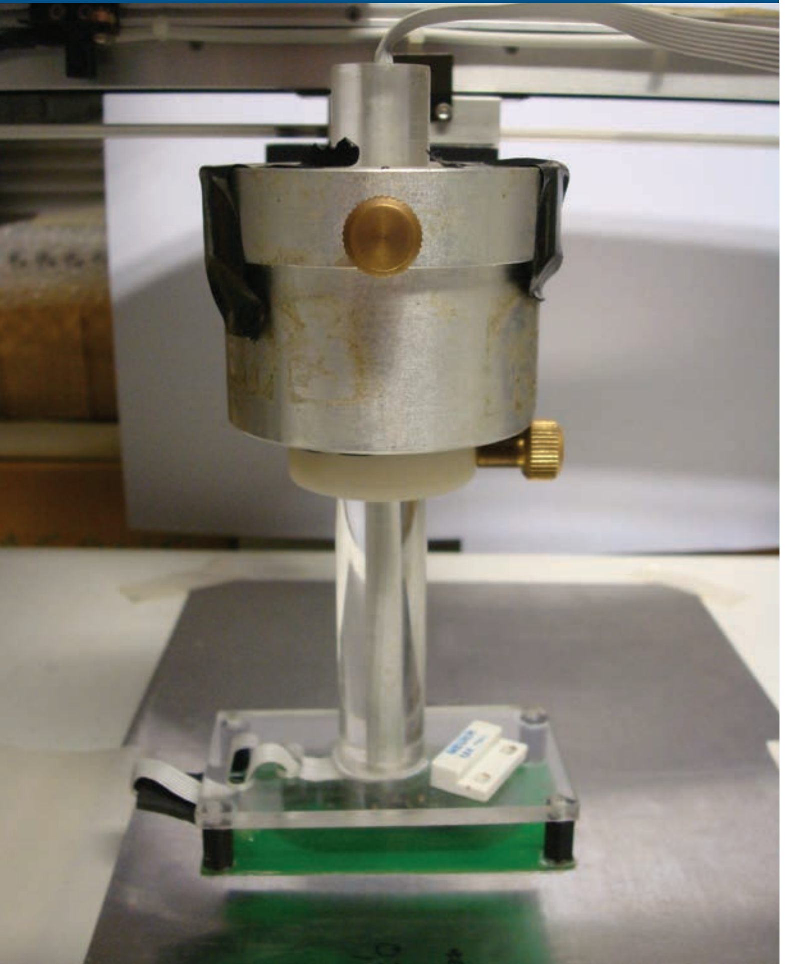
OMEGA

OPTICAL MEASUREMENT OF GUIDED ACOUSTIC WAVES IN SOLID MEDIA

In this project we apply the ultrasound method to establish an experimental detection of defects inside solid structures whose structural health monitoring is of great importance. This is the case of the aircraft structures, the liquid or gas pipelines in nuclear power plants or other containers subject to high pressures. The methodologies that the team adopts are mainly based on experimental procedures. However there are also theoretical tasks that had been carried out.



The importance of the non-destructive evaluation (NDE) techniques to asses the damage inside structures is based on simple evidence. The failure of some structures can cause immense monetary loss and even loss of life. We must remember the sad disasters like the Eschede German train crash in 1998 caused by fatigue cracks in the wheel rims. In other occasions comparable disasters were miraculously avoided, like the accident with the Airbus 310 in 2005 when the vertical stabiliser fell in flight five days after a routine check being the next more rigorous check scheduled for 2006.

It is thus understandable the importance of the structural health monitoring (SHM) in different human activity contexts.

I and the other colleagues in this team have been working on non-destructive testing using the eddy current method. We have obtained some interesting results and we are still working on that area. One important application of the eddy current method is the inspection of metallic parts of airplanes. It is a quite sensitive method capable of detecting superficial fatigue cracks. The eddy current method is included in the inspection periodical routines of all the types of aircrafts.

However, like any other method, the eddy currents present some drawbacks. The most important is the fact that it is only applicable to metallic electrically conductive materials, and a lot of non-metallic composite materials are increasingly substituting conventional aluminium parts. Another difficulty resides in the impossibility of detecting deeply buried defects due to the limitation of the field penetration inside the materials.

In the case of plates the ultrasound waves may be guided by the free upper and lower surfaces forming the so called Lamb waves. An infinity number of modes is possible for a given operating frequency. The propagation modes are usually divided in symmetric and anti-symmetric modes.

To propagate ultrasound guided waves we must know how to excite a given mode using the appropriate transmitter and to extract the damage-scattered wave signal using the appropriate sensor or sensor network.

