

航空发动机 RQL 燃烧室淬熄区掺混特性研究

吉雍彬, 袁用文, 葛冰, 臧述升

(上海交通大学 机械与动力工程学院, 上海 200240)

摘要: 针对航空发动机扇段 RQL(富油-贫油-淬熄)燃烧室掺混主流空气和淬熄射流空气的几种工况下, 利用丙酮作为荧光粒子进行了冷态淬熄区浓度场的 PLIF(平面激光诱导荧光)可视化实验研究, 获得了淬熄孔中心截面上丙酮浓度分布。考察了主流与淬熄射流速度对淬熄区掺混特性(相对穿透深度和掺混不均匀度)的影响规律, 并就主流有无旋流情况进行了对比分析。研究表明: 利用 PLIF 技术测量的结果可以很直观比较不同工况下的掺混特性; 主流有旋流时, 增加淬熄射流速度, 相对穿透深度增加, 掺混均匀性也迅速提高, 但淬熄射流速度达到一定值后, 淬熄区掺混均匀性提高缓慢甚至维持不变, 而增加主流速度, 相对穿透深度减小, 且掺混均匀性也显著变差; 相比于有旋流, 主流无旋流时的相对穿透深度更小, 掺混均匀性也更差, 掺混效果欠佳。

关键词: RQL 燃烧室; PLIF 测试; 激光可视化; 相对穿透深度; 掺混均匀性

中图分类号: V231 文献标识码: A

DOI: 10.16146/j.cnki.rndlgc.2016.01.008

引言

富油-淬熄-贫油(RQL: Rich burn-Quench-Lean burn)燃烧室的概念是在1980作为减少航空发动机 NO_x 排放的有效措施提出的^[1]。由于淬熄区起到连接富油区和贫油区燃烧的关键作用, 需要实现射流与主流快速、有效地混合, 因此针对RQL燃烧室淬熄区的掺混机理和影响因素开展了大量研究^[2-9]。以往研究表明, 淬熄射流与主流的动量通量比对RQL燃烧室中淬熄区的掺混特性的影响很大。但当主流为旋流时, 更为复杂的流动导致掺混特性不完全取决于动量通量比, 它还受制于主流或射流的绝对速度。本文重点研究了主流和射流速度在主流为旋流时对掺混特性的影响, 并与无旋流情况进行了比较。实验测试技术方面, 对于冷

态流场掺混的研究, 平面激光诱导荧光(PLIF)技术在浓度场的显示与测量领域优势显著^[10-13]。PLIF是利用流场中特定物质在激光照射下能发生荧光的特点, 进而显示和测量流场参数的一种非接触式测量技术。丙酮作为荧光粒子可以以较高的浓度注入气流中, 拥有较宽的光谱吸收范围(225-320 nm), 同时具有荧光效率高、低毒和廉价等特点^[14-15], 被广泛用于气相冷流浓度场 PLIF 诊断, 该技术也是了解非反应下燃烧室内燃料分布和掺混情况的重要手段^[16]。

在冷态情况下, 以丙酮作为荧光粒子, 利用 PLIF 测试技术对环形扇段 RQL 燃烧室模型中淬熄区掺混状况进行了可视化研究, 获得淬熄孔截面上丙酮浓度分布后得到掺混的相对穿透深度以及不均匀度, 并总结出相对穿透深度和掺混均匀性受掺混射流和主流流速的影响规律, 以及对比分析了主流是否为旋流的影响程度。

1 实验装置与研究方法

1.1 实验装置

实验是在上海交通大学叶轮机械实验室 RQL 燃烧室试验台上进行的, 实验系统如图 1 所示, 主要由主流空气系统、淬熄空气系统、试验段和 PLIF 测量系统组成。实验中采用 7.5 kW 离心式风机作为主流空气风源, 通过变频器调节转速从而控制主流流量。淬熄空气由螺杆空压机提供。在淬熄空气中加入丙酮作为荧光粒子的方式为: 空压机把压力罐中的丙酮压出, 通过丹佛斯的离心压力雾化喷嘴喷入淬熄空气中, 这样使丙酮较好雾化, 利于与淬熄空气的均匀混合。

