附件 2 浙江水利水电学院“南浔青年学者”申请表

<table>
<tr><td>姓　　名</td><td>杨建山</td><td>出生年月年龄（年龄）</td><td>1989 年 2 月 岁（ 35 岁）</td><td>参加工作时间</td><td>2016 年 12 月</td></tr>
<tr><td>现所在单位（部门）</td><td>机械学院</td><td>最高学历/学位</td><td>博士</td><td>专业技术职务</td><td>九级</td></tr>
<tr><td>符合条款</td><td colspan="5">符合科研类，论文， 150。</td></tr>
<tr><td rowspan="8">所涉业绩</td><td rowspan="2">教学类
绩点：______</td><td colspan="4"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">科研类
绩点： 150</td><td colspan="4">浙江水利水电学院工作期间：1：中科院一区 top 文章一篇（第一作者）；50 分
(1) Jianshan Yang , Ting Dong .Weigang ZhouNumerical investigation of the physical-thermal-chemical behaviours of particles during coal combustion and desulfurization processes in a CFB combustor. Energy ,2024,308(SCI top 3 类文章；50 分)
博士期间发表：1：中科院一区 top 文章一篇（50 分）；
(1) Kun Luo, Jianshan Yang, Yun Bai, Jianren Fan .Large eddy simulation of turbulent combustion by a dynamic second-order moment closure model.Fuel 187(2017)(SCI top 3 类文章博士期间导师一作；50 分)
2： 浙大版中国一级期刊两篇(20+20)
(1) 杨建山，罗坤，白云，邱坤赞，樊建人.动态亚网格二阶矩湍流燃烧模型.工程热物理学报.2015。第 36 卷第 4 期（浙大版中国一级期刊，5 类文章；20 分）
(2)杨建山，罗坤，邵长孝，樊建人. 气液两相旋流燃烧的时均统计特性.2015。第 36 卷，第 2 期（浙大版中国一级期刊，5 类文章；20 分）

3： Ei 检索期刊一篇（10 分）
(1) Jianshan Yang, Kun Luo, Yun Bai, Jianren Fan . Large Eddy Simulation of the Sandia Flame E and F Using Dynamic Second-Order Moment Closure (DSMC) Model.DOI 10.1007/978-981-10-2023-0_15(6 类文章；10 分)</td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="2">人才称号类
绩点：______</td><td colspan="4"></td></tr>
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<tr><td>总绩点</td><td colspan="4">150</td></tr>
<tr><td colspan="5">备注：请严格按照《浙江水利水电学院“南浔青年学者”实施办法（试行）》（浙水院〔2022〕114 号）附件《业绩成果绩点赋值项目库》的类目、分类、等级（等次）、绩点填写。</td></tr>
<tr><td>个人承诺</td><td colspan="5">本人承诺上述所填内容真实、准确；如有不实，本人承担相应责任。
签名：杨建山 时间：2024 年 11 月 18 日</td></tr>
<tr><td colspan="6">以上部分由申请人填写，所在单位审核。以下由单位（部门）和学校填写。</td></tr>
<tr><td>所在单位（部门）意见</td><td colspan="5">1.经审核，申请人所填内容：☐属实 ☐不属实；
2.是否符合所申请的类别：☐符合 ☐不符合；
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其他相关职能部门审核意见	负责人签名：　　　　（部门盖章） ____年____月____日		
学校意见	（学校盖章） ____年____月____日		

备注：表格请用 A4 纸打印，有关佐证材料附后。

证明材料：1) Jianshan Yang , Ting Dong .Weigang ZhouNumerical investigation of the physical-thermal-chemical behaviours of particles during coal combustion and desulfurization processes in a CFB combustor. Energy ,2024,308(SCI top 3 类文章；50 分)

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Numerical investigation of the physical-thermal-chemical behaviours of particles during coal combustion and desulfurization processes in a CFB combustor

