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A COMPUTATIONAL COMBUSTION METHOD FOR TURBULENT PULVERIZED SOLID FUEL USING LES

Marcel ILIE[1], Augustin SEMENESCU[2], Gabriela Liliana STROE[3], Sorin BERBENTE[4]

Rezumat. *Combustibilii solizi sunt încă folosiţi în multe regiuni ale lumii, asigurând necesarul de energie. Actualmente, schimbările climatice impun reguli mult mai stricte legate de folosirea şi arderea eficientă a combustibililor solizi, aşa cum este cazul folosirii cărbunelui. O metodă de reducere a emisiilor este asigurarea unui proces de combustie eficient, care poate fi obţinut folosind cărbunele sub formă de pulbere. Cărbunele pulbere asigură un amestec eficient al aerului şi combustibilului solid şi de aceea asigură o combustie eficientă şi reducerea emisiilor. Studiile experimentale ale proceselor de combustie sunt costisitoare. De aceea, metodele computaţionale oferă avantajul unor soluţii rapide şi precise ale caracteristicilor fluidului şi produşilor de combustie. În acest studiu se propune utilizarea unei metode bazată pe Large-Eddy Simulation (LES), împreună cu un model de combustie cu flacără. Studiile arată că aceste două metode asigură o bună predicţie a fluidului şi a produşilor de reacţie. Prezenta lucrare demonstrează o creştere a entropiei şi o descreştere a densităţii în zona de combustie. Temperatura scade pe măsură ce flacăra se deplasează către ieşirea din camera de combustie.*

Abstract. *The solid fuels are still used in many regions of the world and assures the energy production. Nowadays, the mitigation of climate changes require strict regulations regarding the use and efficient combustion of solid fuels such as coal and reduction of the emissions. One way to ensure reduction of the emissions is an efficient combustion, which can be obtained using the pulverized coal. The pulverized coal ensure the good mixing of the fuel and air reactants and thus, it ensures an efficient combustion and minimization of the emissions. Experimental studies of solid fuels combustion are challenging and costly. Therefore, the computational methods offer the advantage of fast and accurate predictions of the flow variables and combustion products. In this study we propose a computational method using the large-eddy simulation (LES) approach along with the flamet combustion model. The study shows that the LES approach along with the flamet model predict very well the flow variables and combustion products. The study reveals an increase of entropy and decrease of density in the combustion region. As the flame moves towards the exit of the combustion the temperature decreases.*

[1]PhD, Assistant Professor: Dept. of Mechanical Engineering, Georgia Southern University, Statesboro, GA 30458, USA, e-mail: milie@georgiasouthern.edu
[2]PhD, Professor, Dept. of Material Sciences, University Politehnica Bucharest, Bucharest, Romania, augustin.semenescu@upb.ro
[3] PhD, Assistant Professor, Department of Aeronautical Systems Engineering and Aeronautical Management "Nicolae Tipei", University Politehnica Bucharest, Bucharest, Romania, gabriela.mogos@upb.ro
[4] PhD, Assistant Professor, Department of Aeronautical Systems Engineering and Aeronautical Management "Nicolae Tipei", University Politehnica Bucharest, Bucharest, Romania, sorin.berbente@upb.ro

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1. Introduction

Solid fuels still play key role and is the main source of energy in many regions of the world [1]. Nowadays, the strict regulations regarding the climate change generate significant challenges for the use of solid fuels such as coal [1]. One way to mitigate the effects of the coal combustion and the associated emissions is to ensure a full combustion process of the solid fuel [2-14]. In this way the residual toxic components emitted as a results of the burning solid fuel will be diminished. The complete and efficient combustion process of the solid fuel can be achieved using the pulverized solid fuel, pulverized coal in the case of coal combustion. Moreover, in the past decades the mixture of coal with other material such as biomass, tyre powder and plastic waster has been explored. It is assumed that the mixture of the coal with these material would enhance the combustion efficiency and hence, reduce the waste and emissions [15-20]. Previous studies showed that these additive materials act as catalysis and enhance the combustion efficiency of solid fuel. The whole idea of coal mixtures is to increase the combustion of the carbon present in coal. Thus, studies focused on the effect of the C_eO_2 and Fe_2O_3 mixture with coal and showed that the addition of these metals increase the combustion efficiency. Unfortunately, the addition of these metals to the coal combustion resulted in an increase of CO_2 emission, although the CO emissions decreased. Generally, experimental studies of solid fuels are costly and not always available. Therefore, alternative approach must be sought for the study of slid fuels combustion.

Therefore, the present study concerns the development of a computational model for the prediction of the flow variables and products of the coal combustion.

2. Background

Computational methods were employed in the past in the computation of combustion processes [15-22]. Numerical simulations using the Reynolds-averaged Navier-Stokes (RANS) equations were used to compute the fluid flow associated with combustion processes. Generally, the RANS method provides a time-averaged solution and thus, it is not suitable for time-dependent processes, such as combustion. Therefore, for the computation of solid fuel combustion, numerical methods that can simulate the transient nature of the flow are desired. Numerical methods such as direct numerical simulations (DNS) provide higly accurate solution since it does not involve any turbulence modelling. However, the DNS approach poses limitations due to the fact that the grid size of the computational is proportional to the Reynolds number $Re^{9/4}$ and thus, it limited