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EXPERIMENTAL EVALUATION OF THE ACOUSTIC EMISSION TECHNIQUE APPLIED TO COTTON FIBER COMPOSITE MATERIAL

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Abstract. Composites manufactured from natural fibres has gained special attention, since they can present good mechanical properties and can be discarded without polluting the environment, so the availability of their structural employment need to be studied. The objective of this work is to apply the Acoustic Emission (AE) Technique to a cotton fibre composite material in order to identify the fracture modes by means of the parameters obtained by this technique. Samples of this composite at three different orientation of fibre are tested: $[0^\circ]_8$, $[\pm 45^\circ]_{2S}$ and $[90^\circ]_8$ in a monotonic tensile test. Sensors of AE are coupled to samples and detect the emitted signals from the material simultaneously to the monotonic test. The elastic and mechanical properties of the composite are obtained and the AE parameters that presented more variation in function of orientation of the plies are used in the attempt of distinguish the failure mode of composite. It was observed that, for a given orientation, the AE curves for repeated samples were similar in shape but not in amplitude.

Keywords: cotton fibre composite, acoustic emission, failure modes.

1. INTRODUCTION

The use of composite materials has become a tendency in the last years. According to Misnon *et al.* (2014), carbon, glass, aramid, high modulus polyethylene and boron fibers are very common for composite reinforcement due to their properties such as light weight, high strength/weight ratio and high thermal stability. However disposal problems have been caused by the use of large volumes of polymer-based synthetic fiber composites, since they present non-biodegradable properties (Satyanarayana *et al.*, 2009; Begum and Islam, 2013).

Natural plant fibers have some advantages when compared to the synthetic fibers (Sathishkumar *et al.*, 2012). Golbabaie (2006) says that some of them are the low cost, corrosion resistance, improved resistance to high temperature creep, biodegradable. Still there are some challenges to solve, for example, designing and analyzing structures made from natural fiber composites. Therefore, it is important to know their mechanical behavior.

There are destructive and non-destructive techniques that are able to evaluate composites. Non-destructive is the preferred by preserving the structural integrity of component. An example of non-destructive technique is the Acoustic Emission (AE). AE is a method to detect crack growth in the material by the release of stored strain energy. Piezoelectric sensors can detect the elastic waves propagating through the material. An analysis of the signal parameters often allows the classification of cracks (Paul *et al.*, 2015; Muravin *et al.*, 2011; Ohno and Ohtsu, 2010).

The objective of this work is evaluating the signals emitted by AE in cotton fiber composites under monotonic loading, considering different ply orientations.

2. EXPERIMENTAL PROCEDURE

The samples studied were obtained by the VARTM (vacuum assisted resin transfer moulding). Polyester resin and unidirectional cotton fibre were used as matrix and reinforcement, respectively. The composites layup was $[0^\circ]_8$, $[\pm 45^\circ]_{2S}$ and $[90^\circ]_8$. Monotonic tensile test was conducted at a speed of 2 mm/min and were coupled two piezoelectric sensors in order to acquire transmitted signals, like showed at Figure 1. AE was analysed simultaneously to the monotonic tensile test.

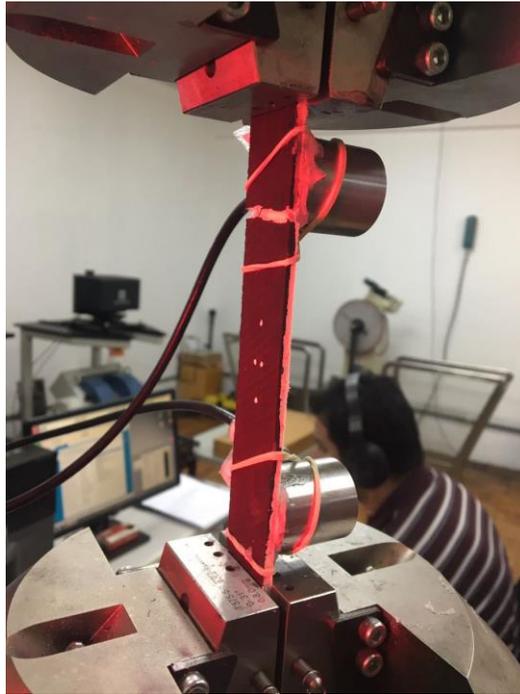


Figure 1. Sensors positioning.