Jianshan Yang [a], Ting Dong [b,*], Weigang Zhou [c]

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Desulfurization process

ABSTRACT

The desulfurization process has been practised for the clean utilization of coal in chemical engineering fields, yet the physical, thermal, and chemical characteristics of particles are still lacking understanding. In this work, a comprehensive numerical model based on the Eulerian-Lagrangian framework was established to study the particle behaviours during coal combustion and desulfurization processes in a pilot-scale circulating fluidized bed (CFB) combustor. After model validation, the effects of several crucial operation parameters (e.g., excess air ratio, calcium to sulphur ratio, and calcium oxide size) on particle behaviours are illuminated. The results show that density-induced segregation causes coal particles to accumulate in the upper part of the riser. The sand, coal, and CaO particles have time-averaged Reynolds numbers of 15, 6.5, and 0.5, respectively. The particle temperature is higher in areas with lower solid concentrations. Increasing excess air ratio (ϕ_g) decreases the temperature of sand particles but elevates that of coal and CaO particles. The average particle heat transfer coefficients (HTCs) for sand, coal, and CaO particles are 205 $W/m^2{\cdot}K$, 172 $W/m^2{\cdot}K$, and 275 $W/m^2{\cdot}K$, respectively. With the increase in ϕ_g, the HTC of sand particles increases but that of CaO particles remains unchanged, additionally, the mass of coal particles decreases and the mass of carbon in coal particles decreases along with the riser. The influence of the Ca/S ratio and CaO size on the axial distribution of coal particle mass and carbon mass fraction is negligible. For each particle species, the axial dispersion coefficient (*Dz*) is two orders of magnitude greater than the radial ones (*Dx*, *Dy*), indicating that the vertical introduction of the fluidizing gas dominates the dense gas-solid flow in the riser.

1. Introduction

The utilization of fluidized bed equipment has significantly expanded the horizons of reliable design and enhancement across diverse industrial technologies, including coal combustion, gasification, and drying processes [1,2]. Whether operating in the fast fluidization regime or the transported bed regime, the circulating fluidized bed (CFB) combustor presents numerous advantages compared to conventional bubbling or turbulent fluidized bed reactors [3,4]. These advantages include the capability to combust a wide array of solid fuels while maintaining low pollutant emissions and high combustion efficiency. Additionally, CFB combustors feature smaller furnace cross-sections, fewer feed points, and excellent turndown and load capabilities [5]. To ensure the successful implementation of new CFB devices, a sequence of scale-up experiments spanning bench, pilot, and industrial scales is frequently required [4,6]. However, it is worth noting that the experiment study is expensive and time-consuming for determining the optimal operational parameters for the CFB reactor [7]. Such experiments can only measure macroscopic quantities at the outlet, making it impractical to obtain comprehensive information on the entire field. CFB reactors involve many different processes, such as fuel devolatilization and complex chemical reactions associated with the combustion, flue gas desulfurization, heat and mass transfer, fuel particle reduction and other mechanisms taking place in dense gas-solid reactive flow [8,9]. These interconnected factors pose substantial challenges for studying the process through experimental means.

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作者: Yang, JS (Yang, Jianshan);Dong, T (Dong, Ting);Zhou, WG (Zhou, Weigang)

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小类	ENERGY & FUELS 能源与燃料	2 区	-
大类	工程技术	1 区	是

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2023 年影响因子:9.0

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JCR® 类别	类别中的排序	JCR 分区
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ENERGY & FUELS	**24/171**	**Q1**

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Fuel 187 (2017) 457–467

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Full Length Article

Large eddy simulation of turbulent combustion by a dynamic second-order moment closure model

Kun Luo, Jianshan Yang, Yun Bai, Jianren Fan *

State Key Laboratory of Clean Energy Utilization, Zhejiang University, Hangzhou 310027, PR China

HIGHLIGHTS

- A dynamic second-order moment closure combustion model is developed.
- The model is applicable for all combustion regimes.
- Two experimental flames are predicted by this model.

