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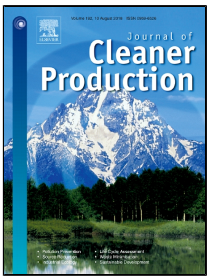

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Abstract

A novel and practical hydrogen storage system is developed and analyzed thermodynamically through transient energy and exergy approaches. The proposed hydrogen storage system stores the hydrogen chemically in ammonia, and is a pressurized multistage ammonia production system. The pressurized multistage ammonia production system stores the produced ammonia in a novel conceptual design of an ammonia tanker truck equipped with an ammonia electrolyzer, which transports and delivers the stored hydrogen. The energy and exergy efficiencies of the proposed system are 72.3% and 71.8%, respectively. The proposed system consumes 59.5 kJ of work per mole of hydrogen stored and recovered using the ammonia electrolyzer. The system is simulated on filling 21,000 liters of ammonia at a pressure of 61 bar, and the system is able to store 13,225 kg of ammonia in a liquid state in 0.518 hour. The system consumes nearly 61.4 GJ of energy to store the 13,225 kg of ammonia and to decompose it during the discharge phase.

Keywords: Ammonia production, energy, exergy, multistage reactor, pressurized storage, chemical hydrogen storage.

1. Introduction

Harnessing renewable energy sources can help in reducing the world's dependence on fossil fuels. However, renewable energy sources have the disadvantage of being inherently intermittent which means they are not generally dispatchable when required, leading to non-optimal operation patterns. A reliable and efficient energy storage technology can assist and increase the use of renewable energies (Dincer and Rosen, 2011). One of the important properties of energy storage technologies is their volumetric energy density, i.e., the amount of energy stored per unit volume of the storage system. The benefits of reliable and efficient energy storage technologies are not limited to renewable energies; they can also enhance the use of fossil fuels. Storage systems can help in matching the supply and demand of power curves (Aneke and Wang, 2015).