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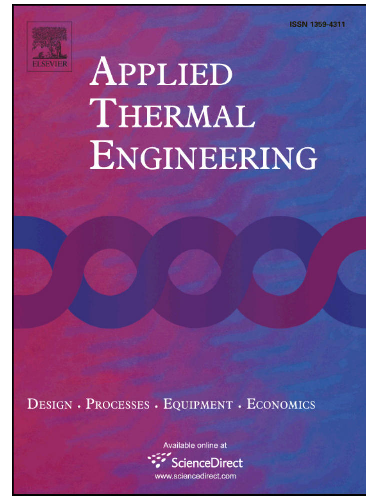

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IMPROVEMENT OF FUEL OIL SPRAY COMBUSTION INSIDE A 7 MW INDUSTRIAL FURNACE: A NUMERICAL STUDY

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Abstract: This paper presents a numerical analysis of fuel oil spray combustion inside an industrial furnace. The industrial furnace is a 7 MW cylindrical furnace which supplies heat to an oil refinery. The commercial CFD software Fluent is used for modeling transport and reaction processes in the furnace. The chosen combustion model is validated against measurement data available in the literature and good agreement is achieved. Fuel oil spray combustion is improved by varying fuel and burner parameters such as relative air-fuel ratio, fuel droplet diameter, fuel spray half-angle and burner swirl number. These parameters affect the flame shape and stability, on which depends the performance of the industrial furnace, particularly the heating output and gas species emissions. The numerical analysis revealed that complete combustion and minimum fractions of unburnt species are obtained by lean air-fuel mixtures, highly swirling flows, wide fuel spray angles and small fuel droplets. On the other side, the highest furnace heating outputs are achieved for near-stoichiometric air-fuel mixtures, narrow fuel spray angles, swirl numbers between 0.6 and 1.0 and small fuel droplets.

Key words: numerical analysis, spray combustion, air-fuel ratio, swirl number, spray angle, droplet diameter

1. INTRODUCTION

With a share of 80% at global scale, fossil fuels are still the major source of energy despite growing concerns about climate change, energy prices and supply security [1]. Fossil fuels are burned in power plants to generate electricity, in vehicles, ships and airplanes to generate mechanical work, or in buildings to supply heating energy. Fossil fuels are converted into energy with combustion processes that generate useful heat but also harmful flue gases. Consequently, the combustion process of fossil fuels is still a frequently addressed field of research. The analysis of combustion processes was confined to measurements and observations prior to the development of computer simulation software. Nowadays, computer simulation is indispensable for the analysis and advancement of combustion processes with pulverized coal [2], gaseous fuels [3-4] or liquid fuel sprays [5-7]. Computer simulations of the physical and chemical processes during liquid fuel combustion include numerical solutions of multidimensional, steady or transient, differential equations for the conservation of mass, momentum and energy. A number of sub-models are coupled within the procedure: turbulence-chemistry interaction, heat and mass interaction between discrete and continuous phase, radiative heat

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