收稿日期: 2014-11-06; 修订日期: 2015-01-26

作者简介: 吉雍彬(1990-), 男, 江苏南通人, 上海交通大学硕士研究生。

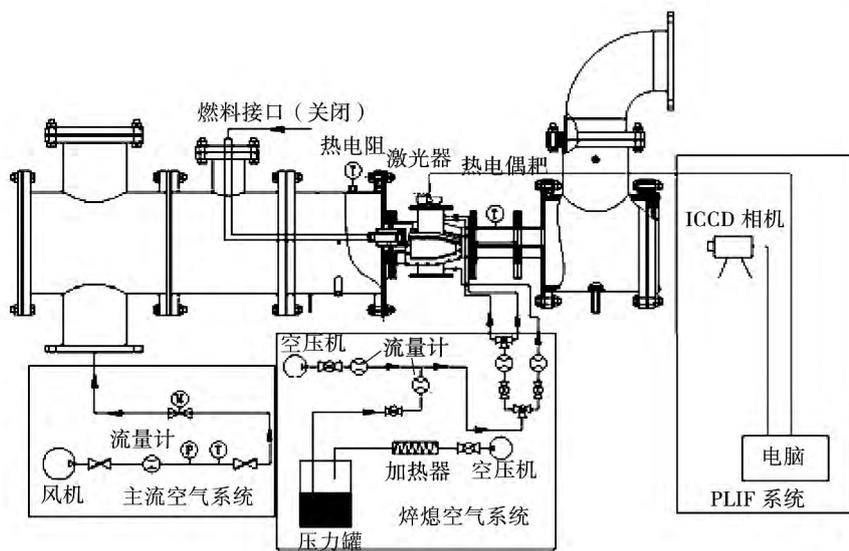


图 1 RQL 燃烧室掺混特性实验系统

Fig.1 The system diagram of the RQL combustor mixing characteristic experimental system

扇形燃烧室试验段是模化而来, 选用 3/20 环形燃烧室, 头部安装有 3 个 45° 轴向直叶片式旋流器, 该试验段为可视化燃烧室, 如图 2 所示。燃烧室的侧面和尾部都开有石英玻璃的可视化窗口。试验段上下壁面距头部旋流器出口 89 mm 处各布置一块淬熄板, 板上开有 14 mm 的掺混孔。

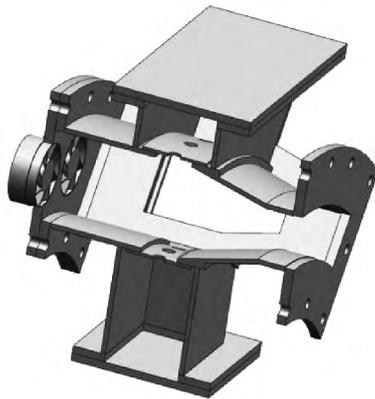


图 2 RQL 可视化燃烧室试验段

Fig.2 The test section of visualizable RQL combustor

1.2 实验方法

PLIF 测量系统主要由激光光源、荧光信号采集、同步系统及其它辅助系统组成, 其中激光片光源是由美国 Spectra - Physics 公司生产的 Quanta - Ray Lab - Series Nd: YAG 激光器产生的波长为 532 nm 的绿色脉冲激光。激光器的工作频率固定为 10

Hz, 单脉冲最高输出能量为 300 mJ, 脉冲半峰全宽为 8 - 10 ns。该脉冲激光产生后经德国 Cobra - Stretch 公司生产 Sirah 可调谐染料激光器改变波长以满足该实验测量需要。其使用的染料为 Rhodamine 6G, 可将 532 nm 泵浦激光波长调谐至 559 - 576 nm 范围内, 调谐波长的精度为 0.0018 nm, 最大误差小于 0.03 nm。荧光信号图像拍摄采用增强型 (ICCD) 相机。实验中采用美国斯坦福研究系统 (SRS) 生产的 DG535 数字延时/脉冲发生器, 作为 PLIF 的同步器精确控制由入射激光到 ICCD 相机开始荧光信号捕捉之间的延时以及 ICCD 相机的曝光时间。

实验时片光源沿垂直于主流来流方向从燃烧室侧面窗口摄入, 处于淬熄孔中心截面位置处, ICCD 相机垂直于片光源平面从燃烧室尾部窗口进行拍摄, 如图 3 所示。由于燃烧室结构的限制, 无法拍摄到整个截面, 其拍摄区域如图 4 所示。

