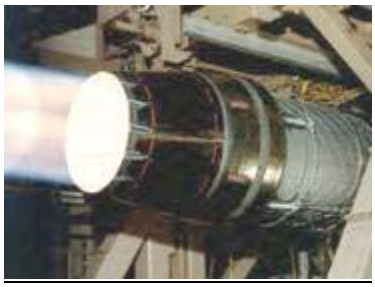
TECHNOLOGY REPORT

Laser Technology Inc.

TURBINE AIRCRAFT COMPONENTS



Holography NDT Inspection

Of

Turbine Aircraft Engine

Components

APPLICATION

Detect Disbonds in Abradable Seals in the Compressor Stage

- **Feltmetal and Plasma Sprayed Abradable Seals**
- **Brazed Honeycomb Seals**

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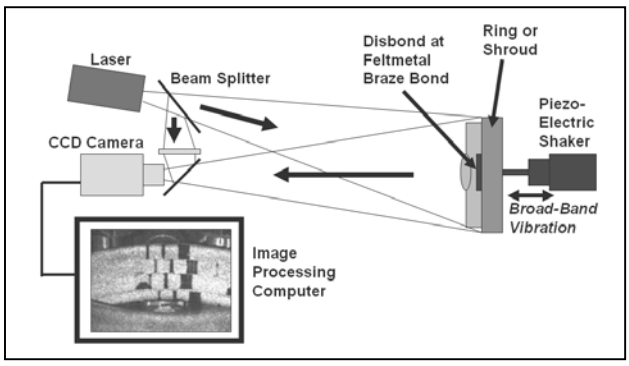
Holography NDT of Turbine Aircraft Components

Holography has been used since the 1970's for tire inspection. Before the development of electronic holography or electronic speckle interferometer (ESPI) cameras, film holography cameras were used in combination with vacuum stress. Early film holography cameras were also use to solve a major production issue in the inspection of abradable turbine engine components.

Since the 1970's turbine aircraft engines have used abradable seals in the compressor stages of the engine to achieve high-pressure ratios per stage, reducing the turbine power required to drive the compressor, engine weight and increasing performance. The loss of this material can affect engine performance and inspection of the bond line in production or engine overhaul is required.

Ultrasonic through transmission C-Scan is capable of detecting disbonds in parts where the shroud geometry is a straight or slightly conical cross section. However, in most engines, the design of the compressor shrouds includes brazed stators, material thickness changes, flanges and other features that obscure or shadow the abatable seal material.

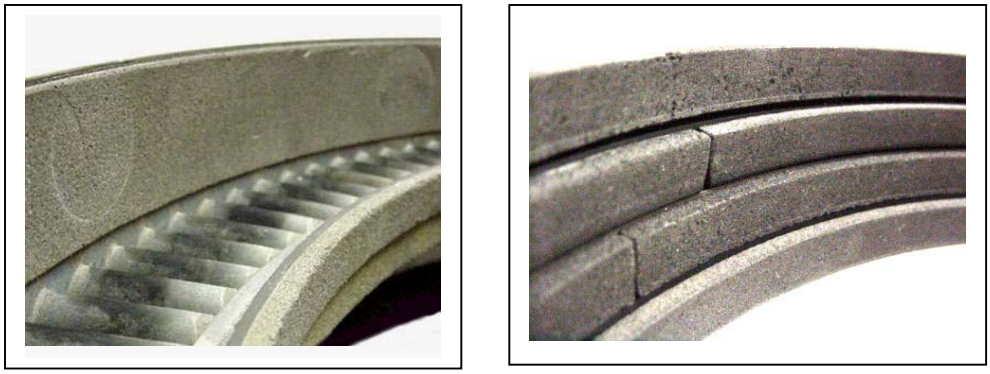
In 1982, a holography NDT technique entered production at Pratt & Whitney, combining time average holography with a low frequency ultrasonic vibration applied to the compressor shroud. Holography provided excellent disbond detection with easily interpreted images essentially identical to UT results, but not affected by part geometry, material thickness changes. Early systems used film holography with a one step chemical process, invented by the author, which produced production quality holograms in approximately 10 seconds. The results were viewed on a video monitor. Electronic holography currently using mega-pixel CCD cameras has radically improved system operation speed and reliability. Since1982, holography has been the inspection standard for Feltmetal and plasma sprayed aircraft abradable seals.



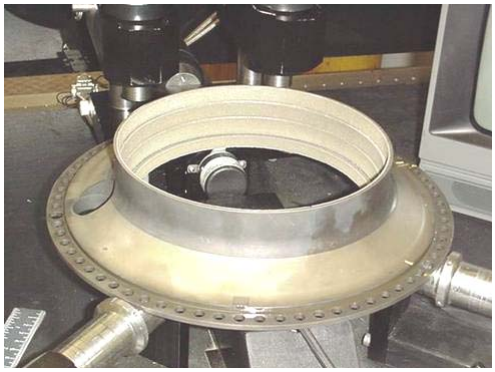
Schematic Diagram of holographic method using low frequency ultrasonic part excitation to image braze bond defects.

Holography inspection has eliminated compressor seal bond failures, yielded large financial savings to the manufacturers and greatly enhanced customer satisfaction and cost savings. Similar applications of holography with vibration part excitation of bonded metallic materials on human orthopedic implants have shown dramatic improvement in product quality. Highly automated systems that monitor all system parameters have been FDA approved. Together, these two applications of holography have yielded significant cost savings, manufacturing quality and provide a means for engineering improvements to processes.

