

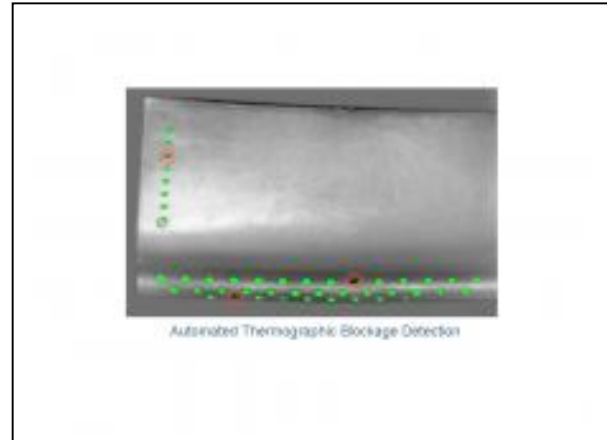
Comprehensive Inspection of Turbine Hot Section Blades and Vanes Using Active Thermography

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Command: NAVAIR

Topic: N06-T011

PROBLEM STATEMENT

Modern Navy combat aircraft are becoming increasingly reliant on turbine engines that employ advanced materials and innovative new designs for hot section blades and vanes. Turbines in aircraft such as the JSF operate at higher temperatures than previous generations, so that it is essential that all components meet design and performance specifications in the manufacturing phase, before they are installed in aircraft, and throughout their service lifetime. Unfortunately, the technology that is currently used to inspect turbine components is time-consuming, labor-intensive, and in some cases, not adequate for newer hardware. Our program is focused on improving both the efficiency and economics of turbine inspection, as well the underlying technology, through the development of a dedicated blade inspection station that is specifically designed to meet the requirements of modern NAVAIR turbine components.

WHO CAN BENEFIT?

The slow, laborious nature of the inspection process is common to older blade and vane designs, as well as their modern counterparts. Thus, our technology is applicable and beneficial to all existing military platforms, as well commercial aircraft, where an identical situation exists. The system can also be scaled up to accommodate the larger components used in ground vehicles, where similar inspection problems exist.

BASELINE TECHNOLOGY

At present, turbine blades are typically inspected using an array of nondestructive tests that address the critical attributes that determine performance and reliability (Table 1).

These tests range from sophisticated instrumentation to manual tests (e.g. inserting piano wire into holes to detect blockage). From the customer perspective, this grab-bag of techniques means that inspectors must be trained and certified in several disciplines, and several different types of inspection equipment must be purchased and maintained. The various inspections are performed serially, meaning that total inspection time is inherently long.

<u>Inspection</u>	<u>Available NDT Techniques</u>
Coating inspection	eddy current, ultrasound, thermography
Hole blockage	pin / wire testing
Crack detection	penetrant, vibrothermography
Internal blockage	flow testing, radiography, neutron radiography
Wall thickness	ultrasound, thermography

Table 1: Current blade inspection techniques

TECHNOLOGY DESCRIPTION

We have developed a hybrid thermographic inspection system that can diagnose most, if not all, typical blade / vane defect conditions in a single inspection. Our system will reduce inspection time, simplify and consolidate training and certification requirements, and eliminate reliance on visual or manual inspections (e.g. pin or wire testing for cooling hole/channel blockages). The system can perform the following tests:

- Wall thickness measurement
- TBC adhesion
- TBC thickness measurement
- Hole blockage
- Cooling channel blockage
- Structural placement/integrity validation
- Structural adhesion
- Crack detection
- Thermal diffusivity measurement

Our system provides complete inspection of blades and vanes. Most inspections can be automated, so that the complete suite of inspections can be performed in less than 1-2 minutes. The system is modular, so that only the necessary inspections are installed in the station, so that a machining facility might only be interested in hole blockage, while a coating shop would perform TBC thickness and adhesion tests, and the OEM or end-user might require the entire set of inspections. All tests (except crack detection) are non-contact and do not require immersion or surface preparation of the sample.

Features	Advantages	Benefits
Single Inspection	Combines 9 discrete inspections into one	Saves cost, manpower and time
Automated	Eliminates reliance on manual inspection	More reliable and saves manpower
Non Contact Inspection	Does not require immersion or surface preparation	Saves time and costs of additional inspection preparation steps

Table 2: Feature Advantages Benefits (FAB) Table

CURRENT STATE OF DEVELOPMENT

To date, working demonstration of blockage, crack detection, thickness and diffusivity measurement modules have been demonstrated on advanced airfoil components. A blockage detection module has been purchased by a major OEM, and is due to be installed in Oct. 2009. A thickness/diffusivity module has been purchased by a different OEM, and will be installed in Dec. 2009.

Each of the module demonstrators is configured to accommodate expansion to include additional modules (both OEM customers who have purchased the modules plan to purchase additional modules within 12 months).

REFERENCES

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ABOUT THE COMPANY

Founded in 1992, Thermal Wave Imaging is the world leader in the development and commercialization of Thermographic NDT systems in the aerospace and power

generation industries. We have played a leading role in the implementation of thermography for inspection of turbine components, working closely with customers including Rolls Royce, General Electric, Chromalloy, Solar Turbine, Boeing Helicopter, Pratt and Whitney, Siemens Westinghouse and many others to develop the equipment, standards and procedures that are currently used in both airborne and ground-based turbine inspection. Our systems are used in applications ranging from inspection of the wing leading edge of the NASA Space Shuttle to Quality Assurance of business jet engine components.