

一种爆膜式动压测量校准系统

空军工程学院 江 勇**

【摘要】 研制了一种结构简单的爆膜式动态压力测量的校准系统, 用于频响不大于 1 kHz 的动态压力测量系统的动态特性校准。实验表明: 其信号发生器能够产生足够的频率成份用于激励; 系统只需一次实验便可得到被校系统的频响特性, 方法简便。

主题词: 动压力 传感器 校正
分类号: TK312

测取压力的动态变化过程时, 气流温度高于 200℃或安装空间所限需用测压探针引出气流压力时, 由于探针的“管腔效应”, 整个系统的频响特性难以确定。因此需在动态测量之前先对测压系统进行动态校准, 以判定系统的频响范围能否满足使用要求。周期型压力信号发生器通常适用于低频。激波管类压力信号发生器产生的阶跃信号其“平台时间”最大不超过 8 μ s, 仅适用于高频响的压力传感器。频响几百至一千 Hz 的测压系统的动校目前还没有简单有效的方法。本文介绍了一种爆膜式动压测量校准系统。用于动校频响在 1000 Hz 以下的动态压力测量系统。经性能测定和校准实验表明: 方法实用、简便。

1 爆膜式动压信号发生器

一种压力阶跃“平台时间”无限长, 适用于上限频率为 1500 Hz 的测压系统的爆膜式动态压力信号发生器如图 1。底盖压紧一个薄膜, 不同强度的薄膜可产生不同的破膜压力阶跃信号。多种组合的内衬套形成不同的内腔长度, 以产生不同的腔内压力振荡频率。顶盖上可安装一只高频响微型压力传感器, 它的输出可看成是不失真的压力激励信号。在同一截面上, 并排安装了另一个被校测压系统的 CYG-01 压阻式压力传感器, 该处也可安装被校测压探针等。

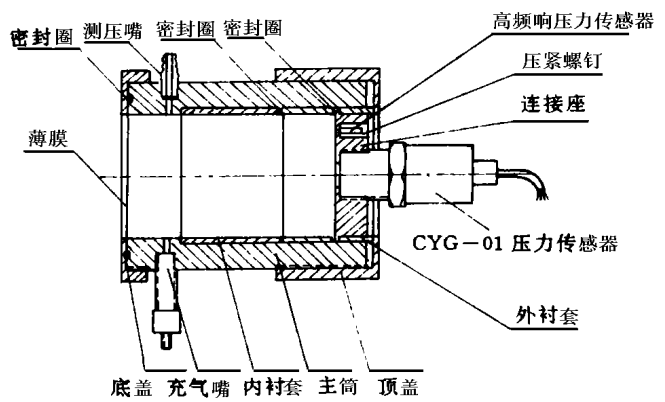


图 1 爆膜式动态压力信号发生器

向信号发生器充压, 发生器因高压破膜时, 管口压力波以音速向内传

播。当管长 $L \ll$ 波长时,管内压力分布可忽略不计,即管内每一截面上的压力可以认为是相等的。忽略气体的可压缩性影响,引用“1/4 波长”公式。通常在估算频响范围时只考虑第一阶振荡频率,故有 $f_n = c/4L$, c 为音速, L 为管内腔有效长度。校准用压力波峰值频率可在 500–1500 Hz 范围调整,故经计算,管腔长度取为 20–120 mm。

2 实验研究

破膜压力约 50 kPa(表压),一只 XCQ–093–50D 型微型压力传感器(频响超过 100 kHz)测取爆膜式压力信号发生器产生的压力信号,在几种不同信号发生器管腔长度上记录其破膜后的压力信号,然后进行频谱分析,得到幅值谱,如图 2 所示(P_0 为破膜压力)。管腔长度

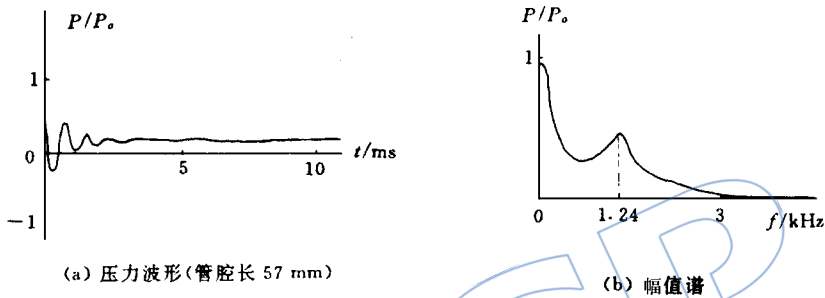


图 2 压力波形及其幅值谱

增加,幅值峰值频率减小,振荡时间增加,数据见表 1。

表 1 不同管腔长度对应的峰值频率

管腔长(mm)	37	57	77	97	120	140
幅值谱峰值频率(kHz)	1.56	1.24	0.92	0.76	0.68	0.522

经试验信号发生器产生的压力信号峰值频率在 0.522–1.56 kHz 之间,可分档调节,与设计值 0.50–1.50 kHz 基本吻合。在峰值以下的频率范围内,幅值足够大,说明信号发生器用作激励源是合适的。同时,信号发生器产生的信号在共振频率以上仍有显著的幅值,仍可供校准之用。在最短管腔时,可用频率大于 3 kHz,满足带探针测压系统的动校要求。

