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稳定器对油雾射流穿透深度与最大浓度线的影响

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一、稳定器水平安放时油雾射流的穿透深度与最大浓度线

二元试验段、连续取样的燃气分析系统及实验方法的详细说明见文献〔2、3〕。

稳定器与油雾射流的相对位置如图1所示。在试验段中安装了火焰稳定器之后，使流场发生了改变，火焰稳定器既改变了气流的方向，又改变了气流速度的大小，而且在稳定器截面不同点处气流速度的方向与大小又各不相同，因此对油雾射流的穿透深度和最大浓度线必然产生影响。

在常温下曾试验研究了喷咀直径、喷咀压降、气流速度与喷咀下游距离对油雾射流穿透深度Y_B与最大浓度线Y_{max}的影响，并采用因次分析法得到下列经验关系〔1〕

$$Y_B = Bd_0^{0.4}\Delta P_f^{0.22}V_a^{-1.1}X^{0.33} \quad (1)$$

$$Y_{max} = Ad_0^{0.2}\Delta P_f^{0.1}V_a^{-1.1}X^{0.3} \quad (2)$$

在此基础上又进一步试验研究了稳定器顶角α与径向位置h_0的影响。在稳定器槽宽（45mm）不变时，研究了稳定器顶角的影响。采用顶角40°、槽宽45mm的稳定器研究了径向位置（h_0）变化的影响，所得试验结果分别示于图2，3，4。

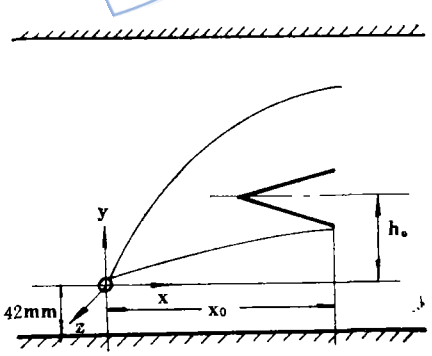

图1 喷咀与稳定器的相对位置

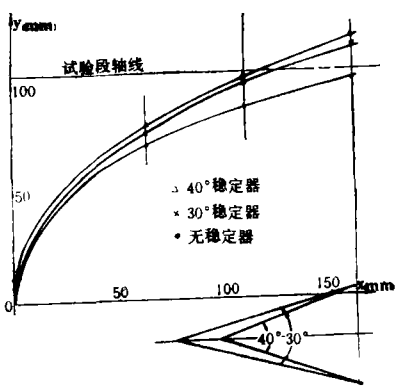

图2 稳定器顶角对最大浓度线的影响

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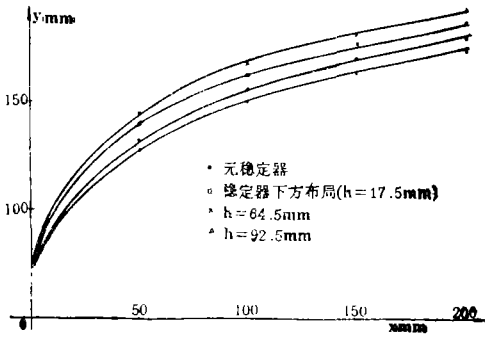

图 3　稳定器水平安放时射流穿透深度随稳定器径向位置变化

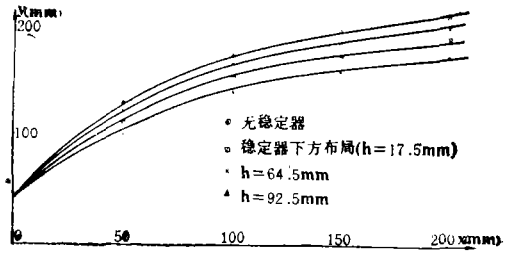

图 4　稳定器水平安放时最大浓度线随稳定器径向位置变化

分别考虑稳定器顶角和径向位置的影响，得：

$$\ln Y_5 = F_5 + e\ln(1+\alpha)\ ,\ \ln Y_6 = F_6 + f\ln(1+h_0)$$

根据图 2、图 3、图 4 所示的试验数据得：$e=1/22$，$f=1/50$。由此得到的包括稳定器顶角和引向位置影响的经验关系为：

$$Y_B = 183 d_0^{0.4} \Delta P_f^{0.22} V_a^{-1.1} X^{0.33} (1+\alpha)^{1/2} (1+h_0)^{1/50} \qquad (3)$$

