DEMONSTRATION TEST OF BURNER LINER STRAIN MEASUREMENT SYSTEMS: INTERIM RESULTS*

Karl A. Stetson
United Technologies Research Center
East Hartford, Connecticut

Howard P. Grant
Pratt and Whitney Aircraft
East Hartford, Connecticut

Abstract

Work is in progress to demonstrate two techniques for static strain measurements on a jet engine burner liner. Measurements are being made with a set of resistance strain gages made from Kanthal A-1 wire and via heterodyne speckle photogrammetry. The background of the program is presented along with current results.

Introduction

A previous program (NAS3-22126) has resulted in identifying two potentially applicable methods for static strain measurement of the thermal deformations of jet engine burner liners. The first employs resistance strain gages made from Kanthal A-1 wire and the second is a form of photogrammetry based upon laser speckle photographs (specklegrams) of the surface under study. The photographs are made by illuminating the object with laser light and making photographic recordings on high resolution plates through a telecentric lens system. The coherence of laser light creates high contrast speckles in the image that move as if attached to the object surface. Strain is revealed as image magnification by photogrammetric comparison of pairs of specklegrams. The accuracy of this comparison is greatly enhanced by use of a heterodyne interferometer.

Both methods have features that are attractive as well as problematic. The wire gages provide continuous output in a conventional format and, because they are bonded to the actual object surface, are not influenced by rigid-body tilts and translations. On the other hand they are subject to failure, they can exhibit large and variable values of apparent strain, they have temperature limitations, they only measure strain at specific locations, and they can influence the mechanical behavior of the object. By comparison, speckle photogrammetry offers virtually no temperature restriction, allows continuous geometrical mapping of strain distributions, has an apparent strain equal to thermal expansion, and is noncontacting. Nonetheless, it only samples the object at discrete times, it can be disturbed by rigid-body motions, it requires optical access to the object surface, and it can be influenced by thermal inhomogeneities in the gas through which the object is viewed.

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Program Description

The current program combines both methods in a prototype study of combustor behavior. A JT12D combustor (see Fig. 1) has been modified for operation in the temperature range desired (Up to 950°K for the Kanthal gages and up to 1140°K for the photogrammetry). A section has been cut from the burner and instrumented with ten gages and seven thermocouples as shown in Fig. 2. A hole has been provided so that the louver lip may be photographed and included in the photogrammetric strain measurement. The gaged section has been put through temperature calibration tests to predetermine the apparent strains of the gages. Reference gages have also been tested on a constant strain bar to determine the gage factor as a function of temperature. The section of the burner was then welded back into place and the burner installed in the test stand.

A window was provided in the test cell as shown in Fig. 3 through which the burner is illuminated and photographed. Figure 4 shows the layout of the optical components. A pulsed laser provides illumination of about 1 msec duration with adequate energy to expose the plates. The system is operated remotely from the control room.

During the actual test runs, specklegram data is recorded in the form of photographic exposures at designated times, while strain gage data is recorded continuously as electrical signals. To maintain correlation between the speckle patterns of successive photographs, the burner is heated isothermally by increasing the inlet air temperature until spontaneous ignition is possible. After ignition, various cycles can be simulated by variation of the fuel flow. After testing is complete, both strain gage and specklegram data are processed to obtain strain information.

Processing for the strain gage data consists primarily of numerical correction for apparent strain and gage factors. Processing for the specklegram data consists of developing the photographic plates and evaluating them on an interferometric comparator. The number of locations on the photographs at which two-dimensional strain data may be obtained is limited by the time available for data processing. Strains are to be measured, therefore, only at the ten gage locations and at ten additional locations including the louver lip. Thermocouple readings will be used to correct for thermal expansion and provide thermomechanical strain.

