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# 双旋流燃烧室冷态流场试验研究

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文献［1］和［2］提出的同轴双旋流方案，从燃烧室前端供入燃烧与掺混空气，形成“中心回流区”和“环状回流区”，在两股反向气流交界处，紊流度高，扩散燃烧快，对缩短火焰筒和均匀出口温度场有利。掺混空气量随加温比提高而减少，表明未来高性能燃烧室的头部供气比例较高，因此深入研究这类燃烧室的流动规律，对发展高性能发动机有重要意义。本文重点研究内外旋流角的大小和方向对流场的影响，寻求内外旋流角的较佳配合。

## 一、模型燃烧室及其流场测定

模型燃烧室（图1）的内外旋流器同心安装，内旋流器叶片安装角为30°及45°，外旋流器为＋45°、－45°和－30°（负号表示反旋）。燃烧室筒体内经150*mm*，外旋流器外径与筒体内径之比为1∶1.5，中心管长31*mm*（外旋流器出口平面至中心管后缘）。

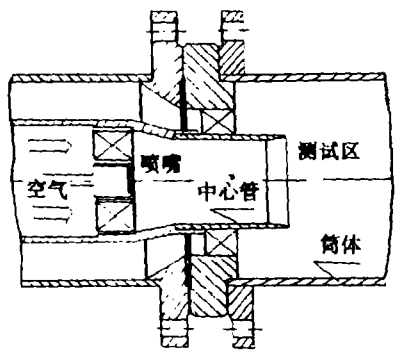

图1 试验件简图

离心喷嘴位于内涡流器中央，当雾化锥角足够大时，油锥甩向中心管内壁，形成油膜，并在中心管尾缘受到内外两股旋流的冲刷而雾化，其过程类似于气动喷嘴。此外，用均布的三个小流量离心喷嘴向环形回流区供油。用单通道热线风速仪，通过单丝旋转法测定流场[3]，并以自编的程序计算出时均速度、紊流强度和雷诺剪切应力等。

## 二、结果分析与结论

1. 图2表明，两股旋流交界处，正轴向速度最大，且反向旋流最大速度比同向旋流高；

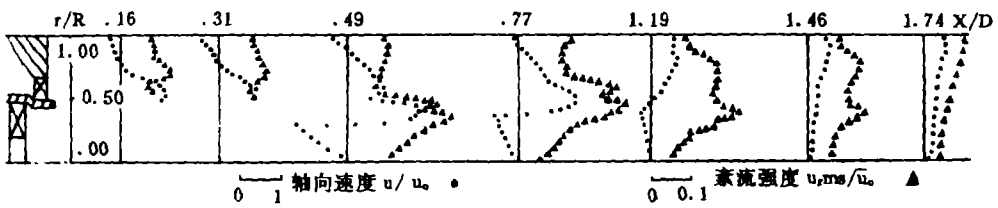

图2 轴向速度、紊流强度分布（内旋流角 $\alpha_i=30°$，外旋流角 $\alpha_0=45°$），$\bar{u}_0$为射流出口平均速度（轴向）

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$\alpha_i=30°$时，$\alpha_0$由$-30°$变为$-45°$。不仅使周边素流强度增高，且导致整个截面的素流强度提高；沿着流向，同向旋流的高素流度区逐渐向轴心线移动，而反向旋流的高素流度区仍维持在两股流交界面附近，这与文献［4］相吻合。

2. 反向和同向旋流的回流区流谱（图3*a* 和 *b*）的特点是：(1) 反向旋流的回流区粗短，而同向旋流的则细长；(2) 反向旋流的回流量较大。可见，反向旋流对于改善火焰稳定性和缩短火焰长度均有利。