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Sandia flame D
Swirling non-premixed flame

ABSTRACT

A dynamic second-order moment closure model is developed for turbulent combustion in the form of large eddy simulation. The filtered reaction rate is directly closed in the form of Arrhenius law, and the whole temperature exponential function is treated as a single variable to avoid the traditional Taylor series expansion. The sub-grid unresolved reaction rate is modeled with a second-order moment closure model. All the coefficients in the sub-grid models are evaluated by the dynamic procedures. To validate and evaluate this model, a priori validation using a DNS database and posteriori validation by LES of the Sandia piloted jet flame (Flame D) and the Sydney bluff-body swirling flame (SM1) are performed. The results demonstrate that the dynamic second-order moment closure model coupled with LES is able to reasonably predict turbulent combustion even with simple chemistry, and has potential to predict more complex combustion with detailed reaction mechanism and acceptable computational cost.

1. Introduction

In most industrial equipment, such as coal-fired furnaces, combustion gas turbines and internal combustion engines, turbulent combustion has been encountered [1]. Predictive capacity for turbulent combustion is thus of paramount importance to those applications in which experimental measurements are difficult, limited and even not accessible. In the recent years, much more attention has been paid to large eddy simulation (LES) of turbulent combustion, since LES has been demonstrated to be able to provide more accurate information and useful qualitative understanding of turbulent combustion phenomena, compared to the traditional ways on the basis of the Reynolds Averaged Navier-Stokes [2–4].

The most challenging issue in turbulence combustion modeling is proper treatment of the multi-scale coupling process of chemical reaction and molecular diffusion. Many of the current approaches could be categorized as PDF-like or flamelet-like based on how to deal with the coupling between chemical reactions and molecular diffusion [5]. The steady flamelet model (SFM) put forward by Peters [6,7] is one of the flamelet-like models. It is relatively simple and has been improved in different methods, such as the unsteady flamelet model (UFM) [8], the flamelet/progress variable model (FPV) [9] and so on. The advantage of the flamelet model is that detailed chemistry can be considered with reasonable computational cost. However, it was basically formulated and developed separately for premixed flames and non-premixed flames. The probability density function (PDF) models have been well developed for combustion by Pope [10,11]. Some PDF-like models have also been developed such as the multiple mapping conditioning (MMC) [12] and the one-dimensional turbulence (ODT) model [13]. One advantage of the PDF method lies in the fact that it can be applied to all combustion regimes, even challenging flames, like extinction, ignition flames and bluff-body swirling flames [14]. But the relatively simple mixing models and high computational cost are still the weaknesses in the current application of PDF models.

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第 1 条，共 1 条

标题: Large eddy simulation of turbulent combustion by a dynamic second-order moment closure model

作者: Luo, K (Luo, Kun);Yang, JS (Yang, Jianshan);Bai, Y (Bai, Yun);Fan, JR (Fan, Jianren)

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小类	ENERGY & FUELS 能源与燃料	2 区	-
大类	工程技术	1 区	是

impact factor

2023 年影响因子:6.7

JCR 期刊分区（2023）：

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ENGINEERING, CHEMICAL	**23/170**	**Q1**
ENERGY & FUELS	**46/171**	**Q2**

输出日期: 2024 年 11 月 22 日

证明

兹证明浙江大学能源工程学院罗坤教授为杨建山(12 级博士生；身份证号：360281198902261937；专业：工程热物理)的博士生导师。

浙江大学能源工程学院

2024 年 11 月 23 日

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2015 年 4 月 JOURNAL OF ENGINEERING THERMOPHYSICS Apr., 2015

动态亚网格二阶矩湍流燃烧模型

杨建山 罗 坤 白 云 邱坤赞 樊建人

(浙江大学能源清洁利用国家重点实验室，杭州 310027)

