DYNAMIC CHARACTERISATION OF A DAMAGED COMPOSITE STRUCTURE WITH STIFFENERS EMPLOYING FIBRE BRAGG GRATINGS

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ABSTRACT

One of the key issues in composite structures for aircraft applications is the early detection and localisation of damage. Often service induced damage does not involve visible plastic deformation, but internal matrix related damage, like transverse cracks and delaminations. Their detection imposes costly maintenance techniques. Vibration based damage identification methods are promising as an alternative for the time consuming and costly Non-Destructive Testing methods currently available. These methods also offer the potential to be used in a real-time health monitoring system. The measured change of the dynamic properties is employed to identify damage such as delaminations.

Earlier performed research [1] showed that the Modal Strain Energy Damage Index algorithm [2] is a suitable method to identify impact induced damage in a fibre reinforced composite plate structure with stiffeners using laser vibrometer measurements. The damage identification algorithm requires the computation of the second derivative of the displacement mode shapes.

The goal is to extent this research by applying fibre Bragg gratings since they can be valuable. Firstly, optical fibre sensors are suitable for integration, which is required in a Structural Health Monitoring environment. Secondly, measured strain mode shapes could be advantageous with respect to the numerical errors induced by the computation of second derivatives of the displacement mode shapes.

Before applying the damage identification algorithm, it is a challenge to accurately extract the dynamic properties. The dynamic properties of a damaged composite T-shaped stiffener section, shown in figure 1, are investigated in this work using fibre Bragg gratings.

![Figure 1: Composite plate structure with stiffeners containing impact induced damage.](image)
A forced-vibration set-up, including a commercially available optical fibre interrogator system, is employed to measure the dynamic responses of the structure experimentally up to 2 kHz. A total of 4 optical fibres, containing 6 gratings each, are used. Operational Modal Analysis is applied to obtain the modal parameters.

The plate structure is built from 16 individual plies of uni-directional co-consolidated carbon AS4D reinforced PEKK. A quasi-isotropic lay-up [45/90/-45/0/45/90/-45/0],s is used. The fibre Bragg gratings are positioned at the connection between skin and stiffener (see figure 1). This is the location with the highest risk of failure under impact. The impact induced damage is also indicated in figure 1.

The main issues addressed in this study are the principal issues concerning dynamic characterization. The effect of extracting dynamic properties, in particular mode shapes, by using fibre Bragg gratings are compared to results obtained by a laser vibrometer. A translation is made between the mode shapes obtained from the velocity measurements (figure 2) and the strain measurements. Special attention is paid to the attachment of the gratings to the structure.

![Figure 2: Measured displacement mode shape of the intact and impact damaged composite plate.](image)

The experimental investigation will allow to conclude on the feasibility of using optical fibre Bragg gratings with a commercially available interrogator system for dynamic measurements. The experimentally obtained strain mode shapes can be used to enhance the damage identification by the Modal Strain Energy Damage Index algorithm.

REFERENCES
