第4卷　第3期　　　　航空动力学报　　　　Vol. 4　No. 3
1989年　7月　　Journal of Aerospace Power　　July　1989

紊流度测点少时最大瞬时畸变值预估

南京航空学院　　梁德旺　张世英

在已有的最大瞬时畸变值的预估方法中，几乎都要求输入各测点脉动压力的均方根值[1,2,3]。然而，在工程实际中，特别是选型阶段的小模型，由于实验模型限制了安装动态传感器的数量，或因为动态测量系统的复杂性及设备费用高等原因，所测得紊流度数据较少。此时，不可能直接用上述文献中介绍的方法来预估最大瞬时畸变值。本文的目的则是要解决紊流度测点较少时最大瞬时畸变值的预估问题。

文献［4］已表明，紊流度测点布置必须满足径向至少3个测点，周向至少4个测点，所测得的平均紊流度及紊流度的平方平均值基本真实地反映了所测流场的真实值。因此可用来预估最大瞬时畸变值。

本文利用文献［1］所介绍的最大瞬时畸变值预估方法，将各种紊流度分布数据下获得的瞬时畸变的时均值、均方根值及最大值与具有相同平均紊流度值，且各点紊流度值相等时获得的瞬时畸变的时均值、均方根值及最大值进行了比较，并归纳出了它们之间的关系式。从而提出了紊流度测点较少时用其平均紊流度来预估最大瞬时畸变值的方法。文中最后用实验数据对用平均紊流度来预估获得的最大瞬时畸变值进行了验证。

用平均紊流度预估最大瞬时畸变值是令各测点紊流度值相等去估算最大瞬时畸变值。

1. **瞬时畸变的时均值、均方根值及最大值的关系**　图1给出了瞬时畸变的时均值和均方根值的关系曲线。图中 $\bar{T}_*$ 为平均紊流度，$\bar{K}$、σ_K 分别为用文献［1］估算方法获得的瞬时畸变的时均值和均方根值，$\bar{K}'$、σ'_K 则为按文献［1］估算方法用平均紊流度方法预估得到的瞬时畸变的时均值和均方根值。图中所用原始数据为 $\bar{T}_*=0.0063\sim0.0492$，$\sqrt{\bar{T_*^2}}=0.0081\sim0.0521$，稳态压力畸变 $K_\theta=0.0118\sim0.7355$，$K_{RAD}=0.0318\sim0.4577$，$K_{A2}=0.1051\sim0.8354$。由图可见，虽然用平均紊流度获得的瞬时畸变的各参数与用不同紊流度分布获得的瞬时畸变的各参数不等，但它们之间有一定的联系。经最小二乘法拟合可得

$$(\bar{K}-K_{st})\bar{T}_* = (\bar{K}'-K_{st})\sqrt{\bar{T_*^2}} \tag{1}$$

$$\sigma'_K\bar{T}_* = \sigma_K\sqrt{\bar{T_*^2}} \tag{2}$$

由文献［1］可知，最大瞬时畸变值与瞬时畸变的时均值、均方根值的关系为

$$K_{max} = \bar{K} + C\sigma_K \tag{3}$$

其中系数 C 为与估算时间和采样频率有关的常数。将式（1）、（2）代入式（3），并考虑到

$$K'_{max} = \bar{K}' + C\sigma'_K \tag{4}$$

可得

$$(K'_{max}-K_{st})\sqrt{\bar{T_*^2}} = (K_{max}-K_{st})\bar{T}_* \tag{5}$$

本文于1989年1月收到。

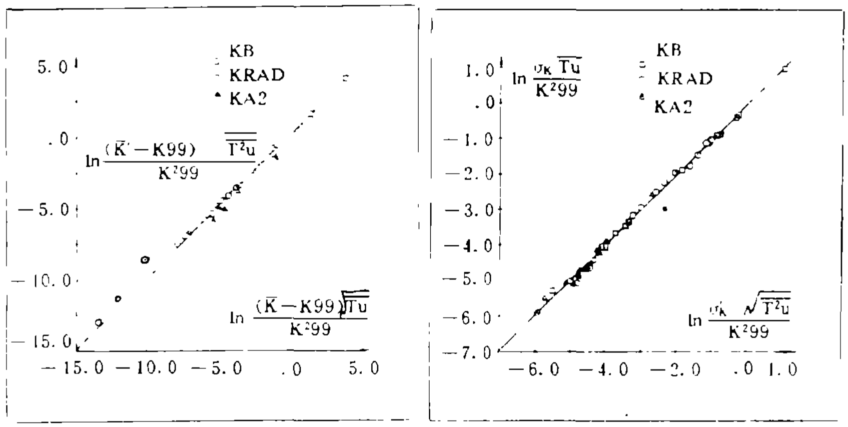

图1　a: 瞬时畸变的时均值的关系曲线　b: 瞬时畸变的均方根值的关系曲线

2. **最大瞬时畸变值的预估**　从上面的讨论可知，可以用平均紊流度方法获得的瞬时畸变各参数求按紊流度分布的瞬时畸变的各对应参数，或反之。用前者获得的最大瞬时畸变值求得后者将获得的最大值 K''_{max}应为：

$$K''_{max} = K_{ss} + (K''_{max} - K_{ss})\sqrt{\overline{T_u^2}}/\overline{T}_u \qquad (6)$$