摘 要 在二阶矩亚网格燃烧模型的基础上，考虑了密度脉动，提出了动态亚网格二阶矩燃烧模型 (Dynamic-LES-SOM)。在此模型中，反应项由平均反应项和亚尺度反应项组成，所有的系数都是通过动态计算得到。使用该模型对美国 Sandia 国家实验室 Flame C 进行了计算，并且与忽略密度脉动的二阶矩亚网格燃烧模型结果进行对比。结果发现，Dynamic-LES-SOM 燃烧模型计算结果与实验值吻合得很好，较忽略密度脉动的二阶矩燃烧模型有所提高。

关键词 湍流燃烧；二阶矩；大涡模拟；动态模型
中图分类号：TK6 **文献标识码**：A **文章编号**：0253-231X(2015)04-0917-05

A Dynamic Second-order Moment Closure Model for Turbulent Combustion

YANG Jian-Shan LUO Kun BAI Yun QIU Kun-Zan FAN Jian-Ren

(*State Key Laboratory of Clean Energy Utilization, Zhejiang University, Hangzhou 310027, China*)

Abstract A new turbulent combustion model, dynamic second order moment turbulent combustion model (Dynamic-LES-SOM) is developed considering density fluctuation. The reaction rate consists of filtered reaction rate and the sub-grid scale reaction rate in the model. All the coefficients in the model are evaluated dynamically. A piloted methane-air jet flame (Sandia Flame C) have been simulated with the new model and compared with the experimental data and the results obtained with the original constant density second-order moment closure model (LES-SOM). It is found that the results of the dynamic SOM model agree well with the experiment data, and the performance of the new model is better than the original LES-SOM model.

Key words turbulent combustion; second-order moment; large eddy simulation; dynamical model

0 前 言

越来越多的学者采用大涡模拟 (LES) 的方法研究湍流燃烧问题。大涡模拟的主要思想是通过滤波函数将大尺度的涡和小尺度的涡分开。大尺度的涡通过控制方程直接求解，而小尺度的涡需要模型进行模化。采用大涡模拟的方法处理燃烧问题时，最大的难点是在于对化学反应的处理。研究者提出了许多燃烧模型，主要有涡破碎模型 (EBU)、小火焰 (Flamelet) 模型、条件矩 (CMC) 模型和 PDF 模型等。

首次由 Spalding[1] 提出的涡破碎模型是基于 Damkohler 数远大于 1 和雷诺数远大于 1 假设的。周力行等 [2] 对此模型进行了检验，发现此模型并不能给出比较好的预测结果。Peters[3] 提出了基于层流小火焰库的小火焰模型，这个模型认为湍流燃烧的火焰可以由一系列的层流小火焰组成。但是小火焰模型只适用于单纯的扩散燃烧或者预混燃烧。Klimenko[4] 和 Bilger[5] 提出了条件矩燃烧模型，其主要思想是把组分和温度的脉动和某单一标量的脉动联系起来。对于预混燃烧，反应度常取为条件变量，对于扩散燃烧，混合分数常被取为条件量。PDF[6] 输运方程模型可以应用于预测预混火焰和非预混火焰，但是其计算量很大，尤其是采用详细化学反应机理时。周力行等 [7] 提出了二阶矩 (SOM) 燃烧模型，直接对化学反应速率进行封闭，理论上来讲，该燃烧模型没有基于预混燃烧或者扩散燃烧的物理假设，因此可以应用于预混燃烧和扩散燃烧同时存在的问题。王方 [8] 采用二阶矩亚网格燃烧模型 (Original-LES-SOM) 对 Flame C 进行了计算，得到了较好的结果，但是该模型没有考虑密度脉动，并且模型中的系数都是经验给定的，不具有通用性。基于

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作者简介：杨建山 (1989-)，男，博士研究生，主要从事动态亚网格燃烧模型研究。