3. RESULTS AND DISCUSSION

The following are some of the graphics obtained by AE technique during the monotonic tensile test of specimens.

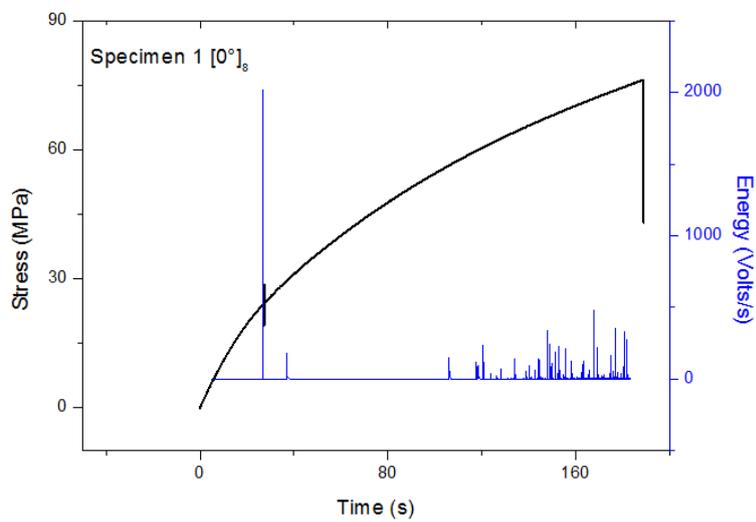


Figure 2. AE energy for sample 1 [0°]_s

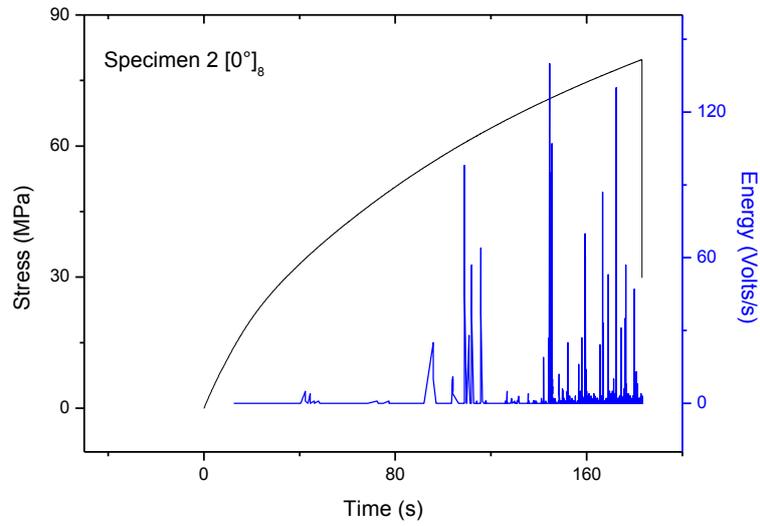


Figure 3. AE energy for sample 2 [0°]₈

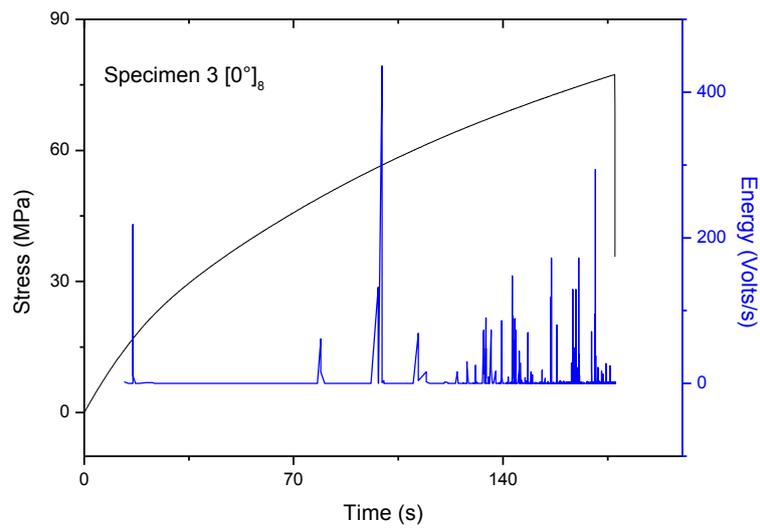


Figure 4. AE energy for sample 3 [0°]₈

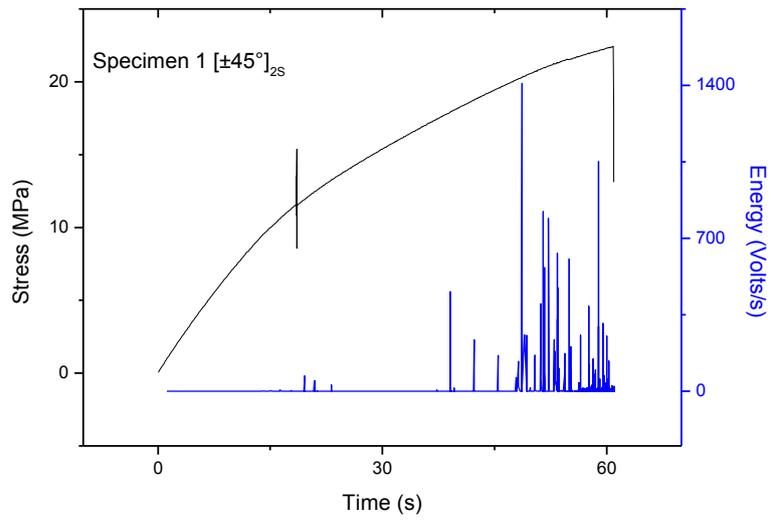


Figure 5. AE energy for sample 1 $[\pm 45^\circ]_{2s}$

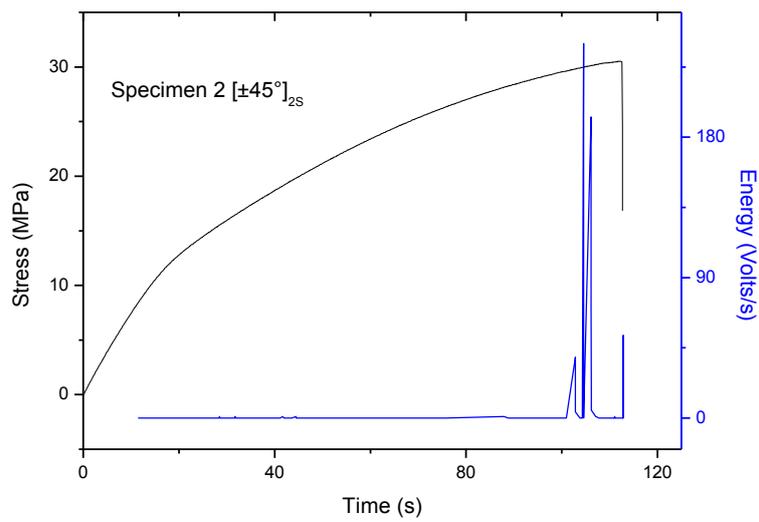


Figure 6. AE energy for sample 2 $[\pm 45^\circ]_{2s}$

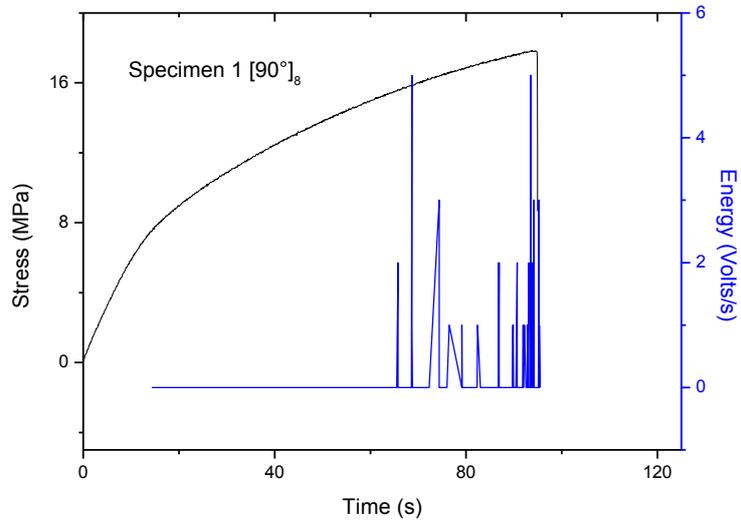


Figure 7. AE energy for sample 1 [90°]₈

