19910015719 N90-25035 51-46 P3

GROUND EVALUATION OF SEEDING AN IN-FLIGHT WINGTIP VORTEX USING INFRARED IMAGING FLOW VISUALIZATION TECHNIQUE

Ted Akinyanju
Assistant Professor (Technology)
Norfolk State University
Norfolk, VA 23504

ABSTRACT

An experimental simulation of an in-flight wingtip vortical ~~vorticity~~ flow visualization technique uses infrared imaging to observe strong and concentrated vortices. This experiment is phase I of a two-phase infrared evaluation program. The system includes a Vortex Generator (Model 320 Vortec Vortex Tube) which generates the required vortex. The mouth of the unit is mounted close to the free end of a half-inch diameter, sixteen and a half foot long stainless steel tubing (sized after tubing currently installed in the wings of an experimental Beechcraft Sundowner 180 aircraft).

Dichlorodifluoromethane (Freon-12) is entrained into the generated vortex. A breakdown of the vortices is indicated by the rapid diffusion and the resulting pattern is tracked using the infrared imager and video systems. Flow rates (volume and mass) are estimated at the laboratory and proposed flight conditions. The nominal flight altitude is expected to be 2500 feet.

NOMENCLATURE

A tube cross-section area

k specific heat ratio (c_p/c_v)

p pressure

ρ_o absoulute density

$\dot{m}$ mass flow rate

$\dot{V}$ volume flow rate

$\bar{V}$ discharge velocity

τ_e effective transmission

$R_c(\lambda)$ Agema 880 spectral response

$E(\lambda, T)$ Plank constant

$\tau(\lambda, CCl_2F_2\%)$ atmospheric/Freon-12 percent transmission at each wavelength

INTRODUCTION

The observation and diagnosis of aircraft off-surface flow fields are traditionally performed in the wind tunnels. But with the present demand for highly maneuverable military aircrafts and high-performance commercial jetliners, the importance of these off-surface flows has greatly increased, and especially the vortical flows. Vortices generated at wingtips and at the side-edges of trailing-edge flaps are typically observed at take-off, landings and during maneuvers at low altitudes.

One of several innovative works in the vortical flow area is the development of the vortex attenuators (spoilers) by NASA. The NASA program concentrated on the axial penetration of vortex wake because it appears the most likely to happen during landings. Strong vortex wakes generated by large transport aircrafts are a potential hazard to smaller aircrafts. Encounters with such wakes could result in loss of altitude/rate of climb, imposed roll and structural load factors. The spoilers alleviate the trailing-edge vortex by injecting turbulence. Other recent efforts to improve performance include aircraft configurations that promote vortex flows which augment lift at high angles of attack.

APPARATUS AND TESTS

A Beechcraft Sundowner wingtip was simulated with a sixteen and a half feet long, half-inch diameter stainless steel tubing. A Teledyne Hastings Flow Meter and its laminar flow element were integrated into the line at the 12 foot mark. Freon-12 from a 30 psig cannister was entrained into generated vortex until a maximum

Freon-12 is an odorless and non-toxic gas at room temperature (20% by volume or less). Since the fluid was compressed under its own vapor pressure as a liquified gas, we can apply the principle developed for isentropic flow of an ideal gas relations with possibility of condensation. A discharge velocity of 90.1 mph and a volume flow rate of 11.1 ft/min (CFM) were estimated for the Freon-12 based on its physical properties, tubing size and cannister size. The maximum flow rate obtained during tests was 6.22 CFM. It was observed that a maximum flow rate stayed constant for only 10 to 12 seconds and the gradually dropped as the gas condensed. The rate of flow decrease was about constant for the tests. Table 1. shows values for volume and mass flow rates. (Values expected to be a little higher at 2500 feet altitude.)

	TEST A	TEST B	TEST C
RUN 1	6.22 CFM 1.98 lbm/min	5.12 CFM 1.60 lbm/min	4.60 CFM 1.46 lbm/min
RUN 2	4.84 CFM 1.50 lbm/min	4.07 CFM 1.30 lbm/min	4.14 CFM\ 1.32 lbm/min

IMAGE RECORDING SYSTEM

The infrared measuring technique has become very popular in recent years, especially in flow studies that involve non-intrusive flow measurements. Gases are in many cases transparent to radiation and absorb or radiate either with discrete spectra or spectra in very small regions of wavelengths. In the current experiment radiation is transmitted by the Freon-12 through the atmosphere to the camera. The background against which the gas is visualized also emits radiation. To estimate effective transmission, one has to discriminate the gas from the background.

The infrared image system used in the current experiment (Agema 880) measures the vortex patterns with a field frequency of 25 Hertz. The camera is equipped with a nitrogen-cooled detector