附件：

以下 1 篇文献被 CSCD《中国科学引文数据库》收录：

文献收藏号：5397060

题名：动态亚网格二阶矩湍流燃烧模型

作者：杨建山，罗坤，白云，邱坤赞，樊建人

机构：浙江大学

关键词：湍流燃烧;二阶矩;大涡模拟;动态模型

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2015 年 2 月　　JOURNAL OF ENGINEERING THERMOPHYSICS　　Feb., 2015

气液两相旋流燃烧的时均统计特性

杨建山　罗　坤　邵长孝　樊建人

(浙江大学能源清洁利用国家重点实验室，杭州　310027)

摘　要　通过直接数值模拟的方法研究了旋流燃烧器中三维正庚烷喷雾燃烧，为实际喷雾蒸发和燃烧问题提供参考．气相燃烧模型采用自适应单步反应机理，液相采用拉格朗日方法跟踪，液滴蒸发采用无限传导蒸发模型．本文研究了气相和液相时均特性．结果发现燃烧和中心回流区 (CRZ) 之间有相互促进作用；同向旋流导致更强的中心回流区 (CRZ)，但是会有更小的外部回流区 (ORZ)；富预混燃烧会有更高的化学反应速率，并且蒸发冷却的影响更为明显；湍流入流会导致更高的液滴散布和更小的液滴直径．

关键词　液雾燃烧；直接数值模拟；旋流燃烧；时均特性
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Time-Average Character of Gas-Liquid Two Phase Swirl Combustion

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Abstract　In order to provide a reference of the actual spray evaporation and combustion, Three-dimensional swirling spray combustion under different condition were studied by Direct Numerical Simulation(DNS). The gas combustion was modeled by an adaptive one-step reaction mechanism, the droplets were tracked in Lagrangian framework and the evaporation was described by infinite heat conduction model. We have learned the time-average character for both gas phase and liquid phase. It was found that there is mutually reinforcing effect between the combustion and the central recirculation zone (CRZ). Co-swirling leads to a stronger central recirculation zone(CRZ), but there will be a smaller outer recirculation zone (ORZ). The reaction rate is much higher and evaporative cooling effect is more obvious in rich combustion. Turbulence inflow will make contribution to higher dispersed droplets and smaller droplets.

Key words　spray combustion; DNS; swirl combustion; time-average

0 引　言

在许多的工程应用问题中，比如内燃机和航空发动机，会遇到液雾燃烧问题．当运行和设计这些设备时，需要能精确预测液雾燃烧特性．但是隐含于液滴燃烧中的喷雾燃烧机理是非常复杂的．液相经历了初步雾化和二次雾化．生成的液滴会经历蒸发、冷凝，进一步的破裂或者与别的液滴碰撞和聚结在一起．在气相中的蒸汽经历了湍流混合，湍流混合为火焰提供未燃烧蒸发燃料．这些共存的过程包括液相动力学、蒸发、湍流和燃烧，以及其相互间的作用．这对实验测量和高精度模拟提出了挑战．

作为一个研究手段，直接数值模拟越来越受到人们的重视，为了揭示液雾燃烧中的物理、化学特性．近几年来有不少学者采用直接数值模拟的方法模拟液雾燃烧 [1–4]．这些研究大部分局限于二维，简单的工况．笔者前期对空气－正庚烷旋流燃烧 [5–7]，发现喷雾燃烧的火焰结构十分复杂，仅采用传统的非预混燃烧模型是不够的．尤其是在蒸发和燃烧共存并存在强烈相互作用的区域，组分与混合物份额之间存在着复杂的关联．并且还发现喷雾燃烧的流动和火焰结构受到旋流方式和当量比的影响．流场中出现了反平行排列的涡管结构．且各种工况下液雾燃烧火焰都是由富燃预混火焰，扩散火焰，贫燃预混火焰组成，这给液雾燃烧的模型模拟带来了新的挑战．本文中将进一步研究不同工况下的时均特性．