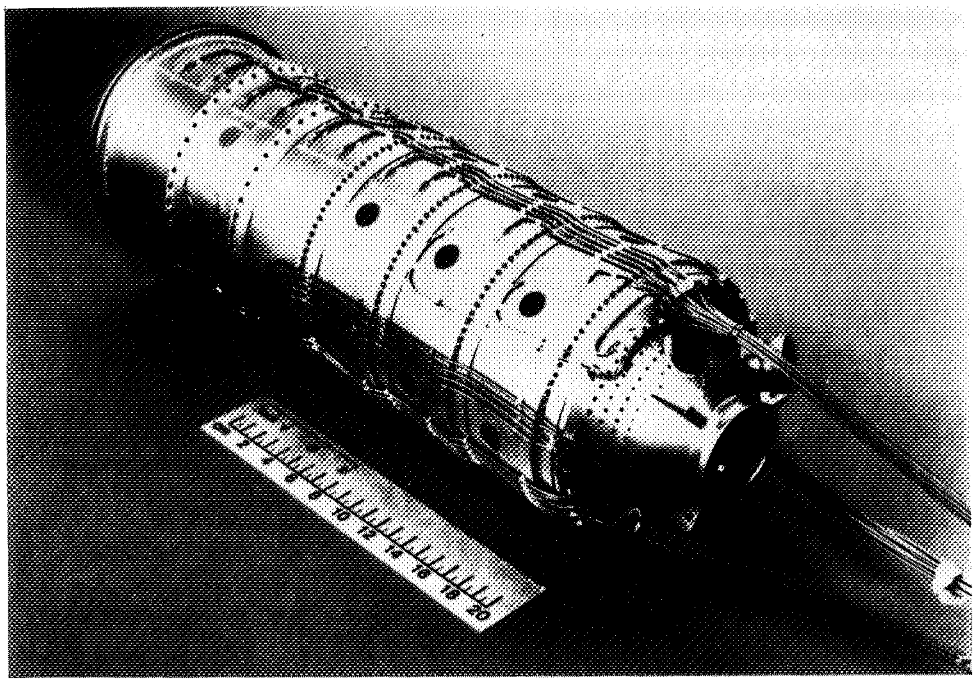
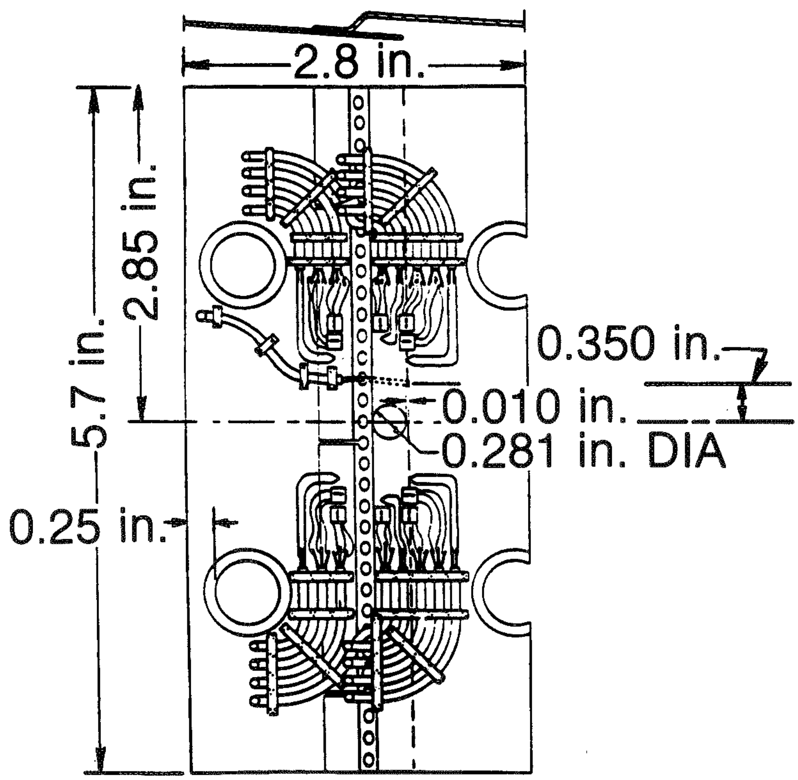

2
4
6
8
10
12
14
16
18
20

FIG. 1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2.85 in.
5.7 in.
0.350 in.
0.010 in.
0.281 in. DIA
0.25 in.

