COMPARING POLYMER OPTICAL FIBER (POF), FIBER BRAGG GRATINGS AND TRADITIONAL STRAIN GAUGE FOR AIRCRAFT STRUCTURAL HEALTH MONITORING

J. Gómez[1], J. Zubia[1], G. Aranguren[1], G. Durana[1], J. A. Illaro[2], I. Sáez[2], M.Kirchhof[3], H. Poisel[3], E. Hartl[3]

[1]Department of Electronic and Telecommunications, University of The Basque Country, Bilbao, Spain

[2]Department of Research, Development and Innovation, Aeronautical Technologies Centre, Miñano (Vitoria), Spain

[3]Polymer Optical Fiber Application Center, University of Applied Sciences, Nuremberg, Germany

Introduction

Recently, the Polymer Optical Fiber Application Center (POF AC) at the University of Applied Sciences, Nuremberg has developed a polymer optical fiber (POF) elongation sensor. This work analyzes if this design could substitute the traditional strain gauges that are commonly used in Structural Health Monitoring (SHM) tests, or the quite recent sensors based on fiber Bragg gratings.

POF sensor and SMH test

This sensor is based on measuring the phase shift between two sinusoidally modulated light signals that propagate through two polymer optical fibers. Changes in the length of the fiber, which can happen, for example by tensions, result in a phase difference and can be detected by the sensor. We have tested all these sensors under the same conditions, with the set-up attached to the surface of an aeronautical wing flap. This was mounted in a testing machine for bending. An actuator deflected the wing flap ±10 cm. Different tests consisting in single, step-by-step and cyclical movements at a varying velocity and with a varying duration was carried out in order to evaluate the sensor behavior.

We decided to make this comparison to see if the POF sensor could be as good as traditional fiber Bragg grating sensors to measure vibrations and elongations in aeronautical structures. The POF sensor had already been used in others environments but not in the aeronautical one[1], however, fiber Bragg grating sensors are usually used in aeronautical structures and wind turbines[2]. In Fig. 1, we can see the testing assembly with the actuator, the interface plate, the wing flap and the framework; and in Fig. 2, there is a block diagram of the detector of phase difference and of the distribution of the fibers, one for the upper side of the wing flap and the other one for the bottom side.

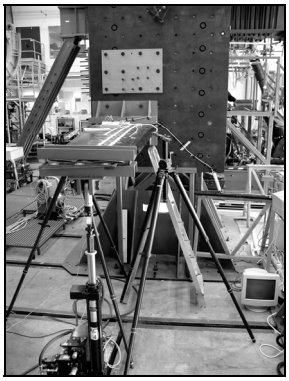

Figure 1. Testing assembly

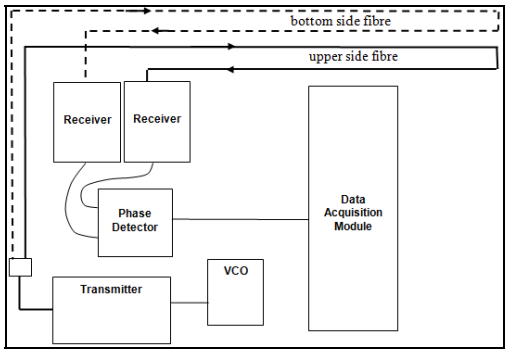

Figure 2. Block diagram of the Phase Difference detector for the POF sensor

Conclusion

We achieved really good results, especially in cyclical tests and with fast movements. In Fig. 3, there are graphics of cyclical movements from -10 cm to 10 cm of both sensors. It is clear that there are not differences between them. Both signals have good resolution, with great amplitude and good repeatability. POF sensor could substitute fiber Bragg gratings on several tests of aeronautical structures with a lower price and the same results.

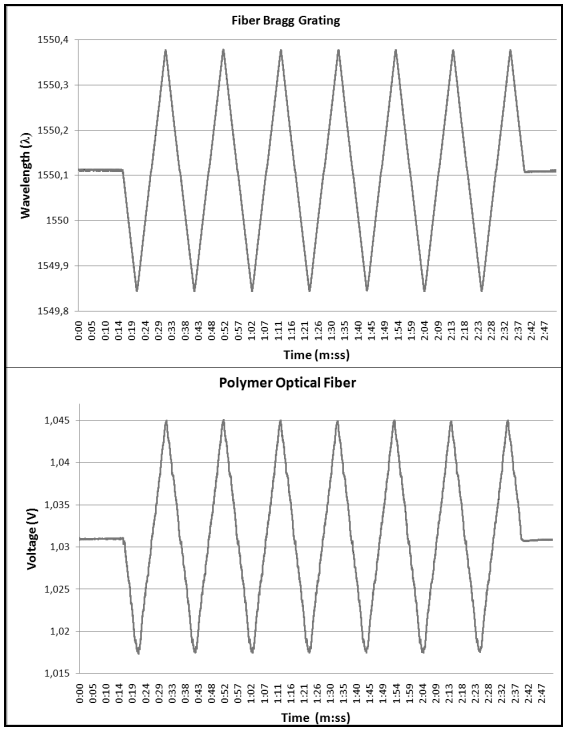

Figure 3. Fiber Bragg Grating vs. Polymer Optical Fiber in cyclical bending test

References

[1] Poisel, Luber, Loquai, Neuener, Bachmann (POF-AC). "POF strain sensor using phase measurement techniques". 16th International Conference on Plastic Optical Fibers 2007 (ICPOF 2007). Turin, Italy.

[2] Fernandez, Güemes, Fritzen, Mengelkamp. "Comparison of Health Monitoring Systems with fiber Bragg grating and piezoelectric sensors". 3th European Workshop on Structural Health Monitoring, 2006, Granada, Spain.