3. 当 $\alpha_i$ 为30°时，$\alpha_o$ 由$-30°$变为$-45°$（图3*a* 和 *c*），将导致回流区缩短，回流量增加。

4. 本文结果表明，同向旋流也能产生中心回流区，与文献[5]吻合。但文献[2]认为同向旋流不能建立起中心回流区，这可能与试件结构、几何和气动参数有关。

5. 表1值与传统的燃烧室相当，或略有减小。

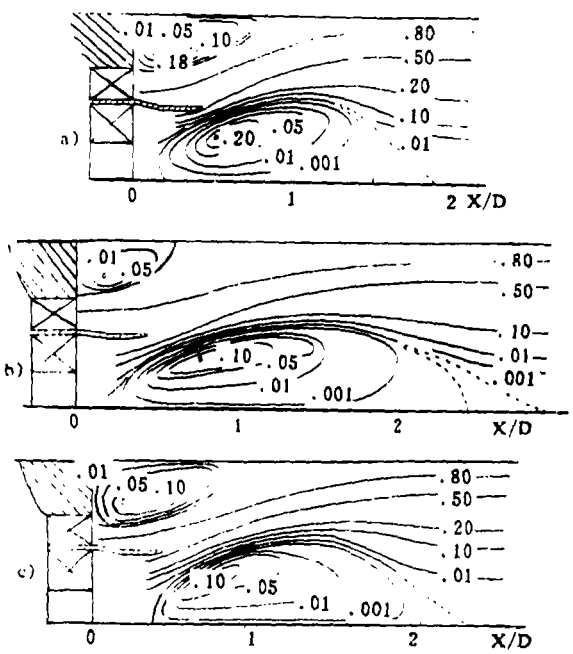


图3 流函数线（$\alpha_i=30°$，a：$\alpha_0=-45°$，b：$\alpha_0=-30°$，c：$\alpha_0=+45°$

表1 实测的冷态阻力系数（按进口截面平均速度定义）

| 内旋流器 | | 外旋流器 | | 阻力系数 |
|---|---|---|---|---|
| $\alpha_i$ | 旋流数 | $\alpha_0$ | 旋流数 | |
| 30° | 0.43 | −30° | −0.51 | 13.9 |
| 30° | 0.43 | −45° | −0.88 | 15.5 |
| 30° | 0.43 | +45° | 0.88 | 13.3 |
| 45° | 0.75 | −30° | 0.51 | 20.2 |
| 45° | 0.75 | −45° | −0.88 | 27.9 |

由此可得以下结论：

1. 在本文的结构和试验条件下，同向旋流和反向旋流都能产生中心回流区。

2. 与同向旋流相比，反向旋流的特点是：中心回流区粗短，回流量大，内外两股旋流交界面附近素流强度高，这些对于改善火焰稳定性，提高燃烧效率和缩短燃烧室长度都有利。

3. 当旋流角不超过45°时，冷态流体阻力与传统设计的燃烧室相当，甚至有可能减小。

## 参 考 文 献

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## AN EXPERIMENTAL RESEARCH ON MIXTURE PRESSURE LOSS IN COMBUSTOR

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**ABSTRACT** Mixture of cold air flow from annular pass through holes with main flow (cold or hot stream) has been researched experimentally. The momentum exchange for annular pass air flow through plain or plunge circular holes into main flow has been studied experimentaaly on a rectagular test section in a simulated combustion chamber. The momentum exchange increases the pressure loss of the main air stream near the jet holes. The results show that the mixture pressure loss of combustor with plunge circular holes is 1 to 1. 5 time as large as that of the combustor with plain circular holes. Therefore, the combustor with plunge circular holes is favourable to combustion and may reduce the length of the combustor.

## COLD FLOW MEASUREMENTS FOR A DOUBLE SWIRLER COMBUSTOR

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**ABSTRACT** The cold flow patterns in a double swirler combustor have been measured by using a six-orientation hot-wire probe technique. The results show that the central recirculation zone for counter-rotating swirling is different from that of co-rotating swirling. A better pattern in the central recirculation zone for combustion will be obtained if the swirler angles of both the outer swirler and the center swirler are chosen reasonably.

## EXPERIMENTAL RESEARCH ON SWIRLING COMBUSTION EFFICIENCY

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**ABSTRACT** This paper describes the experiments of combustion performances in two kinds of swirling augmentor models. The combustion efficiencies and stabilizing limits have been measured. The length of flame have been observed. The experiments of swirling combustion under small swirl angles have been completed, in which the flame could not been stabilized in recirculation zone. Results show that the efficiency of swirling combustion increases approximately 20% in comparison with that of V-flameholder and the length of flame is obviously shortened.