进气道总压恢复和出口流场试验研究

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一、试验对象和测量装置

试验在某型飞机上进行，飞机进气锥按Ma数变化进行无级调节，进气道两侧距唇口约1.5m处各有一放气门，距唇口约5.7m处各有一风戽式辅助进气门（Ma＞1.4自动关闭）。

为了测取左进气道出口总压和流场图谱，在压气机进口装有一米字耙，每支耙上有六个按等环面分布的总压测点，在壁面上有四个均匀分布的静压测点。

试飞由DAM-Ⅱ磁记录系统记录，经电子计算机处理。

二、试验结果与分析

1. 进气道总压恢复特性

当飞行Ma数和中心锥位置给定时，进气道流量系数Φ的变化范围受到发动机工作状态的限制，而发动机工作状态的变化只能籍助改变发动机的工作转速和飞行高度H来实现。在飞行Ma≥1.5时，不允许将发动机油门收到转速小于97%的位置。因此，在飞行试验中要得到完整的总压恢复特性，几乎是不可能的。但相对来说，跨音速范围的总压恢复特性曲线还稍宽些。

我们利用试验机装有两台发动机这一有利条件，将一台推到最大或加力状态以保持飞行速度，另一台逐步收油门来改变共同工作点的位置，从而得出进气道特性曲线。

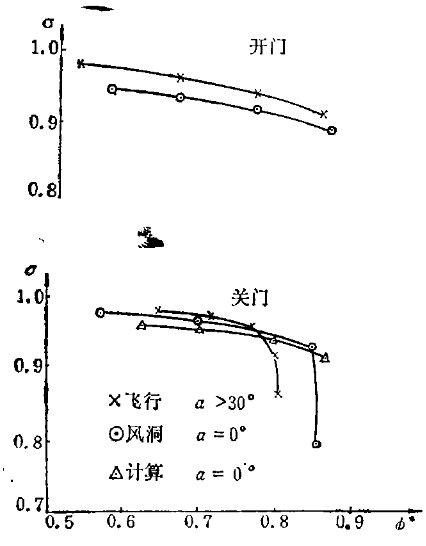

图1　进气道特性（Ma＝0.98，ΔL＝0）

由图1可见：（1）无论辅助进气门是打开还是关闭，在Ma数相同、攻角接近的情况下，当进气道未进入超临界工作时，同一流量系数Φ的飞行总压恢复系数σ比风洞试验结果和计算结果稍高或相当。（2）飞行的临界流量系数比计算结果和风洞试验结果均小。

2. 进气道与发动机共同工作时总压恢复系数σ、畸变指数$\overline{D}$随Ma数的变化。

图2为飞机在11000m高度，发动机以加力状态工作、辅助进气门分别在打开和关闭情况下进气道性能参数随Ma数的变化。在Ma＜1.4，辅助进气门关闭时，随着Ma数增加总压恢复系

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数增加，畸变指数$\overline{D}=(P^*_{1max}(-P^*_{1min})/P^*_{1Ps})$下降。因为，在Ma<1.4，辅助进气门关闭时，进气道处于较重的超临界工作状态，随着Ma数增加，超临界程度减弱，致使总压恢复系数增加，畸变指数$\overline{D}$下降；当飞行Ma数进一步增加，将使头部波系损失增加，从而使总压恢复系数下降。

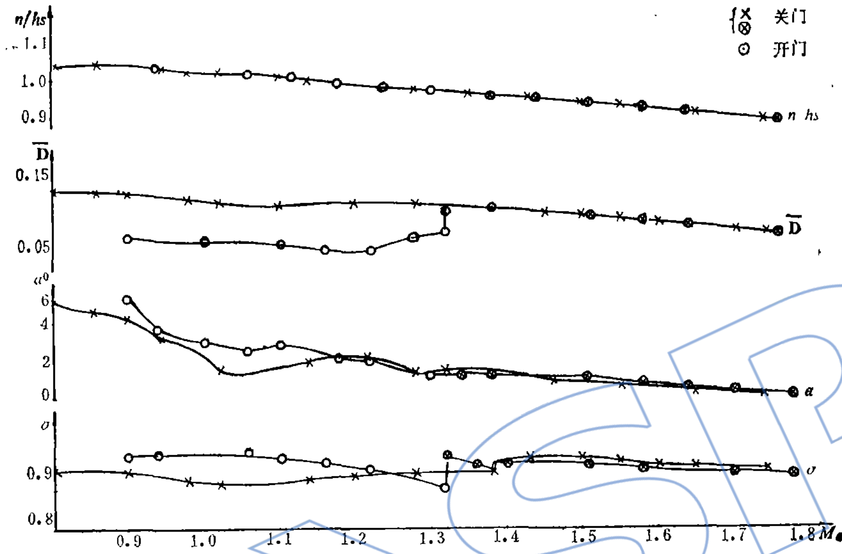
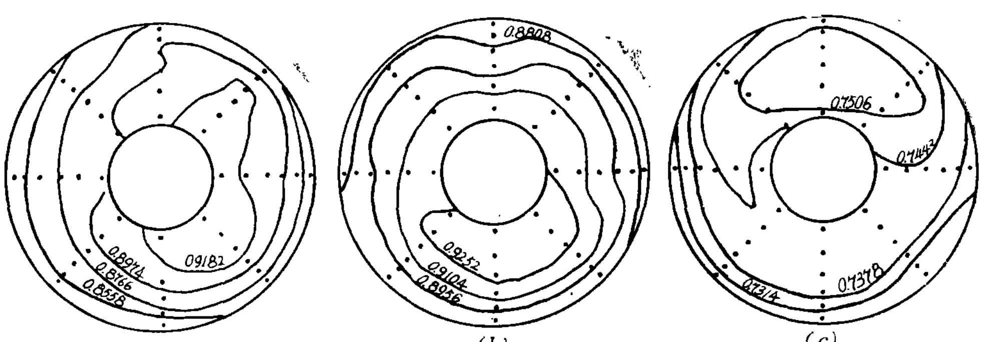