实验分主流有无旋流两组进行, 主流无旋流时只需将头部旋流器卸掉即可。两组实验的工况相同, 各工况下主流与淬熄射流的流速如表 1 所示。

2 实验结果及分析

实验过程中, 维持主流和淬熄射流的温度以及燃烧室内的压力恒定, 因此淬熄孔中心截面上各点

荧光粒子丙酮的浓度值 C_i 与 PLIF 图像上各像素点的灰度值 I_i 呈正比关系,从而可以直观地从每个工况下的 PLIF 时均图像反映的浓度分布看出掺混状况。以每个工况图像上浓度最大值 C_{max} 为基准,可以得到各对应位置处的相对浓度 C^* ,如式(1)所示,其值在 0 到 1 之间。

$$C^* = C_i / C_{max} = I_i / I_{max} \quad (1)$$

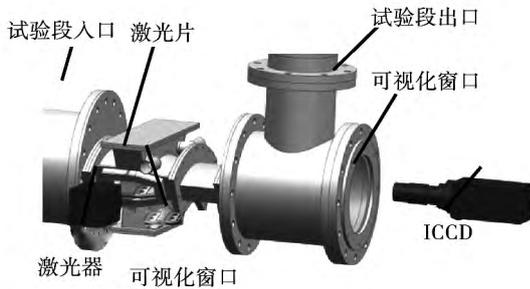


图 3 PLIF 拍摄方法示意图

Fig. 3 The schematic diagram of the PLIF photography

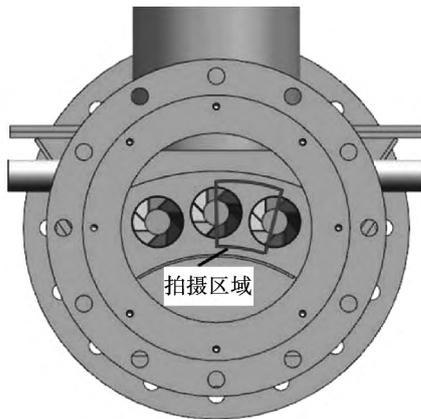


图 4 拍摄区域示意图

Fig. 4 The schematic diagram of the shooting area

表 1 实验工况 (m/s)

Tab. 1 The experimental operating conditions (m/s)

工况	主流速度 V_M	焊熄射流速度 V_Q
1-3	2.5	2.46
4-6	5.0	2.46
7-9	7.5	2.46
10-12	10	2.46

2.1 掺混特性指标

利用相对穿透深度和不均匀度来表征掺混特

性。相对穿透深度表示射流所能穿透进入主流的程度,而不均匀度是衡量掺混均匀性程度的重要指标,二者综合评定是否实现了快速、均匀、有效地掺混。

2.1.1 相对穿透深度定义

通过对比各相对浓度等值线发现当 $C^* < 0.5$ 时焊熄射流浓度迅速降低,因此取相对浓度 $C^* = 0.5$ 等值线作为掺混射流所能运动到的最大位置较为合理。如图 5 所示,以焊熄孔中心轴为 0° 中心线,左右各截取 9° ($\pm 9^\circ$ 扇形区域) 为研究区域,向右为正角度,向左为负角度, D 为扇段燃烧室的高度, D_i 为周向角 θ 下 $C^* = 0.5$ 等值线上的点距离对应燃烧室上壁面的距离,则相对穿透深度 D^* 可以定义为:

$$D^* = D_i / D \quad (2)$$

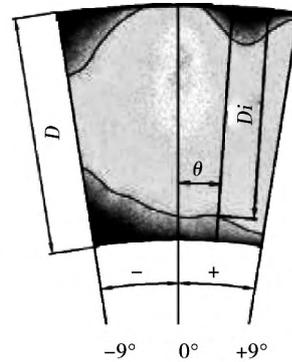


图 5 相对穿透深度定义示意图

Fig. 5 The schematic diagram of the relative penetration depth definition

2.1.2 掺混不均匀度定义

PLIF 图像各像素点上的灰度信息 I_i 正比于荧光粒子浓度 C_i ,研究区域灰度场的标准方差 δ 可以表征浓度场分布即掺混的不均匀度:

$$\delta = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\frac{C_i - \bar{C}}{\bar{C}} \right)^2} = \sqrt{\frac{1}{n} \sum_{i=1}^n \left(\frac{I_i - \bar{I}}{\bar{I}} \right)^2} \quad (3)$$

