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Acousto-ultrasonic analysis of defects in composite specimens used in transportation domain

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Within the transport industry, metal parts have recently been replaced by composite components due to their characteristics such as an increased strength and stiffness and reduced weight. Because of these properties, composite materials can be beneficial also in the railway industry, where there is still room for improvement regarding environmental measures. The adoption of new technologies at the inception of product design and development might decrease the sector's environmental impact. The substitution of steel with composite components can be one of the measures which could lower the rail car-body mass, thus introducing energy saving measures, while maintaining high safety standards.

To maintain these high standards, it is necessary to develop inspection and monitoring tools to detect, identify and measure occurred damage or deterioration state of transport means and infrastructure such as Non-Destructive Testing (NDT) and Structual Health Monitoring (SHM).
While NDT is used to inspect engineering structures in order to detect and identify flaws (cracks, inclusions, internal voids etc.), inhomogeneity in microstructures, loss in thickness, deformation and so on, a typical SHM system consists of an array of connected sensors, which collect data during the service life of the means and infrastructure in a continuous manner. The main objective of such system is to locate, detect and identify any occurred damage or decay state that takes place over the service life.

Acousto-ultrasonics is a non-destructive testing which can be characterised as a type of Acoustic Emission (AE) simulation with ultrasonic simulation of stress waves to assess defect states in certain materials, a widespread methodology within the SHM research.

AE constitute a significant methodology in the SHM research. AE, along with the underlying technology of piezoelectric transducer mechanism (lead zirconate titanate PZT and relevant piezoelectric ceramics and crystal), has played an important role in the detection of failures in the transport industry: AE monitoring applications comprise aircraft material state monitoring, high speed train car-bodies, bridges and rail tracks.
In this paper, the authors utilised the Mistras Micro-SHM system to perform three sets of experiments using composite material specimens and two different sensors: R6a and R15a. The first set of experiments consisted of the attenuation measurement of AE produced by Pencil Lead Breaks (PLB) indicating the impact of the reflection from its edges.

Fig. 1 –– Overview of the experimental layout with specimen and sensors; mistras micro-SHM wireless AE acquisition system

