

Acoustic Emission Monitoring of Iosipescu Shear Test on  
Glass Fibre-Epoxy Composites

M.K.Sridhar, Iyer Subramaniam, Chandra Ajay and A.K.Singh  
Materials Science Division  
National Aeronautical Laboratory  
Bangalore 560017, India

Acoustic emission (AE) monitoring has been extensively used for characterising failure mechanisms in composite materials. Recently several investigators have used acoustic emission amplitude distribution analysis (AEAD) to distinguish failure mechanism in composite materials. In this procedure the amplitude distribution of an acoustic emission is considered a characteristic of the source of emission[1].

In tensile testing of glass-epoxy composites, Brown and Mitchell[2] have associated AE signals with an amplitude less than 50 dB with matrix crazing, signals with an amplitude in the range 65-85 dB with interface damage, and still higher amplitude emissions are associated with fibre breakage. Valentin et al[3] attributed higher amplitude emissions with matrix cracking parallel to the fibres and lower amplitude emissions to fibre break in tensile testing of carbon fibre composites. They argue that because of the fine dimensions of the fibres they can only produce low amplitude emissions.

These discussions indicate that there is some ambiguity in assigning the correct amplitudes to the different failure mechanisms namely matrix cracking, interfacial failure and fibre breaking. Clearly there is a need to carry out AE monitoring experiments using novel test methods where the specimen failure can be carefully controlled. This paper presents some results of experiments conducted using Iosipescu shear test where fibre breaking is almost completely eliminated and the specimen fails only by interfacial failure and matrix cracking.

The details of Iosipescu shear test as applied to shear testing of composites are described by Adams and Walrath[4], and Herkovich and Bergner Jr[5]. It has been established fairly well that in Iosipescu test, only shear stresses are present and normal components are negligible in the test section of the specimen."

Iosipescu shear tests were conducted on unidirectional and crossply glass fibre epoxy composites, and the AE monitored with a PAC 3000 system during the test. The data acquired during the tests were analysed using post data analysis software provided by PAC. The amplitude distribution curves were drawn using the relation[1]

$$(N/N_0) = [A/A^*]^{-b}$$

where  $N$  is the number of events with an amplitude greater than  $A$ ,  $N_0$  is the total number of events,  $A$  is a threshold amplitude which was chosen as 30 dB in our analysis.

The amplitude distribution curves for the unidirectional and crossply specimens are given in Fig.1 and Fig.2. The crossply specimens were prepared by bonding the laminate strips with an epoxy resin in such a way that the 0/90 interfaces were parallel to the shear plane of the test specimen, and the specimen could fail only in that plane. It can be seen from the figures that the AE amplitude distribution is completely different

in the two cases. Also, it is to be noted that there are a large number of events in amplitude range of 65-85 dB even though there are no fibre breaks, confirming Valentin's conclusions. Also given in Fig.1 and Fig.2 are energy distribution for the tests. It is again seen that the two curves are distinctly different. It can be concluded from the energy distribution and amplitude distribution data that the 0/90 interlaminar failure takes place more easily than the 0/0 interlaminar failure. This is indicated by the fact that there are comparatively larger number of events of lower amplitude and lower energy in the case of crossply specimens compared to unidirectional specimens. The initial slope of the AEAD curves are  $-1.95 \times 10^{-2}$  in the case of unidirectional specimens undergoing a 0/0 interlaminar failure, and the slope is  $-4 \times 10^{-2}$  for crossply specimens undergoing a 0/90 interlaminar failure. The slope of AEAD curves is a characteristic of the source of emission(1). Thus different slopes indicate different types of failure and serves to distinguish one type failure from the other.

Acoustic emission monitoring of Iosipescu shear test enables us to identify the AE signals in the 60-85 dB range with the interlaminar failure in unidirectional and crossply composites. The experiments also provide a method of distinguishing the 0/0 interlaminar failure from 0/90 interlaminar failure.

#### References

1. A.G. Beattie, Journal of Acoustic Emission, 2, 95 (1983)
2. T.S. Brown and J.R. Mitchell, Proceedings of the 35th Conference of the Reinforced Plastics and Composites Institute USA, paper 26-B, (1980)
3. D. Valentin; P.H. Bonnian and A.R. Bunsell, Composites 14, 345 (1983)
4. O.E. Walrath and D.F. Adams, Experimental Mechanics, 23, 105 (1983)
5. C.T. Herakovich and H.W. Bergner, Composites, 11, 149 (1980)