式中: \bar{I} —计算区域内灰度的平均值。

2.2 主射流速度变化对掺混特性的影响

2.2.1 浓度分布

图 6-图 9 分别为主流有、无旋流时各工况下,对 100 张瞬态 PLIF 照片进行平均处理得到的时均

PLIF 照片, 并做出了各相对浓度 C^* 的等值线。

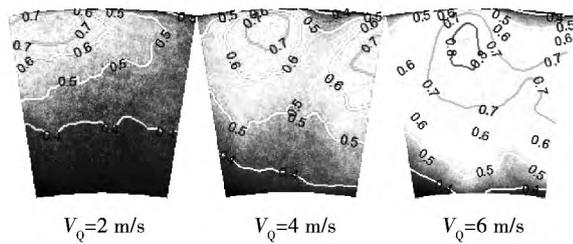


图 6 主流速度 $V_M = 10$ m/s 淬熄掺混区丙酮浓度时均分布(有旋流)

Fig. 6 The time-averaged concentration of acetone concentration for main velocity $V_M = 10$ m/s in dilution zone(with swirl)

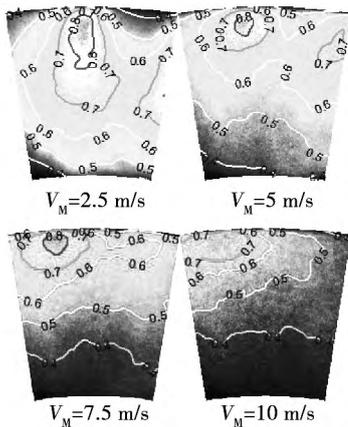


图 7 射流速度 $V_Q = 2$ m/s 淬熄掺混区丙酮浓度时均分布(有旋流)

Fig. 7 The time-averaged concentration of acetone concentration for jet velocity $V_Q = 2$ m/s in dilution zone(with swirl)

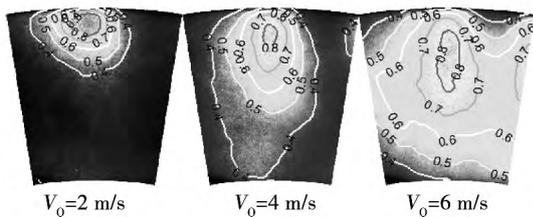


图 8 主流速度 $V_M = 10$ m/s 淬熄掺混区丙酮浓度时均分布(无旋流)

Fig. 8 The time-averaged concentration of acetone concentration for main velocity $V_M = 10$ m/s in dilution zone(without swirl)

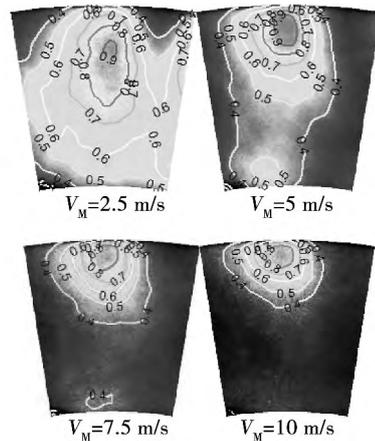


图 9 射流速度 $V_Q = 2$ m/s 淬熄掺混区丙酮浓度时均分布(无旋流)

Fig. 9 The time-averaged concentration of acetone concentration for jet velocity $V_Q = 2$ m/s in dilution zone(without swirl)

从图 6 可以看出, 主流为旋流时, 维持主流速度恒定, 尤其是在主流速度较大时 ($V_M = 10$ m/s), 淬熄射流的速度增加会导致淬熄射流在周向和径向上运动范围增加, 掺混加剧; 而从图 7 可以看出, 当淬熄射流速度维持恒定时, 尤其是在淬熄射流速度较小时 ($V_Q = 2$ m/s), 主流速度的增加会导致淬熄射流运动范围减小, 掺混削弱。此外, 由于主流为旋流, 其具有切向速度, 该切向速度会迫使淬熄射流向旋流方向倾斜, 尤其是在主流速度较大的情况下, 这种现象更为明显。丙酮浓度较高的区域集中分布在左上角, 这是由于旋流具有向左的切向速度, 又因为射流速度较小, 此时主流占支配地位, 旋流作用相对较强。而当淬熄射流速度增大, 具有一定动量的射流进入主流, 削弱了旋流的作用。主流为旋流时, 主流与射流相互干扰加剧, 湍动增强, 加强了掺混, 此时浓度高低界线模糊不清, 表明在主流与射流的交界面上实现了快速掺混, 整体的掺混均匀性较好。