图2　平飞加速时进气道参数变化

打开辅助进气门平飞加速时，飞行Ma数增加到1.2附近，进气道的总压恢复系数σ明显下降，畸变指数$\overline{D}$明显上升。因为飞行Ma数增加到1.2以后，进气道开始进入超临界状态工作。Ma = 1.32辅助进气门关闭，总压恢复系数σ和畸变指数$\overline{D}$均突增到关门的状态。

3. 进气道出口截面畸变图谱

分析进气道出口流场除用畸变指数外，还用压气机进口平面总压分布图。该分布图用于确定进气道出口的低能气流区，直观地反映了进气道出口的压力分布情况。图3(a)为跨音速飞行时的典型图谱（Ma = 0.9573，H = 11052m，N_{1HS} = 1.026，α = 3.27°），高压区在右侧靠内支承环，低压区在左侧靠外环。超音速飞行时，高压区移到下方靠内支承环，低压区仍靠



(a)　(b)　(c)

图3　进气道出口流谱（逆航向看）

外环，但位置移到上侧和右侧，见图3(b)（Ma = 1.5801，H = 10828m，N_{1HS} = 0.903，α = 0.6°）。而在H = 17043m、Ma ≥2以后，高压区移到上方，低压区移到下方靠外环，见图3(c)（Ma = 2.197，N_{1HS} = 0.862，α = 1.67°）。

图4为打开辅助进气门时的图谱（Ma = 0.9575，H = 11252m，N_{1HS} = 1.033，α = 3.50°）。由于辅助进气门离进气道出口较近，从辅助进气门进入的低能气流占据了右侧中间部分，使右侧原来的高压区转移到左下侧的内外环之间，低压区在左侧靠外环。

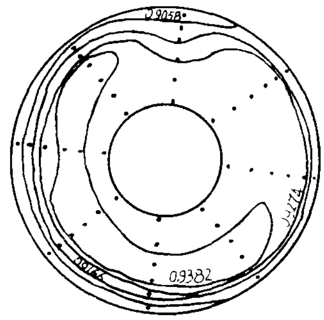


图4 开门时流谱（逆航向看）

由于飞行试验与风洞试验的状态不能完全对应。因此，比较时只能选取较接近的状态，根据风洞试验结果，在同一状态和同一Ma数时，出口流场总压分布基本与流量系数无关[1]。因此我们将关门时Ma = 0.75出口截面图谱（α = 8.31°，Φ^* = 0.8624，σ = 0.9058，$\overline{D}$ = 0.1324）与风洞试验结果（Ma = 0.754，α = 9°，Φ^* = 0.8516，σ = 0.8894，$\overline{D}$ = 0.146）进行了比较。从图5可见，在跨音速关门飞行时，相近的Ma数对应的总压分布图的形状基本上是相似的，高、低压区的位置也基本对应，中间部位由于发动机整流帽罩的影响而略有差别。

