DAMAGE DETECTION IN AIRCRAFT

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ABSTRACT

Micro and nano-electronics have become indispensable in measurement and control technology, meeting the increasing demand for sophisticated sensor systems in many fields of technology. There have been generations of sensors with increasing functionalities like obstacle identification, re and re direction of aircrafts and missiles being used till date. The detection of radiological, biological, chemical warfare agents and other hazardous vapors has great significance in enhancing homeland security efforts. Sensors are playing a vital role in these areas.

1. INTRODUCTION

The automatic damage detection for aircrafts will save a lot of money and time when there is repair, thus the life time of the aircraft is increased. Presently an aircraft runs for an average life of 40 years. This can be improved. The new detection process can be performed remotely, at the press of a button or automatically online. This is possible through structural monitoring. With the advent of latest technology, photon sensors can also be used to upgrade present aircrafts' structure and make it easier for the maintenance in the aerospace industry.

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2. TRADITIONAL REPAIR

A large component in the life cycle costs of large complex vehicles like an aircraft arises from the need to perform structural inspections. These are often performed in a schedule such as for a civil aircraft. A heavy maintenance check will require the aircraft to be out of service for several days and necessitate the stripping down of large parts of structure. Often, no faults are found but the inspections are a mandatory requirement driven by stringent safety or operational requirements.

3. THE CHANGE

"Flying a modern aeroplane is one of the most challenging and exciting activities in the world."
The damage detection technology can one day allow structures to inspect themselves and keep them high in air for a longer life time. Damage to the structures of aircraft or other vehicles can be detected automatically by using sensors that 'listen' for cracks.

Other forms of sensor can continuously probe the structure using sound waves and pick out changes that occur when the structure is damaged. All this amounts to a form of built-in inspection which automatically checks the structure and can provide a structural diagnosis for maintenance. This is done by using acoustic sensors for locating damage in composite and metal structures.

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Structural health monitoring offers the possibility of detecting damage automatically as it occurs. Permanently installed sensors would constantly monitor the structure and flag the occurrence of cracks or damaging impacts. The structure would then only be taken out of service for repair when damage is known to have occurred. This could greatly reduce the need for scheduled inspections and so reduce life cycle costs. The technology is under maturation for aircraft applications and demonstrations of the technology are underway.

4. RESEARCH AND TESTING

British Aerospace (BAE) Systems, Johannesburg has recently demonstrated this integrated real-time automated damage detection system on a Hawk fighter jet that could be joined to the South African Air Force fleet. The British defence company says that the system consists of a constellation of smart sensors that can automatically inspect structures for the onset of damage. It is claimed to potentially save the aviation industry and air forces from millions in servicing and support costs. The flight trial is an important step towards the eventual goal of self-inspecting aircraft.

4.1 The AHMOS (Advanced Structural Health Monitoring System):

The technology of the AHMOS allows information gathered from an inspection performed by sensors to be downloaded on to a computer. This technology is being developed as part of a European Research and Development. Jim McFeat, AHMOS technical manager at BAE Systems, said that the structural inspection is a significant factor in the cost of supporting fleets of both military and commercial aircraft.'The new system aims to avoid lengthy and expensive structural inspections that require the repeated dismantling of large sections of aircraft. Very often such inspections are just precautionary, as no faults that need a repair are found.

Fig. 1 The AHMOS Hawk Fighter Jet that was tested by BAE Systems later this year.

The flight trial, which tested a padded Active Health Monitoring System (AHMOS) on a Hawk trainer aircraft, is claimed by the company to have "demonstrated for the first time the operation of a fully integrated automated damage-detection system within a flight environment".

Structural inspection is recognized as a significant driver in the cost of supporting aircraft fleets. Moreover, as many platforms can now be expected to enjoy a service life of 40 years or more, the servicing required to maintain even more stringent airworthiness standards becomes increasingly costly. During flight testing, the “acoustic emission detection” kit housed in a self-contained pod attached to the underside of the Hawk was able to pinpoint cracks in specifically designed dummy structures and download a diagnosis when the aircraft landed.

4.2 Results sound to be good:

Using a combination of strain gauge sensors and fibre optic cables connected to a computer, and contained within an aerodynamic pod under the fuselage of the Hawk the technology is now demonstrated. They compared all of the aircraft's manoeuvres in flight with the pilot's notes and our own computer, and in the two flights so far undertaken, got good results. They have three other flights planned before the issue of formal report in early 2008.

Ultimately, they are trying to automate the non-destructive testing process in the same way that car manufacturers have done for engine management systems. The customer will plug a computer into a data-box on the aircraft and download in-flight information gathered from gauges and sensors at strategic points. If the sensors fitted deep inside the aircraft structure, can reliably detect the onset of damage, the need to dismantle sections of the airframe will be considerably reduced. The new detection process can be performed remotely, at the press of a button or automatically online. It is estimated that this could save many millions of pounds over the lifetime of a fleet.

