Numerical modeling of high temperature bayonet heat exchanger and decomposer for decomposition of sulfur trioxide

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Motivation
- Hydrogen is an attractive energy carrier in the future energy technology.
- Hydrogen is produced from splitting of water through various processes namely electrolysis, photo-electrolysis, photo-biological production and thermochemical water-splitting.
- The aim of this study is to numerically investigate fluid flow, heat transfer and chemical reaction in bayonet high temperature heat exchanger and decomposer.
- Parametric studies are performed to achieve maximum decomposition with less pressure drop.

Thermochemical water-splitting cycle
- The sulfur-iodine (S-I) cycle was developed by General Atomics (GA) for large scale hydrogen production

Boiler
- Inlet mass flow rate – $0.34 \times 10^{-3}$ kg/s
- Inlet temperature – 473 K
- Solid – SiC
- Operating pressure – 101325 Pa
- $x_{SO_3} = 0.784; x_{H_2} = 0.216$
- Results
  - Pressure drop $\Delta P$ – 1.5 Pa
  - Friction factor – 0.128

Superheater and decomposer
- Superheater inlet temperature – 673 K
- Decomposer inlet temperature – 973 K
- Catalyst – Platinum
- Porosity – 0.46
- Surface to volume ratio – 128 m$^{-1}$
- $x_{SO_3} = 0.485; x_{H_2} = 0.514$
- Results
  - Pressure drop in decomposer $\Delta P = 512.59$ Pa
  - % decomposition of $SO_3$ – 61.97%

Future work
- Multiphase fluid flow can be considered in the future for the whole geometry
- Recuperator can also be modeled and analyzed
- Numerical analysis with turbulent flow can be carried out to find the decomposition percentage of $SO_3$

Parametric studies
- Conclusions
  - Percentage decomposition of sulfur trioxide obtained is 61.97%
  - Numerical results agree closely with the experimental results from SNL
  - Bayonet heat exchanger gives good decomposition rate with small pressure drop

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