ABSTRACT

Acoustic emission technique is a potential technique for online monitoring of critical components/structures. The technique is also used as a materials research tool for understanding the deformation and fracture behaviour of materials having different microstructures.

Acoustic emission (AE) generated during tensile deformation and fracture is strongly dependent on microstructural and test variables. Correlation of AE with microstructural features and/or processes of plastic deformation enables better understanding of the material behaviour and extension of AE technique for online monitoring applications.

A detailed study on the influence of presence of secondary phases, \( \gamma' \) and MC, on AE generated during tensile deformation and fracture in a precipitation hardenable alloy, Nimonic alloy PE16 has been carried out. This study was aimed at understanding AE behaviour in Nimonic alloy PE16 with different microstructures and also discussing results in the light of the two models proposed by (i) Agarwal et al. and (ii) James and Carpenter for explaining the AE behaviour in precipitation hardenable materials.

Different microstructures (\( \gamma' \) and MC) were obtained by giving suitable heat treatments to tensile specimens at the temperatures, 973, 1023 and 1173K. Room temperature tensile testing was carried out on these specimens and accompanying AE signals were recorded and analysed in time domain. Optical microscopy and scanning electron microscopy were carried out wherever necessary to characterise the microstructures and fracture surfaces, respectively. The changes in deformation behaviour due to changes in microstructures were correlated with AE parameters like rms voltage; events; ringdown counts (RDC); peak amplitude (PA), energy (EN), event duration (ED), and rise time (RT) for the events.
Decohesion and fracture of incoherent MC carbides resulted in burst type AE with events having higher PA and EN and longer ED and shorter RT as compared to those in annealed specimen. A broad second peak was observed in the total strain range, 8-38\% in ROC vs strain plot. The weaker events with lower energy generated prior to onset of plastic flow in specimen containing MC carbides is attributed to reduction in dislocation mean freepath and shorter glide distance consequent to precipitation of MC. This is in agreement with the model proposed by Agarwal et al.

The lower energy events generated during decohesion and fracture of M\textsubscript{23}C\textsubscript{6} as compared to those for MC are attributed to lower interfacial energy between γ/M\textsubscript{23}C\textsubscript{6} interface.

Particle shearing process operating in presence of γ' having size around 10nm resulted in generation of large scale increase in events, RDC and broad peak in rms voltage during onset of plastic flow. These events are found to have longer event duration and higher rise time.

Predominant operation of Orowon looping process in presence of γ' having size 19nm resulted in only increase in events and RDC and no change in rms voltage.

The strong AE behaviour during particle shearing and Orowon looping processes is in accordance with the model proposed by James and Carpenter. The higher energy release indicated by broad rms voltage peak observed in specimens undergoing particle shearing process is attributed to irreversible energy release occurring during particle shearing process.

The maximum peak amplitude values and peak rms voltage for the AE generated upto onset of plastic flow are found to be related to size and volume fraction of γ'.
Conjoint presence of MC and \( \gamma' \) resulted in broad rms voltage peak with superimposed bursts. This behaviour is attributed to combined occurrence of particle shearing process and decohesion and fracture of MC.

The strength of the AE signal decreases in the following order of phenomena: (i) decohesion and fracture of carbides (ii) particle shearing process and (iii) dislocation generation and multiplication by operation of Frank-Read and grain boundary sources and motion of dislocations.

The events associated with above three phenomena can be distinguished since the AE parameters, i.e., the maximum values of PA, EN, ED and RT for the events are different.