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Zigzag Flow Reactor for Thermochemical Energy Storage

As the world gears up for the ongoing renewable energy revolution, the temporal variability of the renewable sources remains a big headache for designing a reliable electricity grid. A multi-level energy storage infrastructure is thus necessary to maintain high, year-round dispatchability. No technology that currently exists is ideally suited to meet the medium-term energy storage needs (~20-500 hours). Research in thermochemical energy storage (TCES) shows that TCES holds great promise in meeting the medium-term demand.

In TCES, hot and reduced reactive metal oxide (MOx) particles serve as storage media. Two types of MOx, in particular, have piqued the interest of TCES researchers. Stoichiometric MOx transition between two discrete reduction states representing the charging and discharging steps. Non-stoichiometric MOx, on the other hand, exhibit continuous reduction states depending upon the temperature and oxygen partial pressure in the environment. The main appeal of non-stoichiometric oxides is the wide material space and the possibility of tuning them to maximize the stored energy and minimize the cost of storage per unit stored energy. There is a need to design a reactor that can reliably reduce MOx particles with high particle gas mixing and high particle residence time.

Researchers at Arizona State University have developed a thermochemical energy storage reactor design, a Zigzag Flow Reactor (ZFR), ideally suited for thermochemical energy storage (TCES). The ZFR utilizes temperature and oxygen partial pressure dependent transition of continuous reduction states of non-stoichiometric metal oxide (MOx) particles. The ZFR has been designed to allow for flow of the MOx particles that are heated and reduced (emit O₂) in the presence of a counterflowing inert sweep gas. The reduced particles are stored until the thermal energy is needed wherein the particles are exposed to O₂, the MOx is then oxidized and the stored thermal energy is emitted. The process is reversible and repeatable and the ZFR is simple and scalable. Importantly, the ZFR design with counterflow sweep gas carefully controls and maximizes power density.

Potential Applications:

- Thermochemical energy storage
- Grid energy storage

Benefits and Advantages:

- Can thermochemically reduce metal oxide particles with high particle gas mixing along with high particle residence time
- Fulfills medium-term energy storage demand that is required for stability of a

renewables-dominated electricity grid

- Easily scalable design (e.g., can be scaled to grid levels)