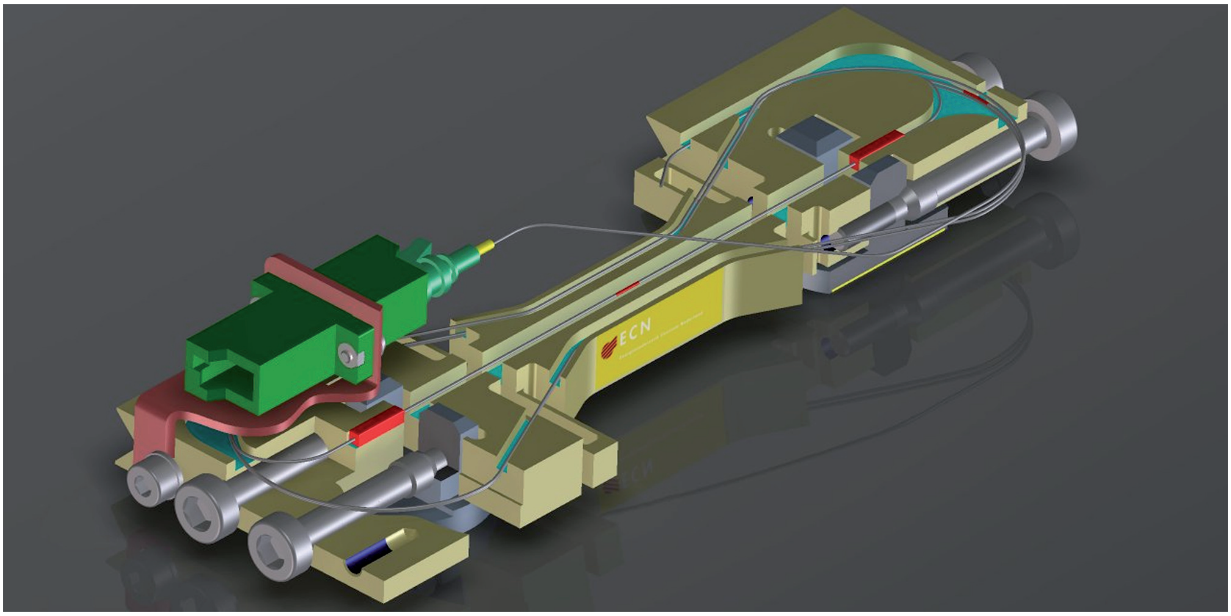
DOWES
Dutch Offshore Wind Energy Services

Strain Sensor Assembly

Based on Fiber Optics

How can strain be measured with Fiber Optics?	The use of Fiber Bragg Gratings is the most eligible technique to replace the electrical strain gauges.
Why Fiber Optics?	→ No EMC → Long life time → Sensitive element needs no calibration
What are challenges to be overcome?	→ Complex installation and maintenance → Expensive sensors and instrumentation → Mutual differences between identical sensors
What is the contribution of this Strain Sensor Assembly to a complete technical solution?	→ Plug and play installation → Replaceable → Potential for cost reduction



Advantages of Strain Sensor Assembly
- Plug and play by regular technicians
- Avoidance of local effects by increased measurement area
- Replaceable without recalibration
- Suitable for long term and recurring measurements
- Temperature compensation included
- More measurement directions possible

Technical specifications
- Accuracy 5 με
- Resolution 1 με
- Long term drift 5 με
- Replaceability 5 με
- Strain range ± 2500 με
- Temperature range -20…40°C
- Maximum strain ≅ 6%
- Long life time (> 10^7 cycles @ ±1000 με)

Objectives

Optical strain measurement based on Bragg technology is a logical successor of the electrical strain gauge, because of the long life time, large allowable strains and the EMC immunity. However larger scale implementation is hindered for several reasons. The installation requires special tools and knowledge and the prices are very high. A breakthrough is hindered by the lack of a complete technical solution.
ECN has developed a sensor which can easily be installed and replaced in the blade of a wind turbine without additional special tooling and skills. The life time of the sensor is sufficient to survive the life time of the blade. The accuracy is sufficient to derive the driving torque from the blade loads.
Another advantage of the optical sensors is that the grating itself does not have any drift. This means that recalibration is not necessary as long as the fiber has a stable connection with the material. This property is exploited in the development of the ECN sensor. The final result can also be applied for other applications, for long term as well as for recurring measurements.

Realization of the sensor assembly

The sensor assembly works similarly to a free fiber with a Bragg grating clamped between two positions of the objects to be measured. This implies that the measured strain is not affected by adhesives in the Bragg area nor by the properties of material which support the fiber.

Carrier

The fiber is mounted on a carrier which:

- Clamps the free fiber under pretension for positive and negative strain measurements;
- Supports an second Bragg sensor in a area free of strain for temperature measurement;
- Supports two connectors at both ends of the fiber in order to build a string of sensors;
- Hardly loads the clamping points (studs);
- Protects the fiber for damage during handling.

The carrier can be calibrated in the laboratory before mounting and needs no re-calibration on site.

Studs

The carrier is mounted on two studs. These studs are the mounting interface for the carrier on the surface. The accuracy of distance between the studs and the mutual orientation are of major importance for the performance of the device. The mounting tolerances can be met by using a simple mounting tool. Mounting of the studs can be done during manufacturing or in the field.

The combination of the studs and the carrier enables simple replacement of the device in case of failure or to execute short recurrent measurement campaigns.

Protection device

A simple protection device can be mounted when the carrier is not mounted on the studs. This occurs during transport, installation and replacement.

Status of the development

Prototypes of the assembly are available and tested statically and dynamically in the laboratory. Field experiments in a large wind turbine are under preparation.

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