Research on AE waveform characteristics of rock mass under uniaxial loading based on Hilbert-Huang transform (HHT)

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July 18, 2020

Abstract

Acoustic Emission (AE) waveforms contain information on microscopic structural features that can be related with damage of coal and rock masses. In this paper the Hilbert-Huang transform (HHT) method is used to obtain detailed structural characteristics of coal and rock masses associated with damage, at different loading stages, from the analyses of the characteristics of AE waveforms. The results show that the HHT method can be used to decompose the target waveform into multiple intrinsic mode function (IMF) components, with the energy mainly concentrated in the c1-c4 IMF components, and where the c1 component has the highest frequency and the largest amount of energy. As the loading continues, the proportion of energy occupied by the low-frequency IMF component shows an increasing trend. In the initial compaction stage, the Hilbert marginal spectrum is mainly concentrated in the low frequencies between 0-40KHz. The plastic deformation stage is associated to energy accumulation in the 0-25KHz and 200-350KHz frequency ranges, while the instability damage stage is mainly concentrated in the 0-25KHz frequency range. At 20KHz, the instability damage reaches its maximum value. There is a relatively clear instantaneous energy peak at each stage, albeit being more distinct at the beginning and at the end of the compaction phase. Since the effective duration of the waveform is short, its resulting energy is small, and so the relatively high value from the instantaneous energy peak, at the time of destruction, is relatively long lasting and is where the waveform reaches its maximum energy value. The Hilbert three-dimensional energy spectrum is generally zero in the region where the real energy is zero. In addition, its energy spectrum is intermittent rather than continuous. It is therefore consistent with the characteristics of the several dynamic ranges mentioned above, and it indicates more clearly the low-frequency energy concentration in the critical stage of instability failure. This study well reflects the response law of geophysical signals in the process of coal-rock instability and failure, providing a basis for monitoring coal-rock dynamic disasters.

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