Study on Creep Fatigue Mechanical Characteristics and Constitutive Model of Salt Rock

Abstract:

To meet the requirements of the United Nations Framework Convention on Climate Change, i.e., the Paris Agreement, countries around the world have developed carbon-peaking and carbon-neutral action programs. The use of renewable energy sources is an effective means of meeting this requirement. Because salt rock has good rheology, low porosity, low permeability and damage self-healing characteristics, compressed air energy storage using salt caverns is an effective way to enhance the efficiency of renewable energy use. Considering the operational requirements for load balancing in compressed air energy storage plants, the surrounding rock of salt cavern reservoirs is subjected to discontinuous cyclic loading with varying gas injection rates and pressures i.e. alternating creep-fatigue loading. Through a combination of theoretical analysis, laboratory experiments, and model studies, this research investigated the creep-fatigue mechanical characteristics of salt rocks with varying high-stress interval times, and the creep-fatigue mechanical characteristics of salt rocks under different confining pressures. Additionally, the impact of different stress levels on the creep-fatigue damage evolution of salt rocks was monitored and analyzed using acoustic emission devices. Long-term creep-fatigue tests on salt rocks under different loading rate and level were conducted based on the actual frequency of load balancing in compressed air energy storage plants. The reasons and patterns of the salt rock's interaction between creep and fatigue under different conditions were analyzed. Based on the consideration of the creep-fatigue interaction in salt rocks, a state variable-based creep-fatigue constitutive model for salt rocks was proposed and established, and its validity was verified. The research findings provide important guidance for ensuring the stability of salt cavern reservoirs.