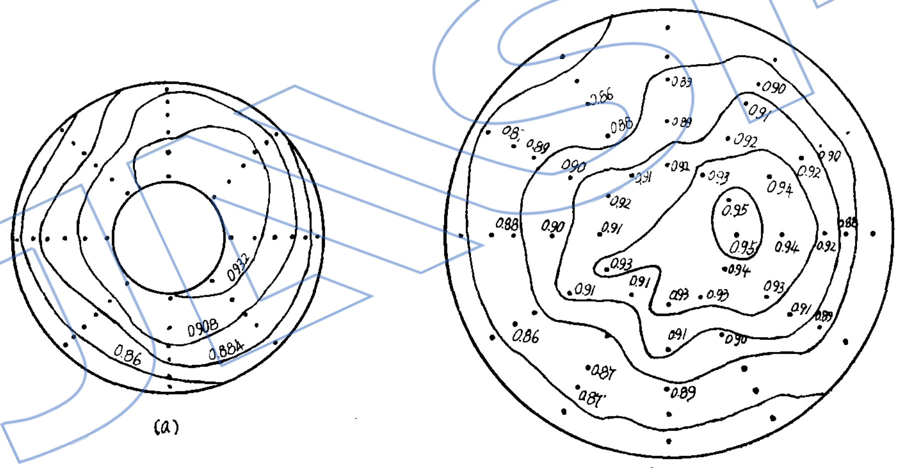


图5 飞行图谱(a)与风洞试验图谱(b)比较

三、结 论

1. 跨音速飞行当进气道未进入超临界工作时，对同一Ma数飞行的总压恢复系数σ比风洞试验结果和计算结果稍高。

2. 飞行的临界流量系数比计算结果和风洞试验结果要小。

3. 发动机以加力状态，辅助进气门关闭平飞加速时，畸变指数$\overline{D}$随飞行Ma数增加而下降，Ma>1.5后，总压恢复系数也随Ma增加而下降。

4. 在跨音速飞行时进气道出口总压分布在试验范围内基本与飞行Ma数无关。而超音速飞行时进气道出口总压分布与飞行Ma数有关。

5. 跨音速关门飞行时，进气道出口流谱与风洞试验结果基本一致。

of the temperature field in the combustion chamber meets the essential requirements and provides smooth combustion with the transparent light blue flame. The temperature of the flame tube wall is permissible. The main combustion chamber is actuated and ignited by the torch ignitors with natural gas as fuel.

TECHNICAL NOTES

RANDOM VERTEX METHOD AND SIMULATION OF VORTEX STRUCTURE BEHIND A TRIANGULAR PRISM

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Zhu Huiling, Tang Ming

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Abstract

In this paper, the flow passing a triangular prism has been calculated by random vertex method. In order to eliminate the oscillation of the tangential velocity at the prism surface, a coefficient Kw is introduced, which is used to consider the interaction of newly generated vortex blobs at the surface. The idea of so called "gravity blob" is proposed to save the CPU time in running the program for simulation of vortex structure behind the triangular prism. The essential features of the large-scale vortex structure in the recirculation region and Karman vortex street downstream are clearly shown in the figures of vortex blob distribution obtained from calculations.

A FLIGHT-TEST STUDY ON THE TOTAL PRESSURE RECOVERY AND EXIT FLOW FIELD IN AN INLET

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Abstract

A flight-test study on the total pressure recovery and the exit flow field in an inlet of a supersonic jet aircraft is presented. The total pressure recovery characteristics and the exit total pressure distortion patterns in the transonic flight are given. The variation of the total pressure recovery coefficient and the distortion factor with Mach number during inlet-engine matching is illustra-

ted. The flighttest study provides valuable data for research on inlet-engine compatibility.

EFFECT OF WAKE-TYPE INLET VELOCITY PROFILES ON PERFORMANCE OF SUBSONIC DIFFUSER

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Abstract

The paper discusses the experimental investigation on subsonic diffuser. When in the front of the subsonic two-dimensional diffuser an elliptic bar is placed perpendicular to the flow stream and parallel to the diverging wall of the diffuser, the wake-type inlet velocity profile is created and the core-stream turbulence level at the entrance of the diffuser is increased, which results in flatter velocity profile implying an increase in momentum transport across the boundary layer. The value of the boundary layer shape factor is therefore decreased. Consequently, the flow separation is delayed and the separation range is reduced. As a result, the static and the total pressure recovery coefficients of the diffuser rise by 30% and by 3% respectively when the maximum Mach number of the diffuser inlet reaches 0.7.

A METHOD FOR MEASURING TWO-DIMENSIONAL UNSTEADY FLOW VELOCITY WITH X-HOT-WIRE PROBES

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Abstract

A method is presented for measuring two-dimensional unsteady flow velocities with X-hot-wire probes. Based on the well-known calibration law incorporated with the yaw angle correction function $f(\theta)=\cos^m\theta$, the magnitude and the direction of the velocity are determined. The applicable range for this method and the errors caused by variation of parameter m with flow angles and velocities are also discussed. Since no approximation is introduced in the calculation, the accuracy of measurement is enhanced. This method can be employed where the magnitudes and the directions of the velocities vary to a great extent. Moreover, the formula provided is simple to use.