Air Force SBIR/STTR

Innovation

Air Force SBIR/STTR Innovation Story

SBIR Topic Number:
AF01-304

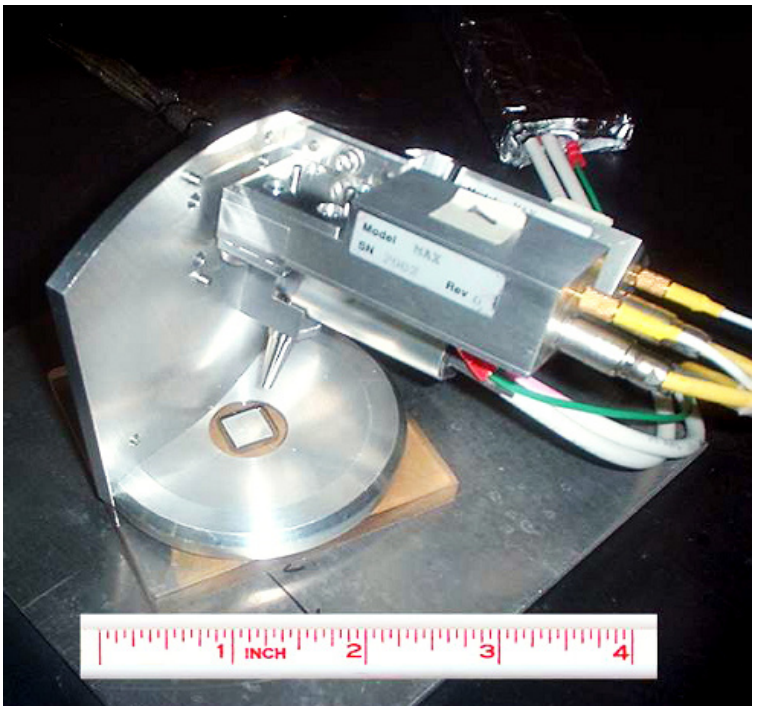
SBIR Title:
Measurement of Residual Stresses in Difficult Locations

Contract Number:
F09650-02-C-0517

SBIR Company Name:
Technology for Energy Corporation, Knoxville, TN

Technical Project Office:
Warner Robins Air Logistics Center, Robins AFB, GA

This Air Force SBIR/STTR Innovation Story is an example of Air Force supported SBIR/STTR technology that met topic requirements and has outstanding potential for Air Force and DoD.



MAX (Miniature Advanced X-ray Diffraction System)

Measuring Stresses in Hard-to-Access Aircraft Locations

- The Air Force has a requirement to rapidly measure residual stresses in hard-to-access aircraft locations while minimizing the removal of aircraft components
- Technology for Energy Corp's miniaturized portable x-ray diffraction system (MAX) makes such measurements while fitting within a six-inch diameter space
- With measuring times as short as 2-3 minutes, rapid and appropriate decisions can be made regarding component assessment, rework or replacement
- Other potential applications include commercial aviation and automotive industries, and large structures such as piping systems, tanks, bridges and towers

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Air Force Requirement

The Air Force has a long-standing requirement to measure stresses in hard-to-access locations in aircraft. Areas of most concern are those where stress concentrations can occur, such as through-thickness holes, blind holes, sharp corners and re-entrant corners. Detrimental stresses in these locations lead to expensive loss of use, excessive inspection and repair costs, and the potential loss of aircraft and personnel. Furthermore, engineering techniques such as damage tolerance analysis and risk assessment have had to rely on overly conservative stress estimates that can actually increase life-cycle and inspection and repair costs. X-ray diffraction--a proven technique for measuring stresses--has been taken from the laboratory to the field for use on large structures. However, current systems do not permit stress measurements in hard-to-access locations.

SBIR Technology

MAX, a Miniature Advanced X-ray Diffraction System developed by Technology for Energy Corporation (TEC), with support from this Air Force SBIR program, promises to have a profound effect on the stress measurement industry. This innovative new product was developed to measure residual stresses in hard-to-access locations on aircraft. The miniaturized measurement head fits within a six-inch diameter space and uses x-ray diffraction to measure stresses in common engineering materials. Initially, development emphasis was placed on measuring stresses in aluminum alloys generally associated with bulkheads, wing skins and other internal aircraft structural components. Subsequently, additional measurement heads have been demonstrated with steel, titanium and nickel alloy systems. MAX's small x-ray measurement head and light-weight controllers make measurements possible while minimizing the need to remove aircraft components or use awkward support equipment.

TEC's strong background in developing portable x-ray diffraction (XRD) equipment was instrumental in their being awarded this SBIR contract to miniaturize existing equipment for this unique application. A rack-mounted 500-lb system was reduced to a system that fits in two rugged, briefcase-sized traveling cases and is operated by a laptop computer. The hardware consists of the measurement head, safety system and electronics. The measurement head contains a low-power, three-watt x-ray tube that reduces potential x-ray exposure and results in a safer system. It also includes a high-voltage power supply and two detectors –actually miniature position-sensitive proportional counters. This system uses a single-exposure technique that does not require the x-ray head to move during measurement. Powerful software routines precisely measure the diffraction peaks and calculate residual stress values. Designed for field use, the MAX system only requires 110V/15A electrical service. Software routines also guide the user through the entire measurement and analysis process with simple, easy-to-use visual guides. An interlocked optical beam provides a barrier to further protect personnel from x-rays emitted during system operation.

Potential Air Force Application

The Air Force was particularly interested in measuring stresses in structures without dismantling the aircraft. This capability is important for routine aircraft maintenance and inspection issues. Stresses can change in a component due to the removal process. Adjacent structures may also be impacted, and replacement fit-up stresses may result in an undesirable stress state. Measuring structures in-situ eliminates these undesirable conditions as well as the need for replacing a structure if beneficial stresses are measured. With measuring times as short as two to three minutes, complete inspections can be performed rapidly and appropriate decisions regarding component assessment, rework or replacement can be made.

Company Impact

Potential applications for MAX seem almost limitless. It is small, user friendly, smart, lightweight, versatile, portable, uncomplicated, fast and accurate. Military and commercial aviation were initially targeted as intended customers. TEC has a long history of measuring aircraft, space shuttle, and space station structures. These measurements and others previously considered to be impractical can now be made quickly and easily. This interest has spread to the automotive industry where engine, transmission and structural components are likely candidates. An aluminum wheel manufacturer has inquired about using MAX to make measurements in previously inaccessible locations. Large structures, such as piping systems, tanks, bridges and towers, are all potential beneficiaries of MAX's capabilities. Strategies for commercialization have targeted aerospace and automotive applications while developing similar opportunities in industries that utilize large structures.

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