

UNDERWATER HOLOGRAPHIC INTERFEROMETRY FOR STRUCTURAL ANALYSIS

MONTEIRO, J.M.¹; LOPES, H. M.²; J. L. VALIN RIVERA³; VAZ, M.A.P⁴

¹INEGI- Instituto de Engenharia Mecânica e Gestão Industrial, ²ESTIG - Instituto Politécnico de Bragança, ³ EST - Universidade do Estado do Amazonas, ⁴DEMEGI - Faculdade de Engenharia da Universidade do Porto
Rua Dr. Roberto Frias, 4200-465 Porto, Portugal
jmont@fe.up.pt; gmavaz@fe.up.pt

ABSTRACT: The main objective of this work was to study the application of holographic interferometry techniques to structural analysis in an underwater environment. These are nowadays well known techniques and with applications in different fields. However, its application in underwater environments, presents some new challenges. In this work it is studied the application of two techniques, ESPI (Electronic Speckle Pattern Interferometry) and digital holography, comparing them and presenting the advantages and disadvantages of each one. A brief study is made concerning the influence of the resultant instabilities of the turbulence in the water and from the particles in suspension; some possible solutions to minimize these problems are also discussed.

1. INTRODUCTION

Some structures like the offshore, gas-lines and pipe-lines are nowadays widely used in the prospecting industry of natural gas and oil. Its use has trend to grow with the use of these structures in new applications like: underwater mineral prospecting and the generation of energy, either through the use of sea waves, or through the installation of wind energy parks in sea platforms. Placed normally in the open sea, these structures are exposed to severe dynamic requests resulting from hydrodynamic loads. Submitted to impact, fatigue and severe corrosion all this factors added can lead to catastrophic structural failures. This way, to guarantee high security standards, a regular maintenance is necessary, either of the submerged structures, or of the non submerged parts. From this results the need to have reliable non destructive inspection techniques that can be used in the maintenance of submerged structures. With these techniques will be possible to detect in useful time structural defects that compromise the structures integrity. The holographic interferometry techniques are nowadays perfectly developed and tested and have enormous potential for this application. Placing a laser and the optical setup on board of small submarines (ROV) will be possible to use these techniques directly on in service structures. The use of small submarines presents another advantage which is the fact that the entire maintenance program can be done without the presence of the human being, avoiding this way situations of human integrity risk. It is not of the knowledge of the authors the existence of any available equipment to execute underwater structural inspection with optical techniques. Several systems are available to execute the underwater inspection of structures using conventional techniques such as: ultra sounds, X rays and Eddy currents.

2. OPTICAL TECHNIQUES

Some preliminary experiences carried out with underwater holography had shown promising results and proved the potential of these techniques in this particular application, namely in what concerns the underwater measurement of the displacement fields [1, 2]. The most recent work was carried out in laboratory without taking in account the turbulence of the water as well as the presence of microorganisms and suspension particles. However, this is a problem to have in account since there is attenuation of the beam through the absorption and dispersion mechanisms and the movements of the water disturb the stability of the assembly [1]. The dispersion is due to the small particles in suspension. The turbulence is probably the main factor in the loss of resolution of the image formation system, and is a consequence of currents or convection phenomena. The aberrations and image movement could be corrected appealing to a solution of adaptive optics for correction of the wave front and to the use of pulsed techniques to eliminate the influence of the instabilities. These problems could still be minimized if the system is stable and rigidly placed near the object.

2.1 ESPI and Digital Holography

ESPI is a holographic interferometry technique that uses laser radiation and a conventional holographic setup being the hologram recorded in a video camera. It is a field technique with high resolution and with the advantage to allow the recording of holograms at video frequency (25 holog./s). The holograms are obtained in real time and stored as numerical files which can be afterwards post processed.

Digital holography is based on the same principle of the previous technique, but in this case no image formation system is used between the object and the video camera. This way the reconstruction of the wave front diffused by the object is made numerically. Both techniques share the electronic recording of interferometric patterns using conventional video cameras.

3. RESULTS

The previous techniques have been applied in different areas but always with the laser radiation propagating in the air. With the objective to verify which were the differences and difficulties due to the fact of the laser radiation propagates in an aquatic medium, a setup was built using an aquarium. All the optical setup was carried out in the exterior of the aquarium being the object to be studied dived in its interior. This situation intends to simulate the conditions of a submerged chamber in any ROV for underwater applications. As object of study we selected a pipe with a partial crack. Fig. 1 shows the phase map of the pipe, dived in aquarium with water and loaded by internal pressure, revealing the crack.

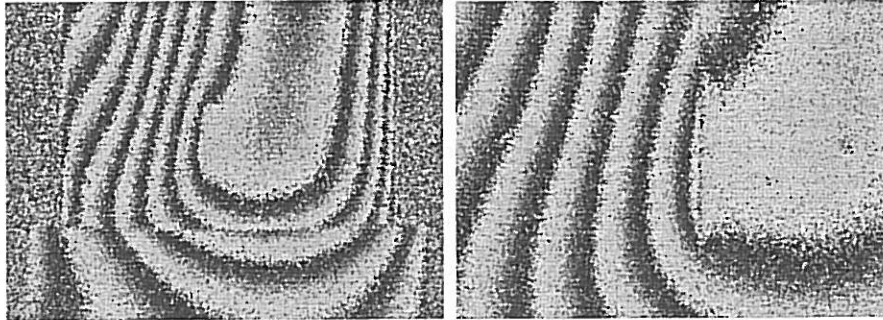


Figure 1- Phase map of the pipe and the crack detail.

4. CONCLUSIONS

The technique here proposed can have positive repercussions in the inspection of offshore structures and pipelines, since optical techniques are reliable and precise tools for structural analysis. With these techniques is possible to detect, with high resolution and without contact, defects that can compromise the structural integrity. It is possible to construct a compact and reliable system capable to be mounted in a small submersible, obtaining this way a tool for inspection and control of underwater structures

5. REFERENCES

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