用 3 种不同长度的压力探针配以 CYG–01 压阻式压力传感器,在两种信号发生器空腔长度下进行了校准实验。第一步仍用 1 只 Kulite 高频响压力传感器测量被校探针的输入波形,与 CYG–01 的输出做波形的传递函数,得到被校系统的幅频和相频特性,图 3 示出了一组实验得到的时域波形和频谱特性。在两种信号发生器管腔长度爆膜激励下,被校系统的共振峰值完全相同,且十分明显,从 0 至 2/3 峰值频率范围有基本平坦的幅频特性,相频特性基本呈线性,因此,被校系统不失真测量频率范围上限为共振频率的 2/3。

仔细分析被校系统可知:高于其共振频率的激励频率成份变化基本上不影响频谱分析的结果,因此用理想矩形波代替实际的激励作为探针的输入波形,得到的频谱分析结果应相同(对共振峰值以下)。可以只记录被校系统的响应波形,用软件产生一个矩形波作激励信号,然后求其幅频和相频特性,使校准变得十分简易。图 3 亦示出了单传感器测量得到的频率特性,

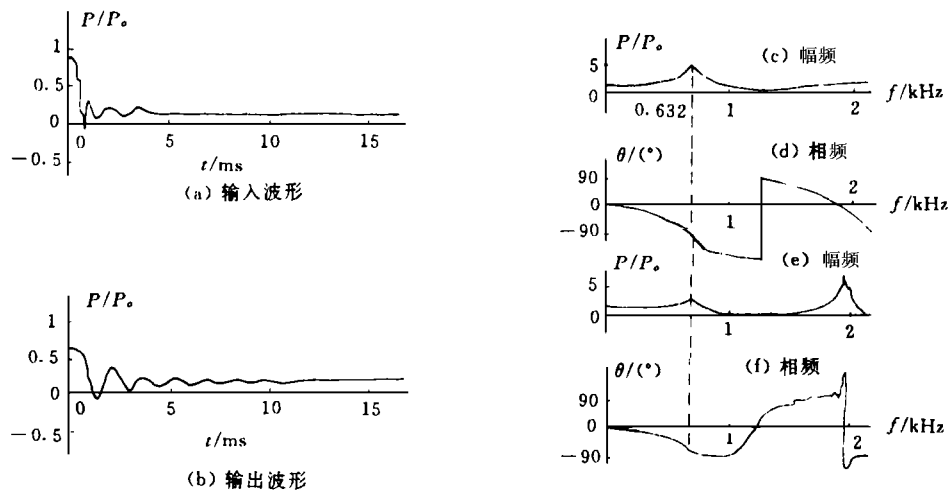


图 3 探针输入、输出波及其幅频、相频特性

分析的结果与两只传感器分析的结果幅频特性相同,相频特性略有一点不同,这是因为用单只传感器在触发时采样信号前端有少许截断造成。可用软件将信号环形存贮,从而获得完整的波形。表 2 列出了几只不同长度的探针在 2 种信号发生器管腔长度下,用一只高频响传感器测被校系统输入,另一只传感器测输出,双传感器校准的结果,以及只测被校系统输出,单传感器校准的结果,可见是完全一致的。

表 2 被校系统响应峰值频率(Hz)

信号发生器 管腔长度(mm)	探针长 80 mm		探针长 92 mm		探针长 100 mm	
	双传感器	单传感器	双传感器	单传感器	双传感器	单传感器
20	680	680	632	632	600	600
40	680	680	632	632	600	600

3 结 论

(1) 这种爆膜式动压信号发生器结构简单,所产生的激励信号频率成份适合用于频响不高于 1000 Hz 的动态压力测量系统校准。(2) 一次实验,就可得出被校系统准确的频响特性。方法简便,便于现场使用。

参 考 文 献

- 1 Pamela A Bolt, Robert W Hess, William T Davis. Portable Dynamic Pressure Generator for Static and Dynamic Calibration of In-Situ Pressure Transducers. NASA-TM-85687, 1983
- 2 Caro F Vezzetti, John S Hiltner, Paul S Lederer. Development of a Dynamic Pressure Calibration Technique. NASA-L-88319, 1975
- 3 朱明武, 梁人杰, 柳光辽, 王宗杰. 动压测量. 北京: 国防工业出版社, 1983

of P_p^*/P_s^* , but the corrected momentum coefficient K_m in the mixing pipe goes up. The mass flow rate coefficient μ of the primary nozzle increases slightly as the entrainment ratio goes up. The theoretical analysis has been done for the above conditions by application of aerodynamics. The comparison between the analysis and the experiment shows a good agreement.

