Firm: Radiation Monitoring Devices, Inc.
Contract Number: NNX11CH16P
Project Title: Wireless, Low Mass, High Sensitivity Sensing Sheet for Structural Sensing and Long Term Analysis

Identification and Significance of the Proposed Innovation

NASA needs structural sensors to inspect space vehicles with minimum human interaction for add-on modular inspection systems, built-in flight monitoring systems, and on-orbit nondestructive evaluation (NDE) systems. Highly integrated, self-sufficient, low mass, simple to operate monitoring systems that provide reliable information are needed.

Eddy current testing (ECT) is a widely practiced, and critically important, NDE method used in aerospace, but traditionally it involves sensor scanning making it unsuitable for long term, autonomous monitoring. RMD proposed an NDE imaging and analysis technology based on a flexible sensing sheet containing a two-dimensional array of microscopic, solid-state eddy current sensors. The 100 um thick sensing sheetcould be added to spacecraft prior to launch or while in space. The system will automatically create and analyze images of defects over time.

RMD designed, fabricated and tested 2D sensor sheets and showed that small defects can be detected with high resolution without the need for scanning sensors.The prototype sensor array is thin, flexible, and suitable for permanent placement and operation on curved surfaces.RMD developed electronics and software to operate the sensor elements.Images were made of defects in and they were shown to be of comparable quality to scanned images.

Technical Objectives and Work Plan

The technical objectives were to show that it is possible to create a 2D array of eddy current sensors on a flexible substrate and create images of defects by placing the sheet on a sample containing minute defects. The following work tasks were addressed:

TASK 1 - Develop a detailed definition of the problem and establish sensor specifications
TASK 2 - Computer modeling and simulation of sensors, sensor module, and defect response
TASK 3 - Fabricate or procure test samples
TASK 4 - Fabricate prototype sensor arrays using silicon and polyimide substrates
TASK 5 – Phase I Prototype - Electronics, software and inspection system
TASK 6 - Test and compare the sensing sheet with a commercial ECT single channel system

Technical Accomplishments

During Phase I, RMD was able to show feasibility of the concepts by accomplishing the following:

TASK 1 – Develop specifications for the Phase I prototype sensor array and electronics support system
TASK 2 – Computer model to simulate the response of the sensor array to defects that was used to design the sensor array
TASK 3 – Fabricated test sample with defects between 100 and 600 um long in aluminum and Inconel
TASK 4 - Fabricate highly functional flexible prototype sensor arrays 100 um thick with 11 by 11 sensor elements
TASK 5 – Developed electronics and software to operate the array, collect data, and create magnetic images of defects
TASK 6 –Showed the 2D sensor array can form images of similar quality to ECT systems using traditional scanning methods and single channel probes

NASA Applications

NASA has identified ESMD, the Exploration System Mission Directorate, as an enabling technology:

- Deployment after micro-meteoroid or orbital debris (MMOD) impact or other structural event damage for use on Human Spacecraft in low earth orbit.
- Validation of fleet leader assets
- Reduction of structural qualification test time

Non-NASA Commercial Applications

As society becomes more and more dependent on complex capital equipment, it is imperative that unplanned downtime be minimized. To ensure that equipment is available, companies are integrating Health Usage Monitoring Systems (HUMS) into their product lines. HUMS are a vital tool to help prevent the degradation or failure of assets by monitoring and analyzing their health status in real time. With this technology, prognostics can be carried out to drastically reduce maintenance operations downtime and dramatically lower costs.

Non-NASA applications can be found in both the public and private sectors. The aviation, automotive, energy generation and transportation industries all have a critical need for structural sensor systems that can be integrated into comprehensive Health Usage Monitoring Systems to inspect vehicles, structures and equipment with minimum human interaction. These systems must be highly integrated, self-sufficient, small, simple to operate and provide reliable data.

The advent of HUMS promises to provide significant new capabilities to redefine reliability by being able to proactively address potential problems before they actually cost the customer repair time, money and expensive downtime. HUMS provides an improved framework to better manage life cycle maintenance for vehicles which, in turn provides an immediate cost saving opportunity.

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