从图 8 和图 9 可以看出, 主流无旋流和主流有旋流时射流与主流速度影响趋势相同。不同的是, 主流无旋流时, 丙酮浓度分布的高低界线清晰可见, 这是因为两股流动相互扰动小, 掺混的均匀性较差, 无法实现快速掺混。

2.2.2 相对穿透深度

为更直观地比较相对穿透深度, 不同工况下相对穿透深度 D^* 随周向角 θ 的变化曲线如图 10 和图

11 所示。

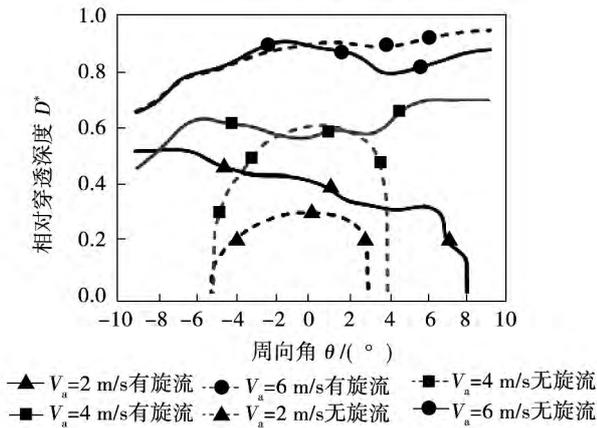


图 10 主流速度 $V_M = 10 \text{ m/s}$ 淬熄掺混区
相对深度 D^* 的比较

Fig. 10 Comparison of nominal penetration depth D^* for main velocity $V_M = 10 \text{ m/s}$

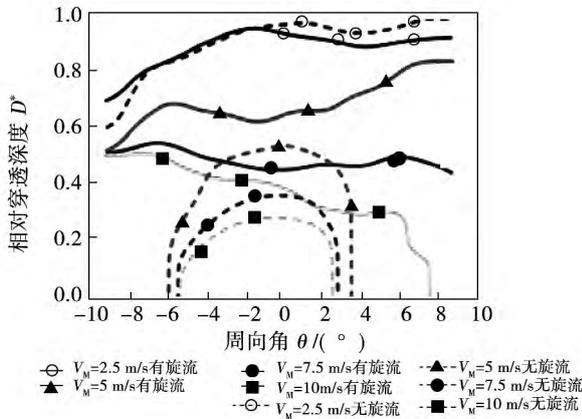


图 11 射流速度 $V_Q = 2 \text{ m/s}$ 淬熄掺混区
相对深度 D^* 的比较

Fig. 11 Comparison of nominal penetration depth D^* for jet velocity $V_Q = 2 \text{ m/s}$

由图 10 可知,主流为旋流时,当主流速度维持恒定,各周向角度下的相对穿透深度 D^* 均随着淬熄射流速度的增加而增加,当淬熄射流速度从 2 m/s 增加到 4 m/s 时,最大穿透深度增加了 35% 。随着射流速度进一步增加,即从 4 m/s 增加到 6 m/s ,最大穿透深度也进一步增加了 30% ,此时射流已接近穿透整个淬熄区。由图 11 可知,当淬熄射流速度维持恒定时,相对穿透深度 D^* 随着主流速度的增加而减小。相比于主流速度 2.5 m/s ,在主流速度为

$5, 7.5$ 和 10 m/s 时最大相对穿透深度分别减小了 12% 、 40% 和 45% 。对于主流为旋流而言,相对穿透深度沿周向的变化无显著规律,只是由于旋流切向效应,相对穿透深度的极值不会出现在周向角为 0° 附近,而是会向旋流一侧偏移,相对穿透深度在周向上的分布较为均匀。