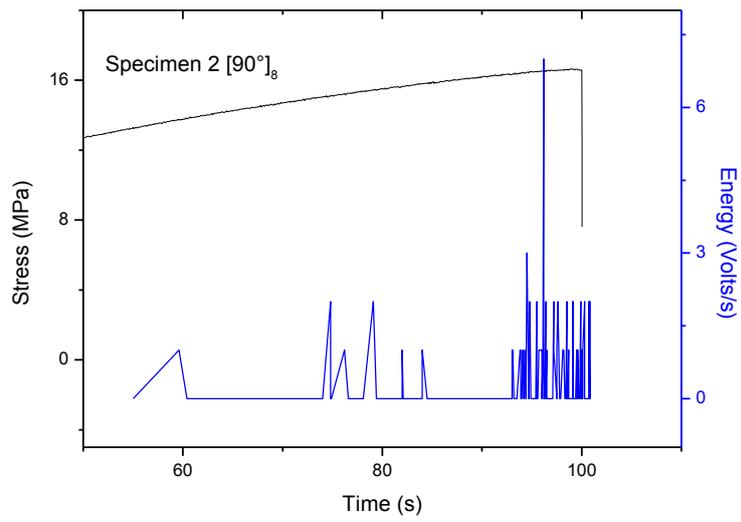


Figure 8. AE energy for sample 2 [90°]₈

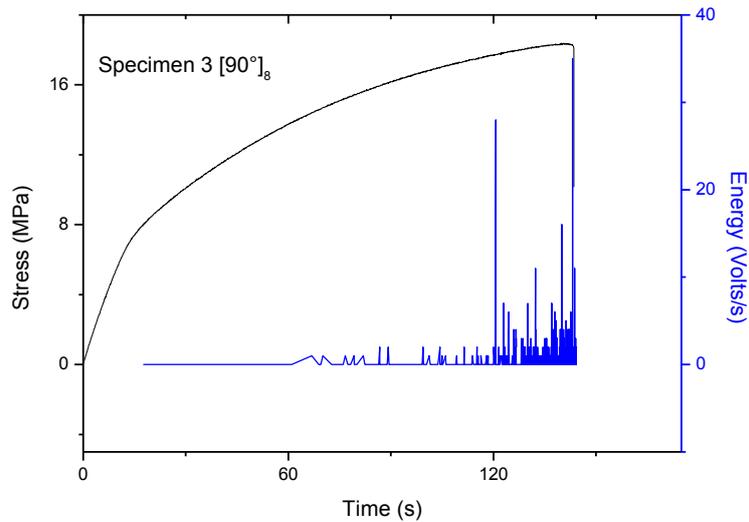


Figure 9. AE energy for sample 3 [90°]₈

For all samples, according to figures the major AE energy emitted was at plastic strain region, because at this region exists ruptures of fibre and matrix, fibres support the loads at 0°, so the signals are due to the fibre rupture. At ±45°, matrix and fibre support the loads and at 90°, the loads are supported mostly by matrix. The beginning of Figures 1 and 4 presents a fibre accommodation inside the loaded composite. At 0°, the counts of peaks were major than at other directions, due to the progressive rupture of fibres. Table 1 presents mechanical and elastic properties of cotton fibre composite tested.

Table 1. Properties of cotton fibre composite.

Properties	Orientation		
	0°	±45°	90°
Ultimate strength (MPa)	77.249±1.622	29.395±4.119	17.715±0.901
Young Modulus (GPa)	5.444±0.213	4.133±0.808	2.849±0.411
Poisson's ratio	0.353±0.096	0.291±0.029	0.242±0.134

4. CONCLUSIONS

The tested cotton fibre composite presented relatively good mechanical properties that can become it in a substitute to synthetic composites. Amplitude of AE energy differed from specimens inside the same orientation, but showed a concentration of peaks close the rupture.

5. ACKNOWLEDGEMENTS

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