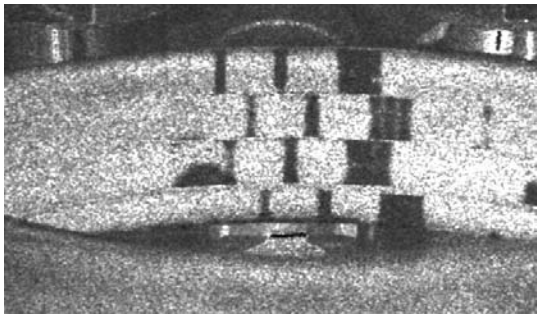
Several examples of turbine engine abradable seals.



Feltmetal abradable seal material bonded to a turbine engine compressor shroud. This 12 stage also abradable seal material bonded to the inner diameter of the stators making conventional UT inspection impractical.

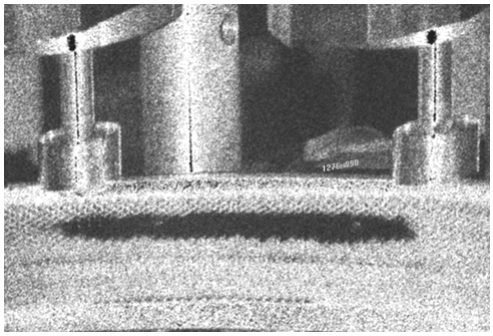


F100 Bearing Seal on test fixture with motorized Rollers and Piezoelectric



Hologram showing programmed disbonds in bearing seal

Brazed bonded steel open cell honeycomb seal on rings, Shrouds and



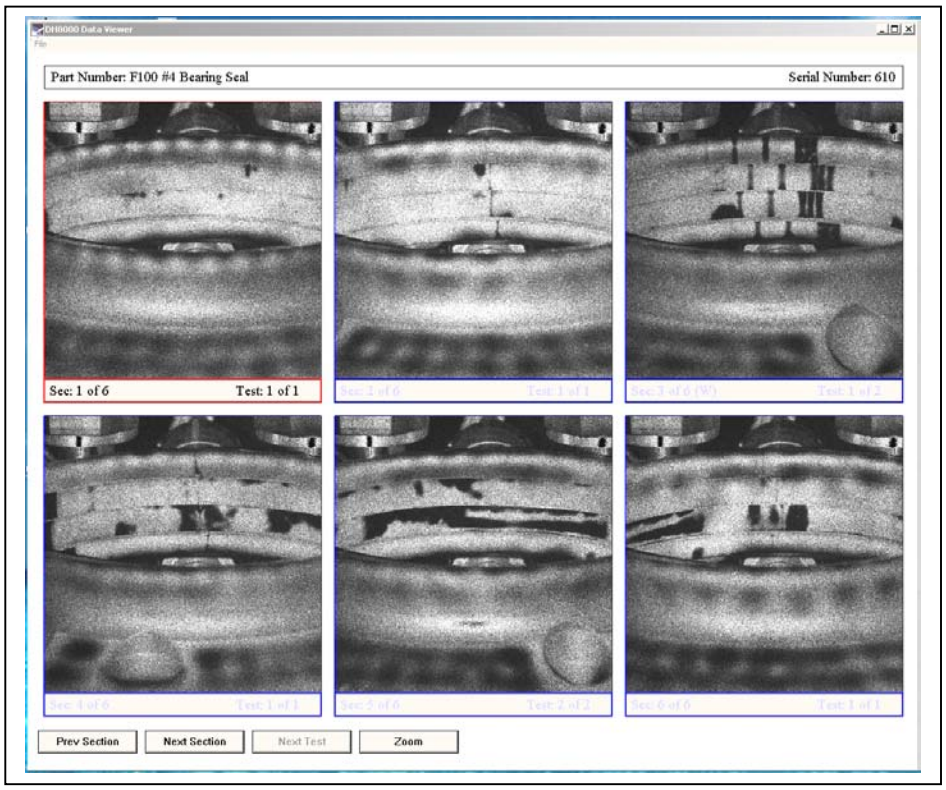
TF-30 Honeycomb Compressor Seal showing a seven Inch long disbond..

Laser Technology, Inc.'s DH-8000 Digital Holography Inspection system has been designed for the holographic inspection of a wide range of both metallic and composite bonded structures. The standard DH-8000 is configured for high frequency vibration stressing although the system is capable of being used with a variety of stressing methods.

Due to varying customer requirements, fixturing, excitation methods, and file saving options are subject to change for specific applications. This manual describes the basic operation and maintenance procedures for the DH-8000 as configured for the inspection of abraidable jet aircraft engine seals (Photo 1).

Photo 1 Laser Technology Inc.'s DH-8000 Holographic Inspection Station. The system is composed of 3 sections, the Inspection Station (table, enclosure, and camera), the Control Console Assembly (front right), and the Excitation Assembly (located under table).

The standard DH-8000 System can be divided into 3 sections; the **Holographic Inspection Station**, the **Control Console Assembly**, and the **Vibration Excitation Assembly**. The *Inspection Station* consists of the systems vibration isolation table and enclosure, holography camera, and the Piezoelectric Shaker and fixture assembly. The *Excitation Assembly* contains the amplifier and matching network used to power the PZT; while the *Control Console* consists of the camera control console, computer chassis, and support electronics.



Composite Display of Abraidable Seal Test Standard after Inspection

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