主流无旋流时,主流和射流速度对相对穿透深度影响的趋势与旋流状况下一致,但其值比相同工况有旋流情况显著下降,且相对穿透深度的极值出现在周向角为 0° 附近,随着周向角向两侧方向增大,相对穿透深度迅速减小为零。但在射流与主流动量通量比较大的情况下(工况 1 和工况 12),无旋流和有旋流的相对穿透深度分布差异很小。

2.2.3 淬熄区掺混不均匀度

为定量比较各工况下掺混均匀性,定义了浓度场不均匀度作为指标,其值越大表示掺混均匀性越差,如图 12 所示。可以看出,当主流为旋流且主流速度恒定时,随着淬熄射流速度从 2 m/s 增加到 4 m/s ,不均匀度均有所减小,最高减小了 31% ,掺混均匀性改善显著。但随着射流速度进一步增加,即从 4 m/s 增加到 6 m/s ,不均匀度减小十分缓慢甚至维持不变,意味着此时淬熄区掺混已经相当均匀,再增加射流速度对提高掺混均匀性的作用不明显;而当淬熄射流速度恒定时,对比各主流速度对掺混均匀性的影响可以发现,主流速度对于掺混均匀性的影响比较显著,除了主流速度较低为 2.5 和 5 m/s 时,掺混均匀程度没有太大差别,其余情况下,掺混不均匀度均随着主流速度的增加而显著增加,掺混均匀性变差,这种现象尤其是在射流速度较低的情况下较为明显。淬熄射流速度为 $2, 4$ 和 6 m/s 时,主流速度从 2.5 m/s 增加到 10 m/s ,不均匀度分别增加了 129% 、 156% 和 90% 。

相比而言,同样的流动参数下,主流无旋流比有旋流的不均匀度大很多,也就是说掺混均匀性差很多,尤其是在淬熄射流速度较小时。此外,主流无旋流时,掺混均匀性的趋势比较明显,但由于旋流对于掺混的影响存在很多不确定性,较之无旋流而言也更为复杂,不单纯取决于动量通量比,还受到主流或射流的绝对速度的制约,此外还与旋流器及燃烧室的结构有关。这也表明,就掺混特性而言,针对 RQL 燃烧室掺混结构的设计,不可以直接采用未经修正的无旋流下掺混特性结果。

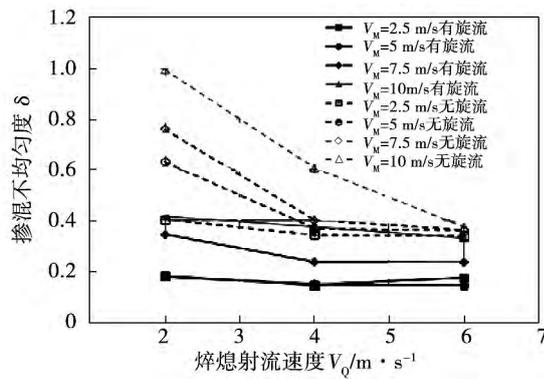


图 12 各工况下掺混均匀性的比较

Fig. 12 Comparison of mixing uniformity for all working conditions

3 结 论

(1) 旋流状态下,由于主流存在一定的切向速度会导致射流向旋流方向倾斜,且主流与射流相互干扰加剧,湍动增强,加强了掺混。

(2) 主流为旋流时,主流速度维持恒定,各周向角度下的相对穿透深度随着淬熄射流速度的增加而增加;淬熄射流速度维持恒定,相对穿透深度随着主流速度的增加而减小。

(3) 主流为旋流时,主流速度保持不变时,增加淬熄射流速度,掺混均匀性显著改善,但淬熄射流速度达到一定时,淬熄区掺混已经相当均匀,再增加射流速度对提高掺混均匀性的作用不明显;淬熄射流速度保持不变时,主流速度对于掺混均匀性的影响比较显著,掺混不均匀度随着主流速度的增加而显著增加,掺混均匀性变差,尤其是在射流速度较低的情况下该现象较为明显。

(4) 主流无旋流时,主流和射流速度对相对穿透深度影响的趋势与有旋流状况下一致,但其值比相同工况有旋流情况有很大下降,且相对穿透深度的极值出现在周向角 0° 附近,且无旋流时,不均匀度比有旋流时大很多,掺混均匀性变差。

参考文献:

[1] Mosier S A, Pierce R M. Advanced combustor systems for stationary gas turbine engines, Phase I. review and preliminary evaluation [R]. FR-11405, U. S. Environmental Protection Agency, 1980.
[2] Howe G W. Simulation of mixing in the quick quench region of a rich burn-quick quench mix-lean burn combustor [R]. 29th Aero-

space Sciences Meeting, 1991.

