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Research Paper

Thermo-chemical storage for renewable energies based on absorption: Getting a uniform injection into the grid

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HIGHLIGHTS

- Evaluation of the viability of the use of an absorption system for the application of renewable energy storage.
- The system can attend the hourly and daily variations of the renewable energy source and the demand simultaneously.
- The overall system efficiency is near 50%.

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ABSTRACT

Renewable energies, such as solar, wind or wave energies show intermittent production patterns that complicates their injection into an electrical grid. In order to overcome this inherent drawback, this paper proposes an innovative permanent storage system that uses both thermal and mass transfer internal processes based on absorption to store mechanical/electrical energy at large scales. This enables a manageable smoother power output to the grid, more suitable for trading. The system consists of two storage tanks for accumulating a liquid solution at two different pressures, connected with a compressor and an expander of the vapor absorbed/desorbed. An additional heat exchanger allows for recovering the absorption heat from the high-pressure tank seeking for storage efficiency. A detailed numerical simulation has been developed in order to predict the performance of the storage system under transient operating conditions and to determine the appropriate design parameters. The results show interesting and relevant conclusions about both the energy exploitation and the efficiency parameters of the energy storage system for reducing the intermittent electricity production.

1. Introduction

The intermittent behavior of renewable energies leads to the need of energy storage in order to inject a smoother electrical power into the grid or/and to have available energy when the demand requires it e.g. [1] among others. This research has been focused on massive and scalable electricity storage systems, regarding an innovative vapor absorption/desorption process as candidate.

The main issue is that there has not been found any system with the advantages and characteristics as the one proposed and described in this work. There are several thermochemical storage methods based on absorption, but with a different purpose; this is making an absorption cycle operate producing either heat or cold without the usual external heat supply for these machines [2,3] among others. Input of electricity is considered in some hybrid absorption cycles, such as [4] and even output with combined cycles, such as [5], and [6], but the present specific design for electricity storage/supply seems clearly original. The alternative will be the use of batteries (see Fig. 1).

The durability of this system is higher than the most of the commonly used storage systems, two orders of magnitude, and with a higher efficiency than the Ni-Cd ion and lower than the lithium ion.

The advantage of this technology is lower environmental impact from the point of view of the raw material and the lack of degradation of the storage tank with the usage, in terms of capacity and properties.

The scalability of the present system seems better as well as the cost reduction with size. The overall cost is difficult to establish owing to the different maturity of the alternatives and the different scales.

The main goals of the storage system are:

- Ability to satisfy an electricity demand profile not coupled with the

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Nomenclature

Latin

A	area [m^2]
cv	specific heat capacity coefficient [$J\,kg^{-1}\,K^{-1}$]
h	enthalpy [$J\,kg^{-1}$]
hm	diffusion mass coefficient
KDA	mass transfer coefficient
M	mass [kg]
m	mass flow [$kg\,s^{-1}$]
p	pressure [Pa]
Q	heat [J]
R	gas constant [$J\,kg^{-1}\,K^{-1}$]
T	temperature [K]
t	time [s]
U	internal energy [J]
UA	overall heat transfer coefficient [$W\,K^{-1}$]
V	volume [m^3]
W	power [W]
X	vapor mass fraction [–]

Subcript

A	high pressure storage tank
acu	storage tank
B	low pressure storage tank
c	compressor
corp	limit for pressure
cort	limit for temperature
cp	polytropic in compressor
d	solution
dc	renewable energy available at the compressor inlet
dt	energy demand at the turbine outlet
ext	exterior
f	fluid
i	internal
m	mass
p	loss
r	recirculation
re	external refrigeration
s	saturation
sal	salt in the solution
sc	compressor outlet
st	turbine outlet
t	turbine
tc	heat transfer
tp	polytropic in turbine
v	vapor
vc	vapor to compressor
vt	vapor to turbine
vv	vapor absorbed/desorbed

Greek

η	efficiency [–]
γ	gas isentropic coefficient [–]
Π	pressure ratio [–]
ρ	density [$kg\,m^{-3}$]
τ	specific work [$J\,kg^{-1}$]

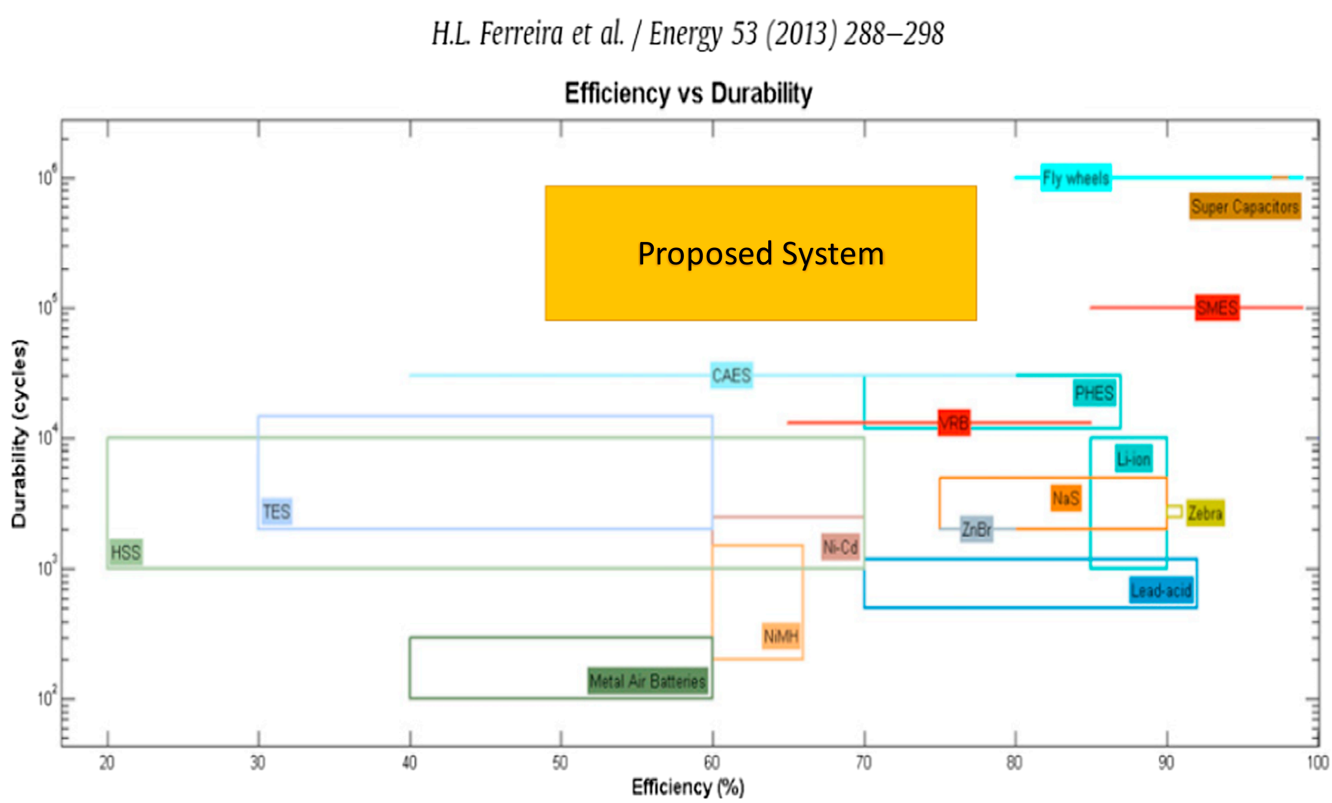

Fig. 1. Efficiency vs durability of the storage system compared with the system proposed.