Key Words Jet nozzles Ejectors Supersonic velocity Performance Analysis

SUBSTRUCTURE ITERATION FOR ANALYZING DYNAMIC BEHAVIOUR OF A CASING- SUPPORT- ROTOR SYSTEM

Liao Mingfu, Wei Xudong, Liu Qizhou

(7th Dept. Northwestern Polytechnical University, Xi'an 710072)

ABSTRACT

In order to investigate the dynamic behaviour of a casing- support - rotor system, an approach associated with substructure iteration and transfer matrix is developed. With help of the approach, the dynamic response analysis of a complex rotor system is simplified and the computation time is lessened. The convergence and stability of the approach are verified with a simple model.

Key Words Substructure Iteration methods Matrix method System architecture

STUDY ON REDUCTION FACTOR OF FATIGUE STRENGTH AND DISPERSION COEFFICIENT OF LIFE IN SEAM WELDED JOINTS

Fan Yinhe

(2nd Dept. Nanjing University of Aeronautics and Astronautics, Nanjing 210016)

ABSTRACT

The purpose of this work is to study low cycle fatigue life of engine cases. A welded test piece has been designed according to reality of cases, using material of 1Cr18Ni9Ti in order to get fatigue function survey of seam welded joints. From tests S- N curve and P- S- N curve are obtained. Then the reduction factor of fatigue strength and dispersion coefficient of fatigue life for the seam welded joints are achieved with statistics analysis methods. Compared with a smooth test piece, the fatigue strength of the seam welded joints is obviously less than smooth test piece, but dispersion coefficient of fatigue life is better.

Key Words Welding joints Fatigue strength Life time

A BROKEN FILM CALIBRATION SYSTEM OF DYNAMIC PRESSURE MEASUREMENT

Jiang Yong

(Mechanics Dept. Air Force College of Engineering, Xi'an 710003)

ABSTRACT

The investigated calibration system of dynamic pressure measurement with response frequency less than 1 kHz includes two parts: a broken- film dynamic pressure signal generator and an acquisition- analysis system. Many experiments were carried out for investigating frequency components produced by the signal generator of different lengths, which indicated that the signal generator, under first- order resonant frequency, can produce sufficient frequency components (0.5- 1.5 kHz) as exciting resources. Moreover, the calibration system was used for dynamic calibration of three pressure probes of different lengths with a pressure sensor respectively. Meanwhile a particular way is adopted to obtain precise frequency response characteristics only by measuring the pressure probe output. It is shown that the calibration system is simple, reliable, and applicable.

Key Words Dynamic pressure Sensors Calibration

EFFECTS OF REINFORCED TURBULENCE ON SPRAY DISTRIBUTION AND TEMPERATURE PROFILE BEHIND AIRBLAST ATOMIZER

Zou Zhengping, Huang Xuemin, Wang Hongming

(4th Dept. Beijing University of Aeronautics and Astronautics, Beijing 100083)

ABSTRACT

The effects of turbulence intensity on liquid spray distribution and temperature profile behind airblast atomizer have been investigated. Three test model airblast atomizers with different turbulence intensity were experimented: the base line model, the one with lots of small air injection in outer swirler channel and the another with turbulence treatment on the outer swirler wall. The measurements were done by PDA (Particle Dynamic Analyser) to map out the spray and flow characteristic on cold condition, and thermocouple was used to acquire the temperature profile during combustion test. The cold tests show that the secondary atomization, spray and air mixing process can be promoted by the model with reinforced turbulence structure, and more uniform spray distribution can be achieved in the nearer downstream section. The combustion tests show that more even temperature profile and higher combustion efficiency can be obtained. It is because that turbulence fluctuation can effectively promote liquid atomization and spray transportation, and also enhance the burning rate of mixture evidently.

Key Words Air- blast atomizers Temperature distributions Spray combustion

APOLOGY: * This paper was replaced by another paper of same authors in final redaction of JAP Vol. 11 NO. 2 1996, but the substitution of abstracts wasn't carried out. The supplement of the paper is as follows.

PREDICTION OF INCIPIENT SEPARATION INDUCED BY 3- D SHOCK/BOUNDARY LAYER INTERACTION

Zhang Yangjun and Chen Naixiang

(Dept. of Hydraulics, Tsinghua University, Beijing 100080)

Tao Deping and Zhou Sheng

(4th Dept. Beijing University of Aeronautics and Astronautics, Beijing 100083)

ABSTRACT

The flow separation induced by three- dimensional shock/boundary layer interaction has an important effect on performance of a transonic rotor. A method is proposed to predict the incipient separation generated by 3- D shock/boundary layer interaction. The numerical results indicate that the secondary flow generated by the shock/boundary layer interaction is a key factor for the incipient separation. When inlet relative Mach number exceeds 1.5, the strong shock wave/boundary layer interaction may induce the flow separation in tip area of transonic fan.

Key Words Three- dimensional flow Separated flow
Shock wave- boundary layer interference