- [3] Smilth C E, Talpallkar M V. A CFD study of jet mixing in reduced flow areas for lower combustor emissions [R]. AIAA-91-2460, 1991.
[4] Leong M Y, Samuelsen G S. Optimization of jet mixing into a rich, reacting crossflow [J]. Journal of Propulsion and Power, 2000, 15 (5): 729-735.
[5] Leong M Y, Samuelsen G S. Jet mixing in a reacting cylindrical crossflow [R]. AIAA-95-3, 1995.
[6] Zhu G. Penetration and mixing of radial jets in neck-down cylindrical crossflow [J]. Journal of Propulsion and Power, 1995, 11 (2): 252-260.
[7] Zhu G, Lai M C. A parametric study of penetration and mixing of radial jets in necked-down cylindrical crossflow [R]. AIAA 92-309, 1992.
[8] Nagao T, Matsuno S. Fluid Mixing of Opposed Jet Flows in the rectangular duct [J]. AIAA-2013-0872.
[9] Law A W K, WANG Hongwei. Measurement of mixing process with combined digital particle image velocimetry and planer laser induced fluorescence [J]. Experimental Thermal and Fluid Science, 2000(22): 213-229.
[10] Law A W K, WANG Hongwei. Measurement of mixing process with combined digital particle image velocimetry and planer laser induced fluorescence [J]. Experimental Thermal and Fluid Science, 2000, 22: 213-229.
[11] SHAO Dongdong, Law A W K. Mixing and boundary interactions of 30° and 45° inclined dense jets [J]. Environ Fluid Mech, 2010 (10): 521-553.
[12] 肖洋, 唐洪武, 华明, 等. 同向圆射流混合特性实验研究 [J]. 水科学进展, 2006, 17(4): 512-517.
XIAO Yang, TANG Hong-wu, HUA Ming, et al. Experimental investigation on mixing characteristics of a round jet in co-flow [J]. Advances in Water Science, 2006, 17(4): 512-517.
[13] Sherwin D J, Koch J D. In situ PLIF and particle image velocimetry measurements of the primary entrainment fuel jet in a naturally aspirated water heater [J]. Journal of Fluids Engineering, 2014, 136: 021104-1-021104-6.
[14] Thurber M C. Acetone laser-induced fluorescence for temperature and multiparameter imaging in gaseous flows [R]. Topical Report TSD-120, 1999.
[15] Thurber M C, Grisch F, Kirby B J, et al. Measurements and modeling of acetone laser-induced fluorescence with implications for temperature-imaging diagnostics [J]. Applied Optics, 1998, 37 (21): 4963-4978.
[16] 耿辉. 超声速燃烧室中凹腔上游横向喷注燃料的流动、混合与燃烧特性研究 [D]. 湖南: 国防科技大学, 2007.
GENG Hui. Flow, mixing and combustion characteristics of fuel jet on the concave plenum upstream in supersonic combustor [D]. Hunan: National University of Defense Technology, 2007.

(丛敏编辑)

section tested were 43 and 76 kW/m² respectively ,the dryness of the refrigerant ranged from 0.1 to 0.7 ,the saturation temperature of the refrigerant in the section tested was in a range from 15 °C to 26 °C and the dryness of the refrigerant at the inlet of the section tested fell in a range from 0 to 0.65. Under the condition of the dryness being kept identical ,a comparison was made of the heat exchange coefficient of the refrigerant obtained when it had not been preheated before entering into the section tested with that obtained when it had been preheated before entering into the section tested. It has been found that to preheat the refrigerant before it enters into the section tested can make its heat exchange coefficient produce a deviation ,of which the average value can reach 14.2% . In the range tested ,with an increase of the dryness of the refrigerant at the inlet of the section tested and inside the section mentioned above ,the deviation of the heat exchange coefficient arisen from the preheating will go down step by step.

