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Experimental and numerical study on simulating state-of-the-art combustion systems in industrial applications

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Flameless oxy-fuel combustion has been proven to be one of the strongest solutions to reduce the fuel consumption, NOx and CO_2 levels, while increasing the efficiency of a combustion system. In this study, the goal was to introduce and employ a tool to investigate the special aspects of such modern combustion systems. In this regard, an accurate CFD model has been developed and validated by comparing the predicted results with those from an experimental trial on a lab-scale furnace and using suction pyrometers. The CFD model uses the realizable k-ε, Probability Density Function (PDF) with the Steady Laminar Flameless Model (SLFM) and Discrete Ordinates Model (DOM) with Weighted Sum of the Gray Gases (WSGGM) to simulate turbulence, combustion and radiation, respectively. Later, this model was validated for a real-size soaking pit furnace, equipped with a flameless oxy-fuel burner and using thermocouple for temperature measurements. Furthermore, this CFD model is used to characteristics of flameless oxy-fuel combustion. The temperature uniformity and flame configuration inside the industrial furnaces are essential parameters in defining the final quality of the heating objects and the operational costs for the industry. Therefore, a special attention has been given to map a correlation between different combustion parameters and these features, when using the flameless oxy-fuel combustion system. The results show that higher injection velocity for both oxygen and fuel and an increased Internal Flue Gas Recirculation (IFGR) within the system improves the temperature uniformity and radiative heat flux from the flame to the heating objects.

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