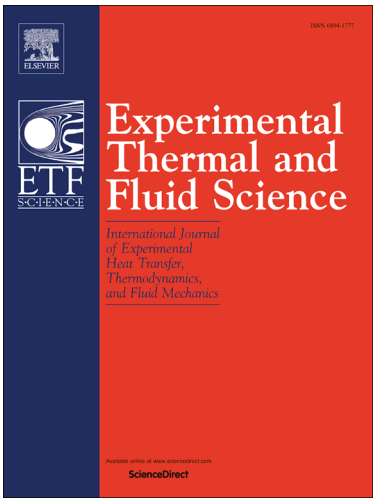

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Abstract

Compressed air energy storage (CAES) has emerged as an effective large-scale energy storage technology. This storage system can have many urban applications based on the time-dependent price of electricity. In China, the electric power companies employ batteries to store electricity when the price drops and generate electricity when the price increases. When compared with storage batteries, CAES systems have larger storage capacity (100 MWh, battery < 10 MWh), are more environmentally friendly (no heavy metals pollution), and have longer service life. However, the major limitation that restricts the application of such systems is its poor (< 60%) turnaround efficiency (electricity to electricity). Most CAES systems are based on adiabatic compression. Approximately half of the electricity is transformed into heat and exhausted due to the poor heat transfer from the air to environment. Most of the previous research focused on enhancing the heat transfer to achieve quasi-isothermal compression. In this study, a contact heat transfer method is used to cool the compressed air by injecting micron-sized (10 μm ~100 μm) water spray into the compressed air. A transient temperature measurement method is developed to investigate the heat transfer behaviour between air and water. The measurements showed the spray-air heat transfer rate to lie in the range of 10~120 $W.m^{-2}.K^{-1}$. When the compression ratio is two in a compression chamber of 0.94 L, the compression power is reduced from 73.8 J/cycle (adiabatic) to 69.0 J/cycle, using water injection of 0.416 g/cycle. The achieved compression efficiency is improved from 86.7% (adiabatic) to 92.4%.

Keywords: Water spray; Cooling; Isothermal compression; Heat transfer; Compressed air energy storage

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Nomenclature