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高密度喷气燃料和常规燃料的油雾场对比试验研究

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【摘要】　本文利用脉冲激光全息技术测量了直流喷嘴侧喷下游的高密度喷气燃料和常规喷气燃料的油雾场。获得了各种油滴直径，索太尔平均直径及燃油浓度的空间分布规律，讨论了气流速度、燃油出口压降对油雾场的影响，并对两种燃料的油雾场进行了比较。

关键词:　高密度喷气燃料　油雾场　试验研究

1　前　言

在国外早已应用高密度喷气燃料作为提高导弹射程的手段[1]，直流喷嘴用常规喷气燃料在高速气流中侧喷雾化特性也已被研究[2]。本文采用常温下密度为 0.9g/cm^3 的高密度喷气燃料在直流喷嘴于高速气流中侧喷，利用脉冲激光全息技术，对喷嘴下游 100– 160mm 处油雾场分布进行了研究，并与相同条件下常规喷气燃料的油雾场进行了比较，为燃烧室内部燃料喷嘴的设计提供了依据。

2　油滴直径的分布

图 1 是直流喷嘴侧喷坐标示意图。图 2 是高密度喷气燃料和常规喷气燃料的油滴直径的频谱分布图。从图中可以看出，在气流速度为 90m/s 时，两种燃料的油滴直径变化范围在 10～90μm 之间，高密度喷气燃料的频谱曲线往大油滴直径方向偏移。这是由于高密度喷气燃料的表面张力较大，使得液柱破碎差，造成其雾化效果不如常规喷气燃料。

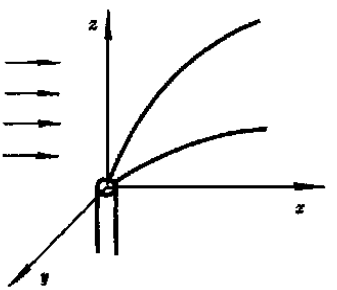

图 1　直流喷嘴侧喷坐标示意

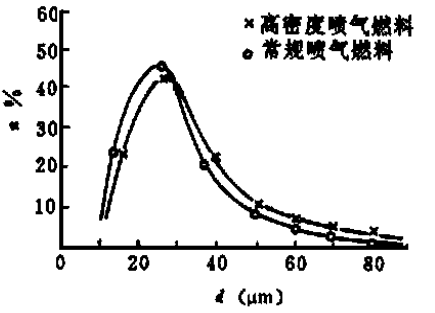

图 2　两种燃料油滴频谱（V_a= 90m/s，P_f= 9.8×10^{5}Pa，x= 130mm）

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3　气流速度、燃油出口压力对油滴平均直径 *SMD* 的影响

3.1　SMD 与外界因素的关系

由图 3、4 可见，气流速度增大，SMD 明显下降，雾化质量变好。油压较低时，油压提高，

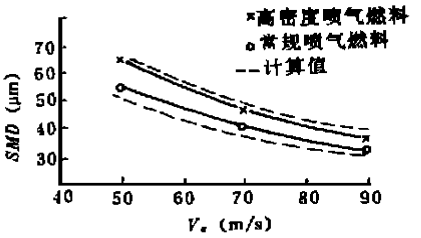

图 3　气流速度对 SMD 影响

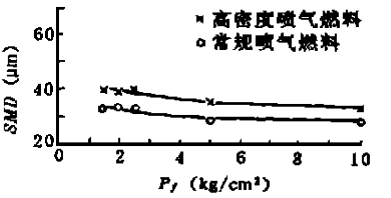

图 4　油滴直径的空间分布

SMD 下降，而油压较高时，油压的变化对 SMD 的影响不明显。从图 3、4 可见高密度喷气燃料的雾化质量比常规喷气燃料差一些。

3.2　SMD 的经验公式

由试验数据的分析得到常温和常压下气流速度和燃油压降对雾化特性影响的关系式:

高密度喷气燃料 $SMD = 1190\bar{V}_a^A \bar{P}_f^B$

$$A = -0.72 - 0.001\bar{P}_f \quad , \quad B = 0.068 - 0.002\bar{V}_a$$

常规喷气燃料 $SMD = 5890\bar{V}_a^A \bar{P}_f^B$

$$A = -1.11 - 0.0086\bar{P}_f \quad , \quad B = -0.41 + 0.0044\bar{V}_a$$

式中 $\bar{V}_a = V_a / 1\ (m/s)$。$\bar{P}_f = P_f / 10^5\ (Pa)$。本公式适用范围为 $50m/s \leq V_a \leq 90m/s$，$P_f \leq 9.8 \times 10^5 Pa$，$d = 0.4mm$，$x = 130mm$。从图 3 可见由经验公式计算的 SMD 曲线和试验曲线很接近。

4　油滴频谱的空间分布

图 5 中把油滴群中的油滴分成几个组，某一组油滴的空间分布定义为当地这一组的油滴

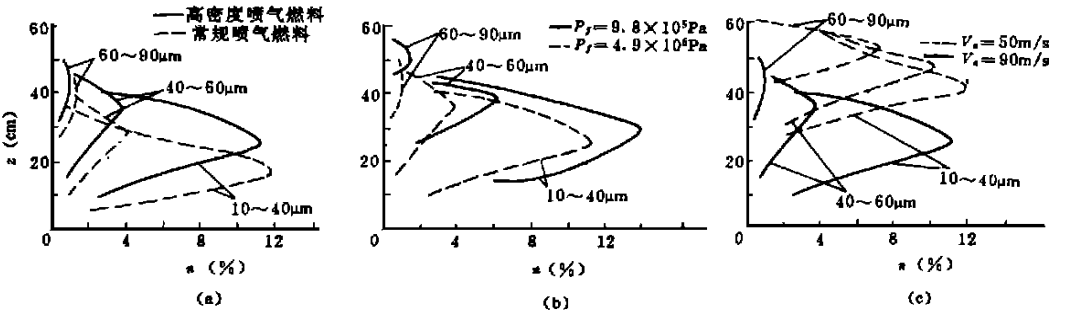

图 5　油滴直径的空间分布

数与油雾群总油滴数之比。从图 5*a* 和 *b* 可知在相同工况下，高密度喷气燃料各组油滴群最大值的空间 z 坐标比常规喷气燃料的大些，这说明其的穿透深度较大。从图 5b 和 c 可知随着油压增加，高密度喷气燃料油滴群各组峰值向 z 坐标增大方向移动。当气流速度降低时高密度喷

气燃料油滴群各组穿透深度增加，大油珠增多。

5 油滴平均直径 SMD 的空间分布

从图 6 可知随着离喷嘴距离加大，油滴的 SMD 明显增大。在 z 坐标较小处，SMD 增加缓慢，在 z 坐标较大处，油滴的 SMD 迅速增大。两种燃料分布是相似的。

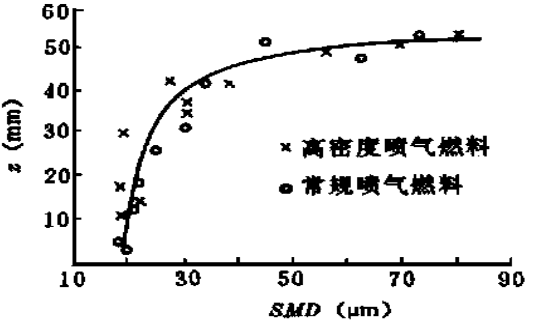

图 6 SMD 在 z 向分布

6 燃油浓度场

油雾场中某一点浓度（即燃油百分比）定义为这一空间的燃油量与所在截面燃油总量之比。限于篇幅只研究最大燃油浓度点的变化。从图 7 可知最大燃油浓度点随速度变化是一条直线。在低速度时高密度喷气燃料的最大浓度线更向 z 增大方向偏离，这主要是由于气动力减小后，燃油表面张力的影响加强了。从