1 数学模型及数值方法

本文中相关数学模型和数值方法已经在前期的研究中阐述过 [5–7]，在此不作赘述．本文的计算工

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作者简介：杨建山 (1989–)，男，博士研究生，主要从事液雾燃烧的直接数值模拟研究．

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附件一：

CSCD《中国科学引文数据库》收录论文 1 篇

文献收藏号：5369808

题名：气液两相旋流燃烧的时均统计特性

作者：杨建山，罗坤，邵长孝，樊建人

机构：浙江大学

实验室：能源清洁利用国家重点实验室

关键词：液雾燃烧;直接数值模拟;旋流燃烧;时均特性

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文摘：通过直接数值模拟的方法研究了旋流燃烧器中三维正庚烷喷雾燃烧,为实际喷雾蒸发和燃烧问题提供参考。气相燃烧模型采用自适应单步反应机理,液相采用拉格朗日方法跟踪,液滴蒸发采用无限传导蒸发模型。本文研究了气相和液相时均特性。结果发现燃烧和中心回流区(CRZ)之间有相互促进作用;同向旋流导致更强的中心回流区(CRZ),但是会有更小的外部回流区(ORZ);富预混燃烧会有更高的化学反应速率,并且蒸发冷却的影响更为明显;湍流入流会导致更高的液滴散布和更小的液滴直径。

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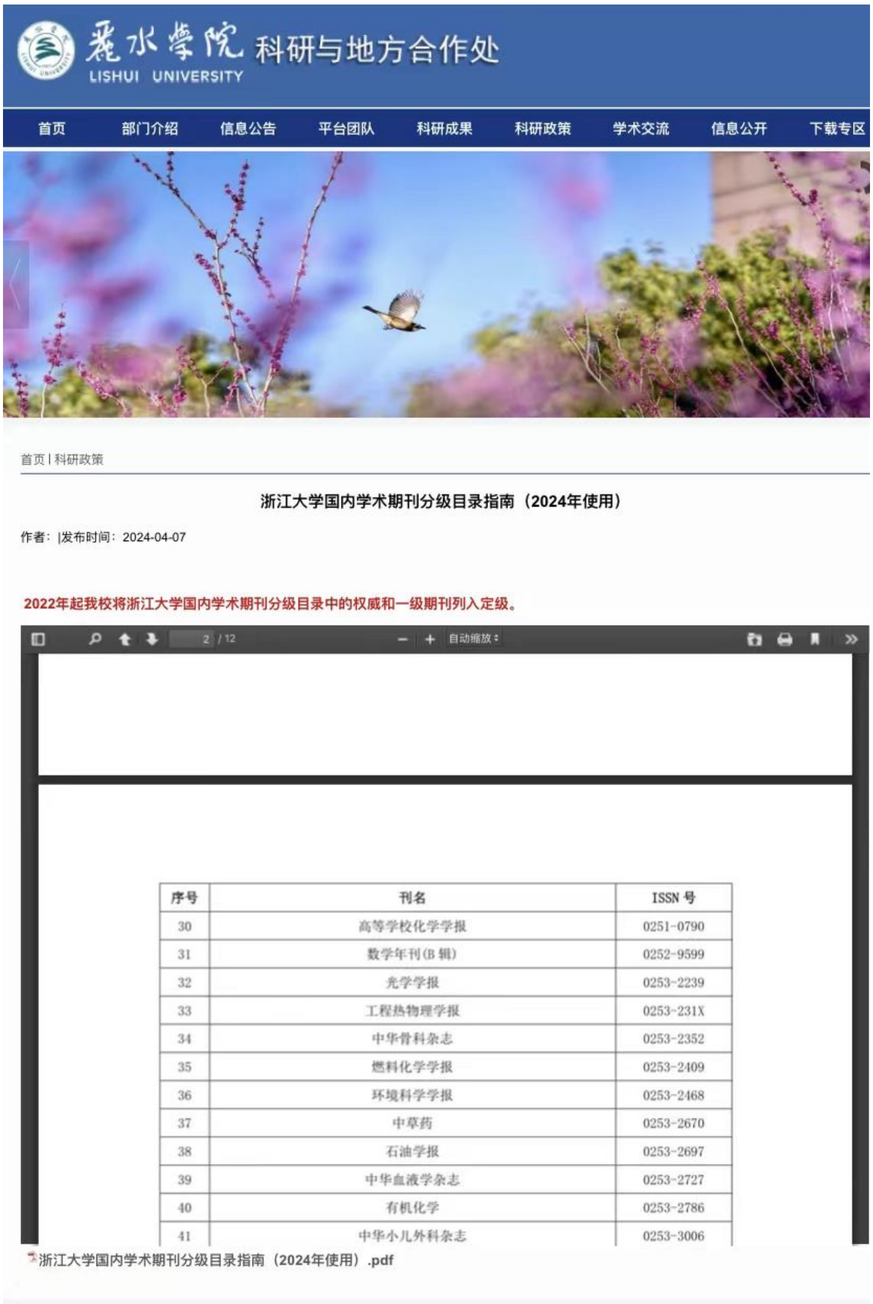