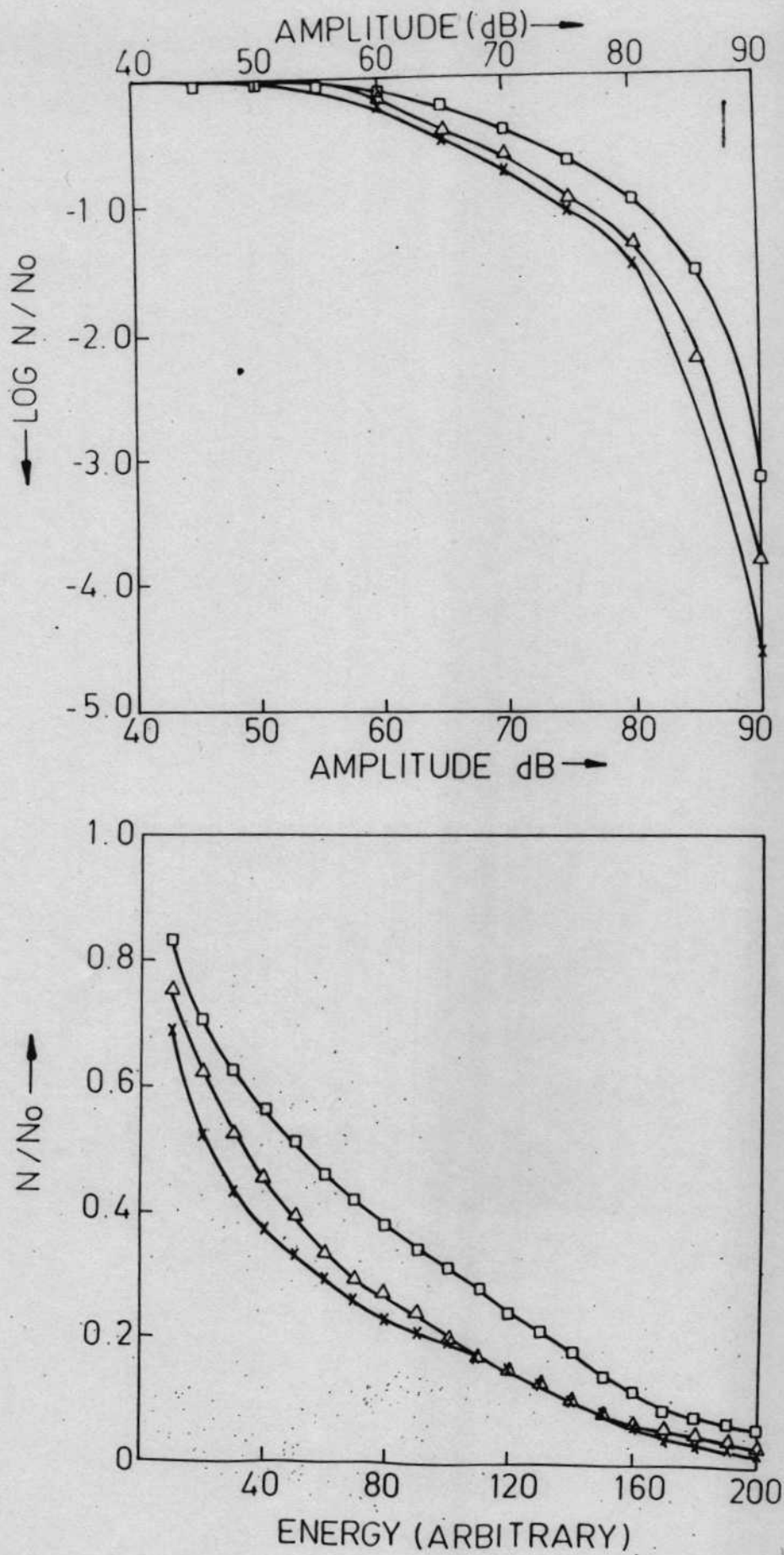


Figure 1: Amplitude and Energy Distribution Curves for Unidirectional specimens. The three curves show the data for three specimens.