图2比较了用本方法得到的最大值 K''_{max}和实验测得的最大值（K_{max}）$_m$ 和直接由紊流度分法用文献［1］预估方法获得的最大值 K_{max}。由图可见，K''_{max}与 K_{max}吻合很好。

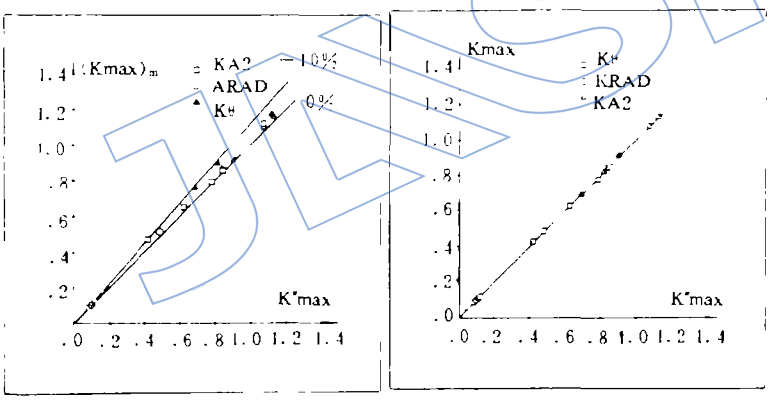

图2　最大瞬时畸变值的比较

由前面的讨论可见，当紊流度测点较少时，可根据其测得的平均紊流度，并令各点紊流度值为其平均紊流度值，用文献［1］方法去估算最大瞬时畸变值，然后利用式（6）进行修正。（图2）表明，这时的估算精度与用多点紊流度分布的预估精度是相当的。

参　考　文　献

［1］　Liang D. W., Zhang S. Y., "The Estimation of the Maximum Instantaneous Distortion from Inlet Total Pressure and RMS Measurements", AIAA paper 89-2470.

［2］　Melick H. C., Ybarra A. H. and Bencge D. P., "Estimating Maximun Instantaneous Distortion from Inlet Total Pressure RMS and PSD Measurements", AIAA 75-1213.

［3］　Motycka D. L. "Determination of Maximun Expected Instantaneous Distortion Patterns from Statistical Properties of Inlet Pressure Data",, AIAA 76-705.

［4］　梁德旺，张世英．"测点的布置对紊流度测量的影响"，南京航空学院学报（待发表）。

FLIGHT TESTS FOR AIR INTAKE FLOWFIELD AND ENGINE OPERATING STABILITY

Lun Yiyun *(Shenyang Aeroengine Research Institute)*

ABSTRACT The operating compatibility between air intake and engine during the flight tests of a supersonic fighter is considered. The flight tests were completed under conditions of horizontal accelerating flight, uprated and retarded throttles of the engine during horizontal flight and constant-Mach climbing with maximum and augmented thrust rating. The flow conditions at the intake and the tendency of flowfield variation at the inlet of the engine were evaluated by means of six pressure tappings at the variable intake cone and a cross rake pressure probe at the exit of the intake. The technical measures have been taken to cope with the engine troubles and their effects are also described in the paper.

ESTIMATION OF MAXIMUM INSTANTANEOUS DISTORTION WITH A FEW RMS MEASUREMENTS

Liang Dewang and Zhang Shiying

(Nanjing Aeronautical Institute)

ABSTRACT A method for estimating the maximum instantaneous distortion with a few measured RMS values of the fluctuation pressures is presented based on reference[1]. This method enables to estimate the maximum instantaneous distortion value by assuming that the turbulence distribution is uniform and equal to the average value of s few measured RMS values. A comparison between the maximum instantaneous distortion values measured experimentally and estimated by this method shows that the maximum instantaneous distortion can be estimated by the average value of a few measured RMS values of the fluctuation pressure with the same accuracy as that obtained by the method in reference [1].

OPTIMUM DESIGN FOR GEOMETRIC PARAM ETERS OF AXISYMMETRIC CONVERGING-DIVERGING NOZZLE

Zen Jun and Zhao Jingyun

(Gas Turbine Establishment)

ABSTRACT A mathematical model of a axisymmetric converging-diverging nozzle in design conditions is set up by quadratic-regression equation. The thrust force coefficient is taken as objective function. The three geometric parameters (half-convergent angle, half-divergent angle, radius ratio of throat curvature to throat) are chosen as design variables. The optimum design is completed by the random-walk method. Then the relationships of the optimum geometric parameters to the designed pressure ratio of the nozzle are obtained. The results provide the basis for designing the axisymmetric convergent-divergent nozzle of an exhaust system.