Fig.2 C130 aircraft

5. SENSORS USED TO CREATE SMART STRUCTURES

5.1 Optical Fibre Sensors:

Airframe fatigue management relies on recording and predicting the usage of the aircraft. Strain gauges distributed on a structure will give the most direct and accurate indication of fatigue consumption. This approach does, however, rely on reliable strain measurements in a sufficient number of locations.Optical fibre sensors (like Bragg grating strain sensors) offer significant advantages over electrical, resistive foil strain gauges which are currently the state of the art for structural monitoring. Also there was a maritime application in the form of a 35m composite yacht mast with embedded Bragg grating sensors that was demonstrated. Having gained confidence, the work then progressed to the more demanding aerospace environment, only this time using surface mounted sensor configurations. Fibre optic sensors were embedded into a carbon fibre, ocean going yacht mast. A complete structural monitoring system was developed and underwent sea trials aboard a luxury yacht equipped with a 35-metre mast rig. Following the successful maritime demonstration a similar system was fitted to a BAE Systems Jet stream test aircraft and underwent a series of test flights from the Air Systems Wharton aerodrome.

Fig.3 Fibre optic sensor

5.2 Nano Sensors:

However compact the system may be, the shift is toward developing smaller portable systems with highly sensitive sensors. With the advent of nanotechnology, gold nano-materials are currently being experimentally developed and evaluated for use in sensors for bioweapon and toxin detection.

5.3 Humidity Sensors:

As the name suggests these sensors are used to sense the relative humidity. The performance of a humidity sensor can be determined by its accuracy, repeatability, interchangeability, long-term stability, ability to recover from condensation, resistance to chemical and physical contaminants, size, packaging, and cost efficiency. With advancements in materials technology and technologies such as thin film deposition, ion sputtering, and ceramic/silicon coatings, humidity sensors with high accuracy and resistance to chemicals and physical contaminants are more readily available economically. Capacitive polymer RH sensors can offer such advantages as a relatively wide humidity and temperature range, very minimal hysteresis, good stability and repeatability, low temperature coefficient, and a relatively rapid response time.

5.4 Magnetic Field Sensors:

Magnetic field sensors are widely used to provide information about rotational speed or position in diverse automotive applications, such as wheel speed sensing (used in conjunction with antilock braking systems [ABS]), engine management (for example, camshaft or crankshaft ignition timing), transmission speed sensing, seat position sensing, seat belt sensors, electric power steering, transmission range sensors, transfer case position or speed sensors, i.e., they

5.5 Variable reluctance (VR) sensors:

The VR sensor use a magnet and coil, represent an older magnetic sensing technology that has, historically, been used in volume for automotive wheel speed sensing, high-volume automotive applications like engine and transmission speed sensing. It is a passive sensor, which does not require an input current. Active sensors use an input current to generate a digital signal. It has limitations, for example, in camshaft position or angle sensing for ignition timing (the moment at which to fire a spark in each cylinder). Other automotive applications where the sensor's ability to provide a zero-speed signal can be advantageous include car navigation and ABS applications.

5.6 Photon Sensors*:*

Photon sensors use the photon detection technology. There are fast photon detectors capable of achieving 100-200ps timing resolution per single photon being developed. A multi-pixel photon sensor with single-photon sensitivity has been developed. Based on a hybrid photo-detector (HPD) technology, it consists of a photocathode and a multi-pixel avalanche diode (MP-AD). The developed HPD has a proximity-focused structure, where the photocathode and MP-AD face each other with a small gap of 2.5 mm. The MP-AD, which has an effective area of 16mm×16mm, is composed of 8×8 pixel and has been specially designed for the HPD. The gain of the HPD is sufficiently high to detect single photons with a timing resolution better than 100ps. Up to four photoelectrons can be clearly identified as distinct peaks in a pulse-height spectrum, thanks to the low noise characteristics of the HPD. It is also demonstrated that the HPD can be operated with good performance in a magnetic field as high as 1.5 T. The most important point in the era of gaseous detectors is to suppress the ion backflow to cathode, which limits the maximum achievable gain in these types of devices.

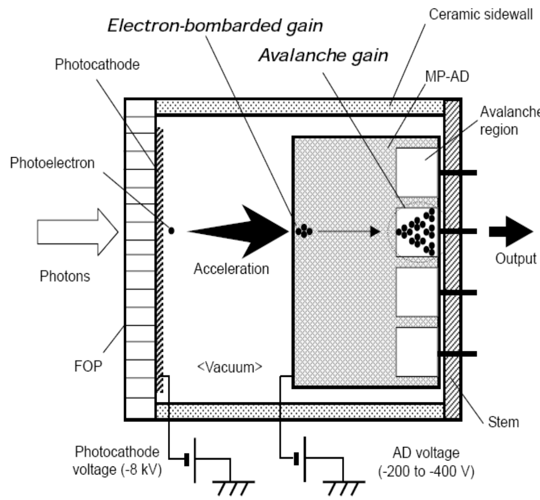

Fig 5: Schematic illustration of the developed HPD.

6. CONCLUSION

Sensors are gaining importance in the field of technology day by day with new inventions and discoveries. The combined use of these sensors in an aircraft would lead to a new sophisticated smart and self inspecting aircrafts and the causes of accidents can be minimized.Commercialization is being aimed at with the usage including the high energy experiment of the semiconductor light detector of a new type.

If we INDIANS can utilize this technology and develop more sophisticated systems we are sure that we would see one day where we can beat the world. “Engineers are just beginning to realise the potential value of this type of structural monitoring.”

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8. REFERENCES

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