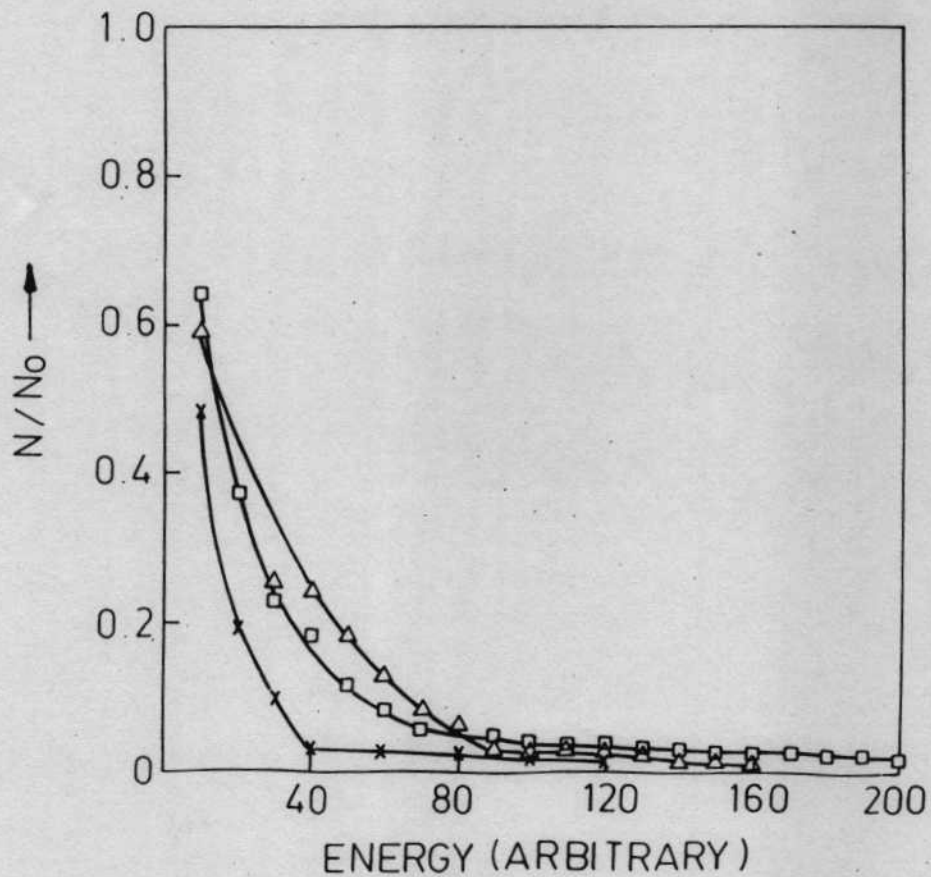
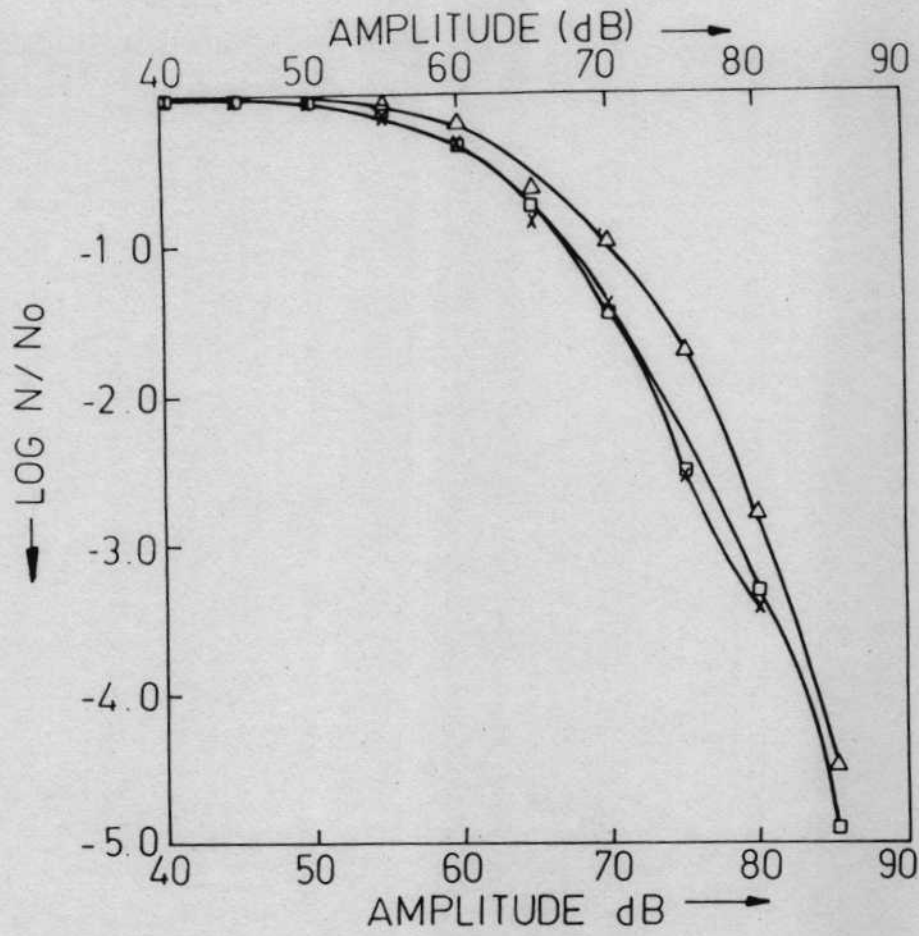


Figure 2: Amplitude and Energy Distribution Curves for Crossply specimens. The three curves show the data for three specimens.