MASTER OF SCIENCE IN AERONAUTICAL ENGINEERING

EXPERIMENTAL INVESTIGATION OF VORTEX SHEDDING IN HIGH REYNOLDS NUMBER FLOW OVER COMPRESSOR BLADES IN CASCADE

Lim Choon Peng-Major, Republic of Singapore Air Force
B.E., Nanyang Technological University, 1997
Master of Science in Aeronautical Engineering-March 2003
Advisor: Garth V. Hobson, Department of Aeronautics and Astronautics
Second Reader: Raymond P. Shreeve, Department of Aeronautics and Astronautics

An investigation of vortex shedding downstream of a cascade of compressor stator blades, at off-design inlet-flow angles of 35, 33 and 31 degrees and Reynolds numbers, based on chord length, of 625,000, 750,000 and 800,000 is reported.

The objective of the study was to characterize the flow and vortex shedding through blade surface pressure measurements and hot-wire anemometry. Vortex shedding was determined to be a leading edge phenomenon as periodic shedding was only detected on the pressure side of the wake. The relationship between vortex shedding frequency and Reynolds number was nearly linear. The vortex shedding frequency at three incidence angles was observed to be quite similar at lower Reynolds numbers (i.e. 450,000 and below), but developed into a larger scatter at higher Reynolds numbers. Similarly, the Strouhal numbers were observed to be fairly consistent (0.22 to 0.24) at low Reynolds numbers and more scattered (0.18 to 0.25) with increasing Reynolds numbers. The result obtained was comparable to the experimental results obtained by Roshko [Ref. 14], for vortex shedding behind a circular cylinder.

KEYWORDS: Controlled-diffusion, Compressor, Stator, Cascade, Turbomachinery, Hot-wire Anemometry, Laser-doppler Velocimetry, Vortex Shedding

DESIGN AND TESTING OF A COMBUSTOR FOR A TURBO-RAMJET FOR UAV AND MISSILE APPLICATIONS

Ross H. Piper, III-Lieutenant, United States Navy
B.S., United States Naval Academy, 1995
Master of Science in Aeronautical Engineering-March 2003
Advisor: Garth V. Hobson, Department of Aeronautics and Astronautics
Second Reader: Raymond P. Shreeve, Department of Aeronautics and Astronautics

An existing freejet facility was upgraded and its range of operation extended into the high subsonic regime for operation as a test rig for the development of a combined-cycle, turbo-ramjet engine. A combustor was designed, developed, and tested as the afterburner for the turbo-ramjet engine. At subsonic speeds with the afterburner running, an increase in thrust of 40% was measured over the baseline turbojet running at 80% spool speed. A Computational Fluid Dynamics model of the flow through the shrouded turbojet engine was developed and successfully used to assist in predicting the bypass ratio of the engine at different Mach numbers. Numerous recommendations were made to improve the operation of the test rig, to improve the performance of the turbo-ramjet engine, and refine the numerical models. These recommended improvements will extend the present capabilities to design and analyze small combined cycle engines which have an application in unmanned aerial vehicles and missiles.

KEYWORDS: Turbo-ramjet, Afterburner, UAV Propulsion, Missile Propulsion, Computational Fluid Dynamics, OVERFLOW, Freejet, Small-scale Engines

PERFORMANCE MEASUREMENTS, FLOW VISUALIZATION, AND NUMERICAL SIMULATION OF A CROSSFLOW FAN

M. Scot Seaton-Lieutenant, United States Navy
B.S., Purdue University, 1993
Master of Science in Aeronautical Engineering-March 2003
Advisor: Garth V. Hobson, Department of Aeronautics and Astronautics
Second Reader: Raymond P. Shreeve, Department of Aeronautics and Astronautics

A 12-inch diameter, 1.5-inch span crossflow fan test apparatus was constructed and tested using the existing Turbine Test Rig (TTR) as a power source. Instrumentation was installed and a data acquisition program was developed to measure the performance of the crossflow fan. Performance measurements were taken over a speed range of 1,000 to 7,000 RPM. Results comparable to those measured by Vought Systems Division of LTV Aerospace in 1975 were obtained. At 6,000 RPM, a thrust-to-power ratio of one was determined; however, at 3,000 RPM, twice the thrust-to-power ratio was measured. Flow visualization was conducted using dye-injection methods. Performance and flow visualization results were compared to predictions obtained from 2-D numerical simulation conducted using Flo++, a commercial PC-based computational fluid dynamics software package by Softflo. A possible design for a light civil V/STOL aircraft was suggested using a similar crossflow fan apparatus for both lift and propulsion.

KEYWORDS: Crossflow Fan, Cross Flow Fan, VTOL

PRECISION AIR DATA SUPPORT FOR CHEM/BIO ATTACK RESPONSE

Kwang Liang Tan-Captain, Republic of Singapore Air Force
B.E., Nanyang Technological University-1997
Master of Science in Aeronautical Engineering-March 2003
Advisor: Richard M. Howard, Department of Aeronautics and Astronautics
Second Reader: Vladimir N. Dobrokhodov, National Research Council Research Associate

The defense response against chemical and biological (Chem/Bio) weapons has gained a renewed focus in light of the 11 September 2001 terrorist attacks. A successful response to a Chem/Bio attack would involve measuring and predicting the dispersion of a toxic cloud in the atmosphere. The NPS Aeronautics and Astronautics Department is working together with the Meteorology Department on a technique to take toxic cloud measurements using an Unmanned Air Vehicle (UAV). In support of this mission, the UAV will require precise and accurate air data (airspeed, angle of attack [“alpha”], and sideslip angle [“beta”]) so that wind data extraction can be carried out from air and inertial data for use in plume dispersion modeling. The efforts in this thesis concentrate on the air data system to produce precise and accurate air data for the support of the Chem/Bio response UAV flights. The primary concerns are the choice and design of the air data system; the calibration of the system using the flow fields from computer simulation; and the processing of air data. The air data extracted will be used for wind determination so that the movement of the Chem/Bio agent dispersed in the atmosphere can be predicted.

KEYWORDS: Unmanned Aerial Vehicles, UAV, Air Data, Chem/Bio