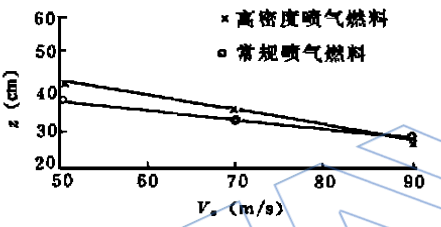

图 7 最大燃油浓度点随速度的变化

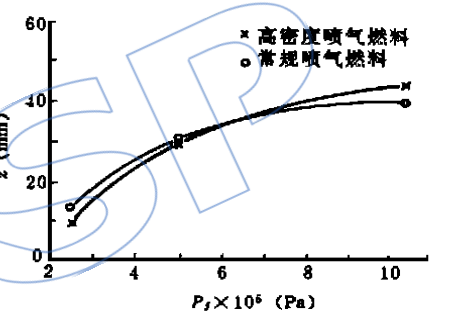

图 8 最大燃油浓度点随压力的变化

图 8 可知在油压较低时高密度喷气燃料最大浓度线比常规喷气燃料的最大浓度线更向 z 较小的方向偏离，而当油压较高时，z 较大的方向偏离。

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has obtained with the kerosene coolant through an even-heated straight tube, and relation between the heat transfer cooling of kerosene and water has been determined in the case of the vapor-liquid two-phase boiling flow. The key problem of the kerosene used as coolant is "coking property" and instability of wall temperature. However, it does happen in some particular working conditions, but the working conditions can be regulated with an empirical formula for the initial point annular flow Z_N to eliminate the coking zones. The Several useful conclusions have been drawn for the cooling passage of turbine vane.

STUDY ON FLOW CHARACTERISTICS OF SEPARATED IMPINGEMENT JETS AT SHORT DISTANCE

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ABSTRACT In conventional practice a row of separated circular jets is used in turbine blade or vane for impingement cooling and the relative distance z_n/d_n is very small ($z_n/d_n \leq 2$). In this case, study on longitudinal uniformity of the cooling on the surface of the blade or vane is necessary. In our experiments, the uniformity of the velocity distribution at large relative distance ($z_n/d_n > 10$) is achieved by free jet in atmosphere, but the distribution of jet velocity is rapidly uniformized when the jets srtike against the target surface and flow along the surface. The reason of the uniformization is the turbulence mixing and the effect of pressure difference. This work contributes to good understanding for uniformization of cooling on the surface of the blade or vane.

COMPARATIVE EXPERIMENTAL RESEARCH ON SPRAY FIELDS OF HEAVY AND CONVENTIONAL AVIATION KEROSENE

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ABSTRACT Laser holography was used to measure the fuel spray characteristics of heavy jet kerosene and conventional aviation kerosene downstream after a simple orifice injector. The spatial distribution of droplet size and Sauter Mean Diameters (SMD) for two kinds of kerosene have been obtained and compared. In this paper, the effects of air velocity and pressure drop on the fuel spray field are considered. The following conclusions are drawn from the experimental data: 1. The magnitude and distribution of droplet size are determined by the air velocity. 2. The SMD for the two fuels are, to some extent, related to the fuel pressure. 3. The variation of the fuel pressure has less influence on the SMD of the two fuels. 4. The empirical formulas are provided for evaluating the effects of the air velocity and the fuel pressure on the SMD.

RESEARCH ON WZ-5 TURBOSHAFT ENGINE WITH A REBUILT HIGH- TEMPERATURE TURBINE

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ABSTRACT A WZ-5 turboshaft engine has been modified with a rebuilt high-temperature turbine as a ground power plant. The engine can make full use of its turbine inlet temperature through varying areas of both gas generator turbine and power turbine nozzles and reduce the rotor speed, thus a sufficient surge margin is provided and the output shaft