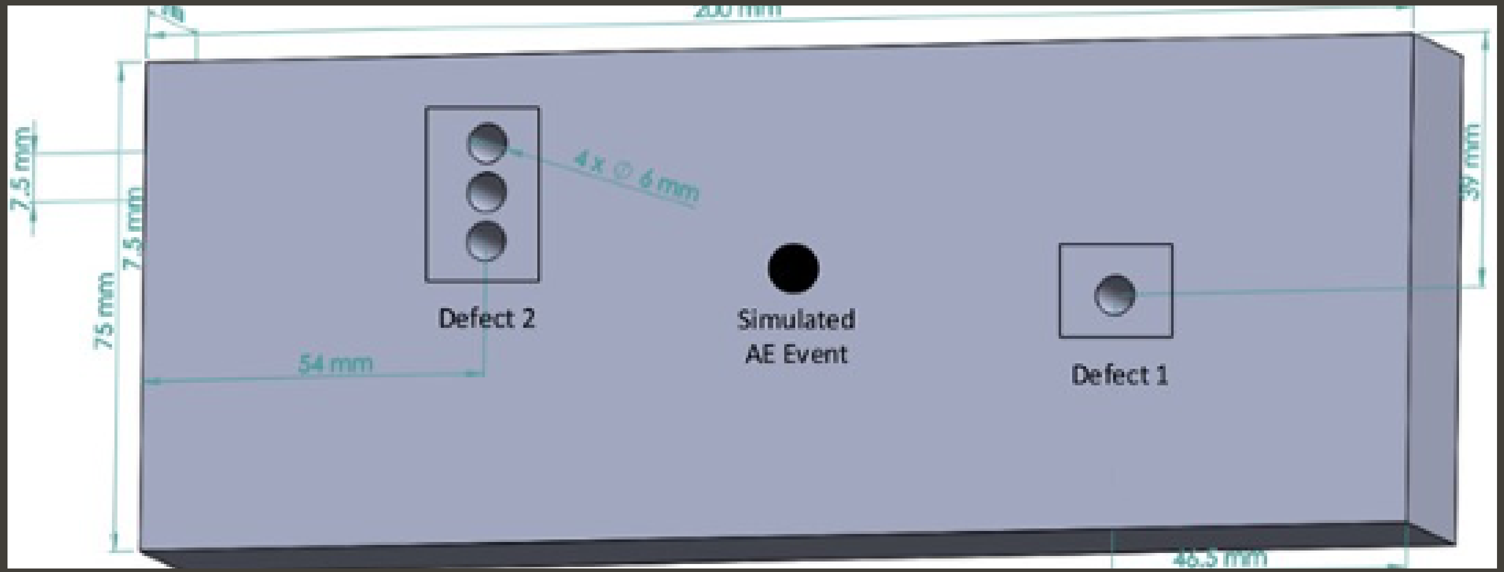

Fig. 2 –Model of defect experiment

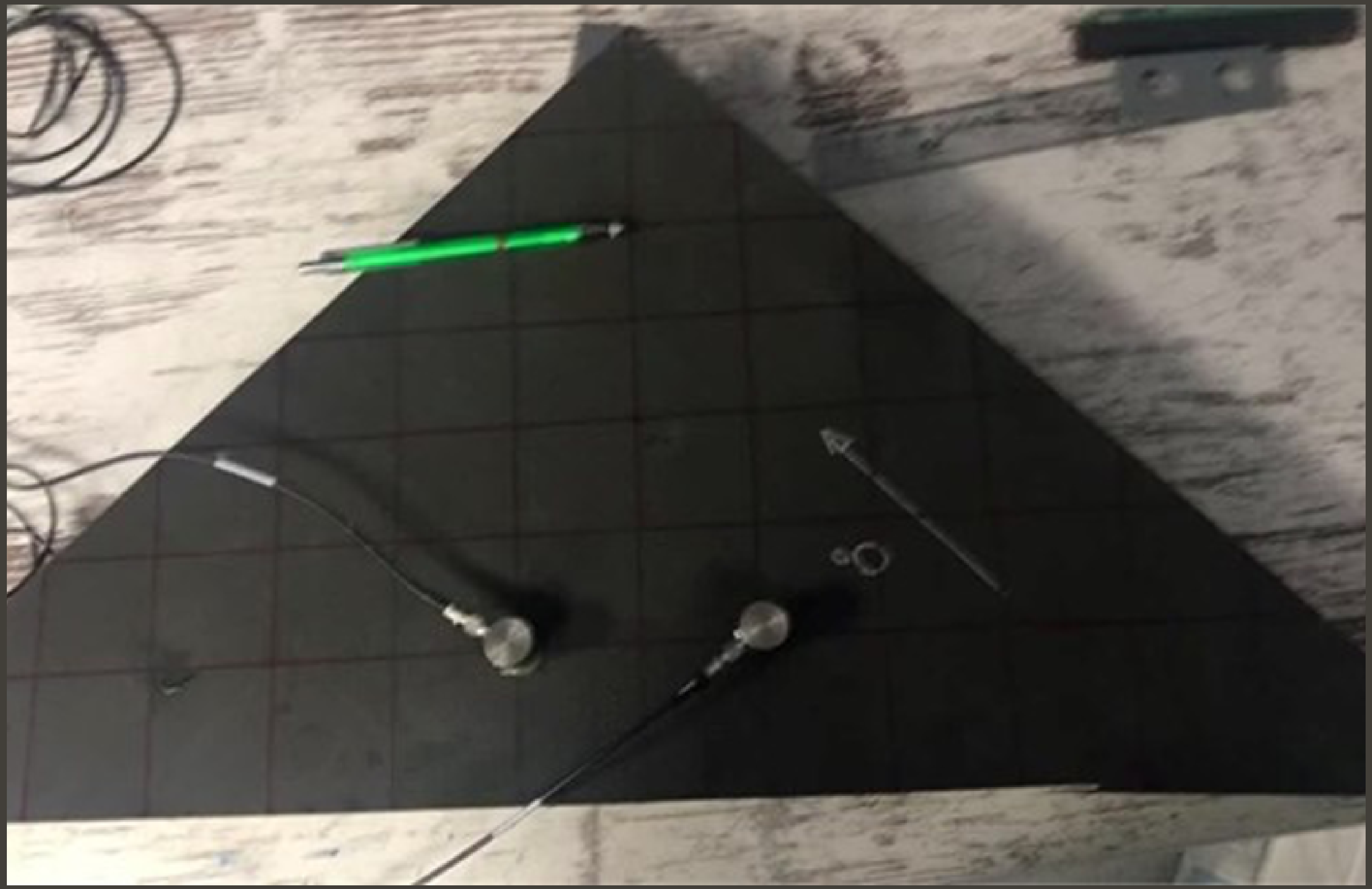

Fig. 3 Triangular-shape specimen with sensors and PLB position

The second experiment set consisted of three sub-experiments and its objective was to identify defects using two signal features. Finally, a new larger triangular-shape composite specimen was utilised in order to stress out the difference in the two signal features between the specimens.

The authors discovered that by increasing the distance between the sensors on two composite material specimens of different thickness from 50 mm to 190 mm, damping occurs. Furthermore, regarding the detection of defects, it was determined that the defects could be identified by the AE sensors, since the energy count and the amplitude are reduced in the presence of defects.
Moreover, utilising the two sensors on a larger specimen, the results showed that even though the distance is higher, the amplitude and PAC energy were higher than when using a smaller specimen.
These findings are indeed promising for future works on Non-Destructive Testing and Structural Health Monitoring, opening the way for the possibility of detecting defects – and improve railway safety – through innovative systems.

Link to the full Paper.

"An initial acousto-ultrasonic experimental investigation of defects in composite specimens used in the transportation domain", presented in the 48th International JVE Conference November 4-5, 2020 in Colombo, Sri Lanka, published in the Journal of Measurements in Engineering, Vol. 9, Issue 2, 2021, p. 117-127. with a new title "Acousto-ultrasonic analysis of defects in composite specimens used in transportation domain".

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