Key words: preheating ,R290 ,micro channel ,boiling heat exchange coefficient ,dryness

航空发动机 RQL 燃烧室淬熄区掺混特性研究 = **Study of the Mixing and Dilution Characteristics of a RQL (Rich-quench-lean) Combustor in Its Quenching Zone in an Aeroengine** [刊 ,汉]JI Yong-bin ,YUAN Yongwen ,GE Bing ,ZANG Shu-sheng (College of Mechanical and Power Engineering ,Shanghai Jiaotong University , Shanghai ,China ,Post Code: 200240) //Journal of Engineering for Thermal Energy & Power. -2016 ,31(1) . -48
-53

Under the operating condition of a sector-shaped section in a RQL model combustor being in a combination of various main stream air speeds and quenching jet flow air speeds ,with acetone serving as the fluorescence particles ,a PLIF (plane laser-induced fluorescence) visualization experimental study was performed of the acetone concentration field in the cold-state quenching zone and the distribution of the acetone concentration in the centerline cross section of a quenching hole was obtained. The law governing the influence of the main stream and quenching jet flow air speed on the mixing and dilution characteristics i. e. relative penetration depth and the mixing and dilution non-uniformity was observed and a contrast analysis was performed of the following two circumstances ,i. e. the main stream having and having no swirling flows. It has been found that the results measured by using the PLIF technology can be used to apparently compare the mixing and dilution characteristics under various operating conditions. When a swirling flow is present in the main stream ,to increase the quenching jet flow air speed can increase the relative penetration depth and quickly enhance the mixing and dilution uniformity ,however ,after the quenching jet flow air speed has reached a certain value ,the mixing and dilution uniformity in the quenching zone will increase slowly or even remain unchanged. To increase the air speed of the main stream will decrease the relative penetration

depth and the notably worsen the mixing and dilution uniformity. Compared with the circumstance that a swirling flow is present in the main stream ,when no swirling flows are present in the main stream ,the relative penetration depth will become smaller and the mixing and dilution uniformity will become worse ,thus the mixing and dilution effectiveness will be not good. **Key words:** RQL (rich-quench-lean) combustor ,PLIF (plane laser-induced fluorescence) testing ,laser visualization ,relative penetration depth ,mixing and dilution uniformity

折线型三通道除雾器内部流场的数值模拟与除雾效率分析 = Numerical Simulation of the Flow Field Inside a Polyline Type Three-channel Demister and Analysis of Its Demisting Efficiency [刊 ,汉] HONG Wen-peng , DENG Guang-qiang , LEI Jian-qi (College of Energy Source and Power Engineering , Northeast University of Electric Power , Jilin , China , Post Code: 132012) // Journal of Engineering for Thermal Energy & Power. - 2016 , 31 (1) . - 54 - 58

The CFD (computational fluid dynamics) software was used to conduct a numerical simulation of the flow field inside a polyline type three-channel demister. According to the flow characteristics of the flow field inside the demister ,the Reynolds time-averaged equation-based RNG $\kappa - \omega$ turbulent flow model was used for the gas phase and the Euler-Lagrange method-based DPM (discrete phase model) model was used for the liquid phase. It has been found that the demisting efficiency of a demister is influenced by the plate type of itself ,gas flow speed and liquid drop diameter. To increase the interval between any two plates will decrease the demisting efficiency. To increase the liquid drop diameter and the gas flow speed will invariably increase the demisting efficiency. The demisting efficiency of a polyline type three-channel demister is generally higher than that of a two-channel one. When the gas flow speed is less than 2 m/s or greater than 5 m/s ,the difference between the demisting efficiencies of both types of demister is not notable. When the gas flow speed is greater than 2 m/s or less than 5 m/s ,a polyline type three-channel demister enjoys a conspicuous leading edge. **Key words:** numerical simulation ,two-phase flow ,demister ,demisting efficiency

超临界锅炉螺旋水冷壁流量分配和壁温特性的研究 = Study of the Flow Rate Distribution and Wall Temperature Characteristics of the Spirally-coiled Tube Water Wall in a Supercritical Boiler [刊 ,汉] WANG Wei-shu , SHANGGUAN Shan-shan , XU Wei-hui (Energy Source Engineering Research Center , North China University of Water Conservation and Hydropower , Zhengzhou , China , Post Code: 450011) , GUO Hui-jun (Shanghai