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图表中 33 号：

Large Eddy Simulation of the Sandia Flame E and F Using Dynamic Second-Order Moment Closure (DSMC) Model

Jianshan Yang, Kun Luo, Yun Bai, and JianRen Fan

Abstract

Turbulent piloted methane/air diffusion flames (Sandia Flame E and F) are evaluated using dynamic second-order moment closure (DSMC) model. The DSMC model is a combustion model for large eddy simulation, which is assumed that the model could be applied to both premixed flames and non-premixed flames. And the density fluctuation is taken into account. In the model, the averaged reaction rate is directly closed in the form of Arrhenius law. The third-order fluctuation correlations are neglected, and the second-order fluctuation correlations are closed using the algebraic form. All the coefficients in the model are evaluated dynamically. The results from simulation have been compared with the available measurement data. In general, there is good agreement between present simulations and measurements both for Sandia flame E and F, which gives a reasonable indication on the accuracy and adequacy of the DSMC model. And the further application is considerable for the model. The sub-grid effects in this combustion model have been studied. The reaction rate of methane for flame E is higher than the value of flame F and the sub-gird reaction rate is in the reverse value of its filtered reaction rate with 25 %. The sub-gird effects play an important role in this combustion model and should be treated carefully.

Keywords

Second-order • Turbulent combustion • Combustion model • Large eddy simulation

1 Introduction

There are increasing number of attentions that have been paid in large eddy simulation (LES) of combustion, which could give a more accurate result than Reynolds Averaged Navier Stokes (RANS) [1]. And the LES cost littler than the direct numerical simulation (DNS). It is complicated to simulation combustion using LES, due to that processes of reaction and molecular diffusion need to be concluded simultaneously. The combustion model and sub-grid scale stress model are needed in LES of combustion. A lot of combustion model have been proposed for LES to model combustion, in which, the most well-known combustion model are probability density function (PDF) model [2] and flamelet model [3]. The PDF combustion model is an accurate model and could be applied to the flame, which includes premixed and non-premixed flame. But the PDF model costs a lot of computational resource and need a mixing model, which is relatively simple and counts a lot in the PDF model. The flamelet model could predict non-premixed flame and premixed flame (with premixed flamelet approach) well, respectively. The most acceptable SGS stress models are Smagorinsky eddy-viscosity model [4], the dynamic kinetic energy model [5], and Germano dynamic model [6]. Recently, a dynamic second-order moment closure (DSMC) model, which could deal with the premixed flame and non-premixed flame, is proposed by the present authors. This paper is aimed to demonstrate the ability of the DSMC model. The Sandia flame E and F have

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