$$Y_{max} = 602 d_0^{0.2} \Delta P_f^{0.1} V_a^{-1.1} X^{0.3} (1+\alpha)^{1/22} (1+h_0)^{1/50} \qquad (4)$$

由(3)、(4)两式可以看出，随着α和h_0的增大，Y_B和Y_{max}均增大，而且α的影响比h_0的影响大，这点是可以理解的，因随着α的增大，气流流经稳定器时，垂直方向分速增大，故Y_B和Y_{max}的坐标值增大。另一方面可以想象，随着h_0的变化，油雾射流穿透深度不会一直增大。若油雾射流全在稳定器下方时，由于气流流经稳定器产生垂直向下分速，会使油雾射流穿透深度降低。由此可见，由于稳定器的分流作用，油雾射流的穿透深度由增大到降低。试验结果表明，当h_0增大到70mm时，油雾射流穿透深度已开始降低，所以上述经验关系仅在 $0 \leqslant h_0 < 70$mm范围内用于估算油雾射流穿透深度与最大浓度线。

二、稳定器竖直安放时油雾射流穿透深度

油雾射流对着稳定器，即喷咀中心处于稳定器中心剖面上，采用顶角40°、槽宽32、45、80mm三种V型稳定器，喷咀直径0.54mm，在进口气流速度50m/s及常温下利用照相法研究了油雾射流穿透深度沿X轴的变化规律，并与无稳定器的试验结果进行了比较，如图5所示。喷咀下游150mm处油雾射流穿透深度随几何诸塞比的变化示于图6。稳定器竖直安放与水平放相比，油雾射流穿透深度有明显不同。竖直安放时，油雾射流穿透深度随稳定器堵塞比增加而增大。主要原因是：当稳定器槽宽加大时，流经稳定器的气流向两侧偏转，速度增大，使对着稳定器的中心区域形成低速区。稳定器槽宽加大，低速区扩大，气动阻力减小，油雾射流穿透深度增大。

同样，由试验数据得到下列经验关系

$$Y_B = 655 d_0^{0.4} \Delta P_f^{0.22} V_a^{-1.1} B_g^{0.13} \qquad (5)$$

式中B_g为稳定器几何堵塞比

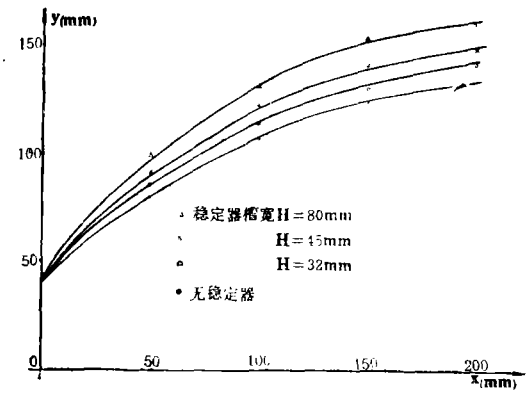

图5 稳定器竖直安放时油雾射流穿透深度随X变化

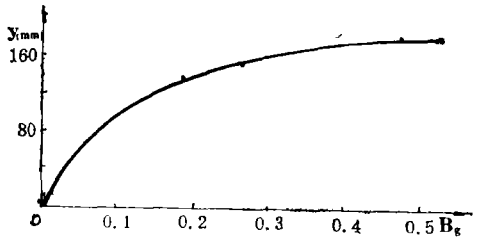

图6 稳定器竖直安放时油雾射流穿透深度随堵塞比变化（X=150）mm

这些试验结果表明，不同的喷油方向与稳定器匹配时，稳定器对油雾射流穿透深度产生的影响明显不同，从而产生不同的燃油浓度场，因此在设计加力燃烧室喷油系统以及燃油浓度场的计算模型中，应考虑喷油与稳定器的相对位置及稳定器的几何特性对油雾射流穿透深度与最大浓度线的影响。