To extract information from the acquired signals good signal processing schemes are needed.

To establish a quantitative or qualitative connection between the extracted signals characteristics and the damage parameters we used physical models or pattern classification procedures.

To couple the ultrasound waves into the material we intend to use both contact and non-contact transducers. The contact transducers were of the piezoelectric type and the non-contact were electromagnetic acoustic transducers.

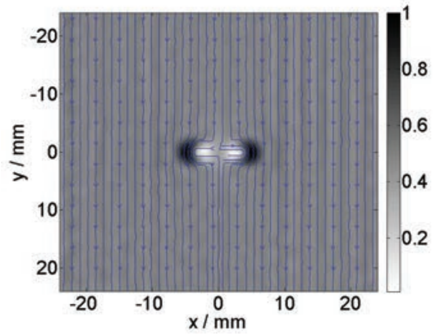


Fig.1 -

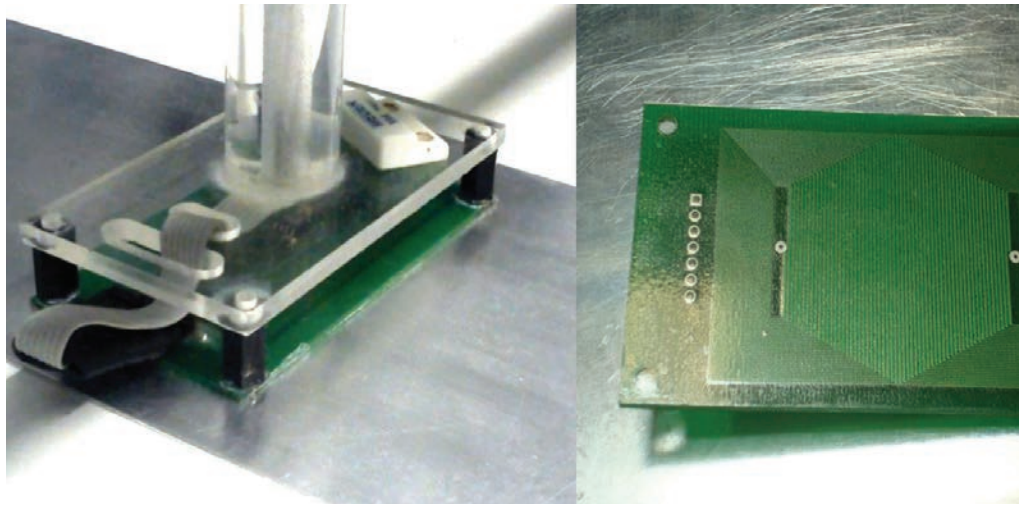


Fig.2 -

ACHIEVEMENTS

In our experimental tests different types of transducers were used. These tests included the ultrasound excitation by piezoelectric (PZT) transducers and electromagnetic acoustic transducers (EMATs) as receivers. Due to budget shortage we had to construct our sensors.

One important test consisted in the determination of the maximum gap between the EMATs and the metallic plates that can be used without too high signal attenuation. The result could prove that EMATs are usable in non-contact experiments when the material under inspection is moving with relative high speeds. This condition occurs in several industrial environments and also in the inspection of railways where superficial ultrasonic waves can be propagated on the rail heads to detect the presence of dangerous breaking cracks. Our interest in this issue was motivated by the talks that we maintain with people in the aeronautic and railways industries.

One prototype using electromagnetic acoustic transducers (EMATs) was constructed. The aim was to produce and detect acoustic Lamb waves.

In this project the work on eddy current inspection was further developed due to the continuation of the supervision of the thesis of one of our students. One prototype with software able to determine the geometry of electric current lines within the non-ferromagnetic metal was constructed.

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FUNDING	41 K€
JOURNAL PAPERS	6
CONFERENCE PAPERS	14
REPORTS	2
MSC THESES	2
PROTOTYPES	3

PUBLICATIONS

- Ribeiro, A. L.; Ramos, H. G.; Postolache, O.; "A simple forward direct problem solver for eddy current non-destructive inspection of aluminum plates using uniform field probes", Measurement, Vol. 2012, No. 45, pp. 213 - 217, January, 2012.

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- Pasadas, D.; Ribeiro, A. L.; Rocha, T.; Ramos, H. G.; "Remote field eddy current tube inspection using giant magneto-resistance sensors ", International Journal of Industrial Electronics and Drives, Vol. 1, No. 3, pp. 167 - 173, July, 2014.