more for electricity, while promising higher efficiency with a smaller build. However it is still challenging and complicated to design the cycle components due to its extremely high operating pressure and injection of high dilution level of CO2 into the combustor approximately at 1000 K. To simulate the combustion process of the cycle under these conditions, a combustion model that can evaluate real fluid properties and deal with a three-feed system. In fact, any real-fluid based three-feed stream steady laminar flamelet models (3sRSLFM) are not yet available in OpenFOAM, a widely-used open-source computational fluid dynamics (CFD) tool. In this study we present a newly-developed platform including 3sRSLFM in OpenFOAM-6 for sCO2 oxy-fuel combustion simulations. This new framework is developed based on real-fluid thermophysical library [1] and the flamelet model of a previous study by Muller et al. [2]. Then it is validated against experimental data and previous studies. There is a good agreement between the present study and the benchmark data, which confirms that the new platform is accurate enough to investigate sCO2 combustion. Several RANS simulations of a coaxial simplified sCO2 gas turbine combustor based on a configuration proposed by Banuti et al. [3] are performed at 200 atm with different levels of CO2 dilution in a two-dimensional axisymmetric computational domain. The results confirm that the newly-developed platform can capture reasonably well the characteristics of turbulent flames under Allam-Fetvedt power cycle conditions. It also shows that the flame temperature of sCO2 combustion can be effectively controlled by CO2 dilution stream injected into the combustor.

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