三、讨 论

根据文献〔1〕的研究，直射式喷咀跨流喷射时，喷咀下游的浓度锥呈不对称的头盔形，y向燃油浓度分布是不对称的，z向燃油浓度分布呈正态分布，油雾射流穿透深度与最大浓度线是描述燃油浓度场特征的重要参数，以最大浓度线为界，其上方的积分燃油量约占喷咀总流量的40%，下方的积分燃油量约占60%。因此，知道了油雾射流的穿透深度与最大浓度线，就可知道燃油浓度分布的概况和油雾射流相对于稳定器的位置。由此可见，试验研究稳定器的几何特性对油雾射流穿透深度和最大浓度线的影响有实际意义。

在设计加力燃烧室喷油系统时，若采用直射式喷咀跨流喷射的方式，可利用上述经验关系初步估算每个喷咀燃油浓度分布的概况及其相对于稳定器的位置，检查喷油布局是否合理。对于已有的发动机，知道了喷油布局和工作参数，也可用它估算燃油浓度分布与稳定器匹配的概况，这有助于燃烧性能的分析。

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AN EXPERIMENTAL INVESTIGATION OF FORCED SURGE BY WATER INJECTION IN A TWIN-SPOOL TURBOJET ENGINE

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Abstract

An experimental investigation of forced surge by water injection in a twin-spool turbojet engine has been performed on the ground thrust bed. It is demonstrated that water injection into the main combustion chamber coupled with the flow area scale-down of both turbine nozzle and jet nozzle is satisfactory for the test. An optimum scale-down percentage of both areas was found from a large number of tests.

During such combined forced surge process, the engine operating condition can approach the surging boundary accurately along the line of the corrected constant rotation speed. Hence, exact stable operating margin as well as stable operating boundary for the compressor can be obtained.

A DATA AQUISITION AND PROCESSING SYSTEM FOR SMALL WIND TUNNEL TESTING

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Abstract

This paper presents a data aquisition and processing system designed and adapted to small wind tunnels for testing simulation models. For convenience and efficiency a remote control subsystem is especially designed for communication between the computer and the testing site. The relevant data aquisition and processing software package has been composed. Actual operation of this system shows that its performance is satisfactory. This system can process a data collection of 5x50 messages in 10 different conditions in only a few minutes.

EFFECTS OF FLAMEHOLDER GEOMETRY ON PENETRATION AND MAXIMUM CONCENTRATION LINE OF FUEL SPRAY

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Abstract

The penetration and the maximum concentration line of fuel spray are very

important for designing afterburner. The effects of airstream velocity, pressure drop across the orifice of fuel ejector and diameter of fuel ejector on the penetration and the maximum concentration lion of fuel spray have been studied. When the flameholder is mounted in the test section, both the direction of flow and the magnitude of velocity vary consequently. It is necessary to consider the contribution of these factors to the fuel distribution. Therefore the effects of vertex angle and position of the flameholder on the penetration and maximum concentration line of fuel spray are further investigated experimentally. The expirical formulas are obtained from the test results.

NUMERICAL RESEARCH OF TURBULENT FLOWS IN A CYLINDRICAL COMBUSTOR

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Abstract

A two-dimensional transient finite difference technique has developed to predict recirculation zones behind bluff body flameholder in a cylindrical combustor. For turbulent flow simulation, the two-equation k-ε turbulent model has been comprised in a simple computer program. The governing equations consist of continuity equation, momentum equation, turbulent kinetic energy equation and turbulent kinetic energy dissipation rate equation. The calculations show that the dimensionless length L/d of recirculation zones and the maximum mass flow rate Mr/Mo increase with the flameholder cone angle α. The results are in fair agreement with experimental data. Therefore, the transient time-marching method employed in this paper is quite simple and reasonable.