FIG. 2

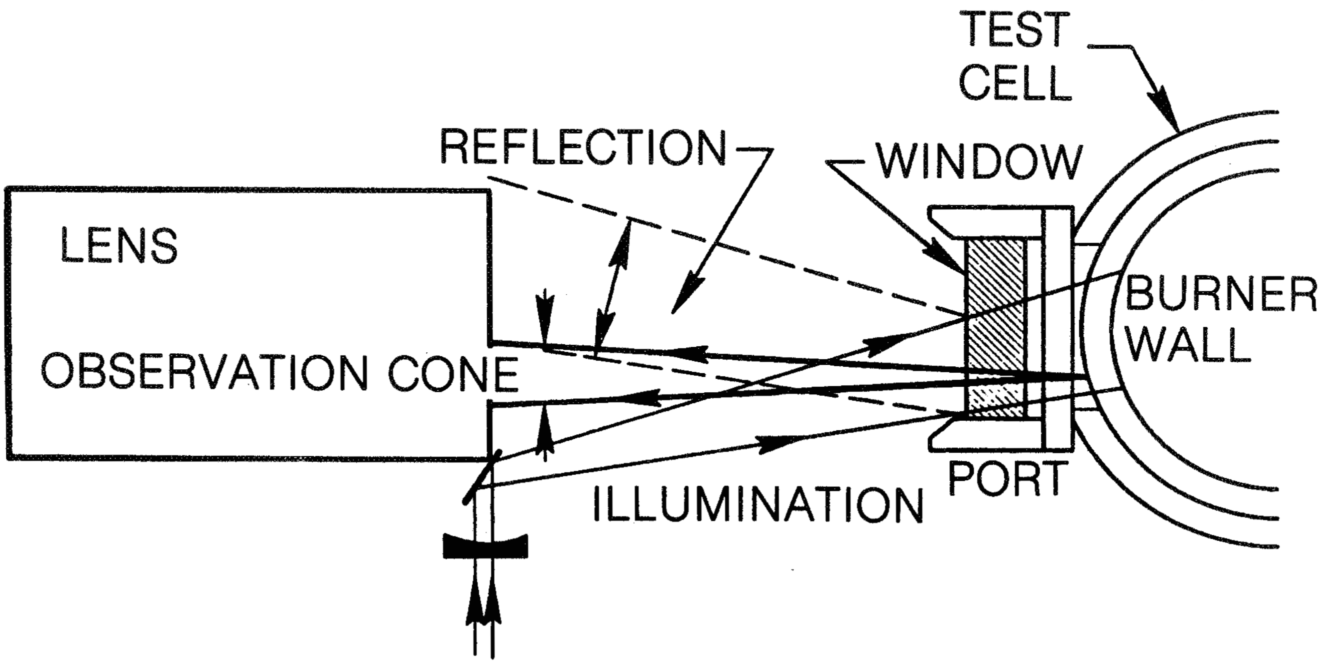
TEST
CELL
REFLECTION
WINDOW
LENS
OBSERVATION CONE
BURNER
WALL
ILLUMINATION
PORT

FIG. 3

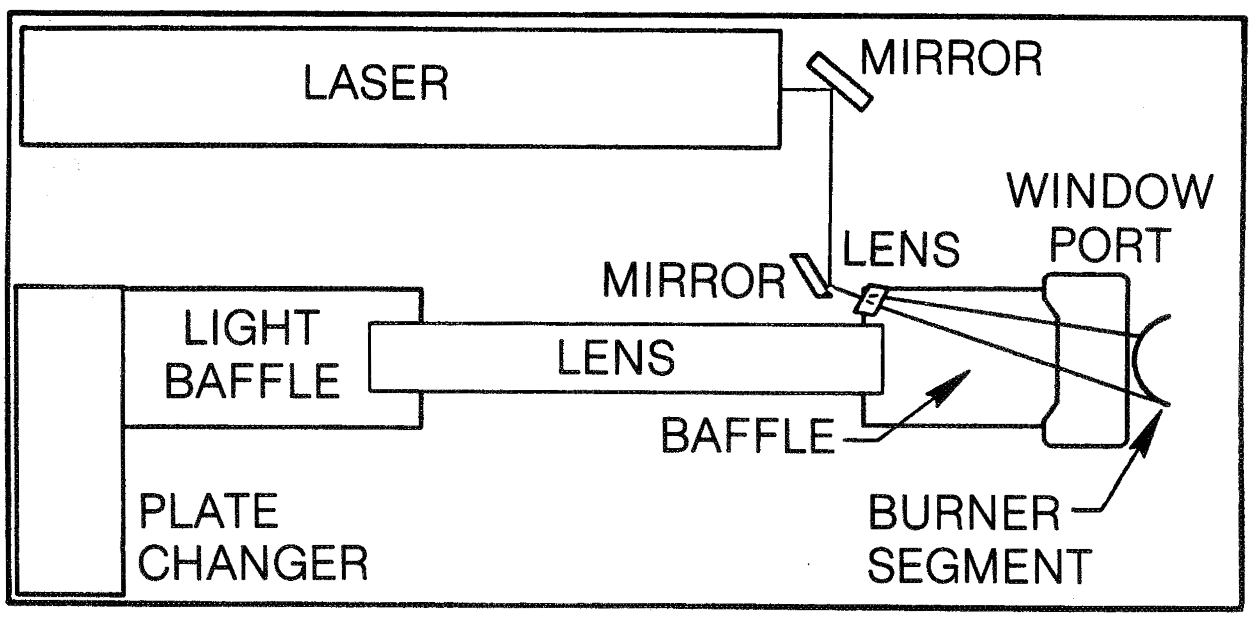
LASER
MIRROR
WINDOW
PORT
LENS
MIRROR
LIGHT
BAFFLE
LENS
BAFFLE
PLATE
CHANGER
BURNER
SEGMENT

FIG. 4