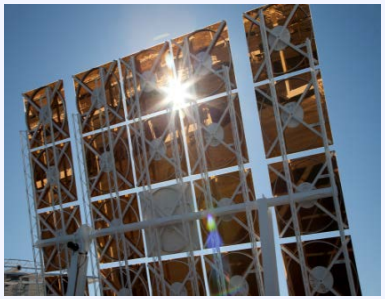
PARTICLE LIFT CHALLENGES AND SOLUTIONS FOR SOLID PARTICLE RECEIVER SYSTEMS

Joshua Christian
Jeremy Sment
Clifford Ho
Lonnie Haden
Kevin Albrecht

ASME 2019 13^{1h} International Conference on Energy Sustainability
July 14- July 17, 2019

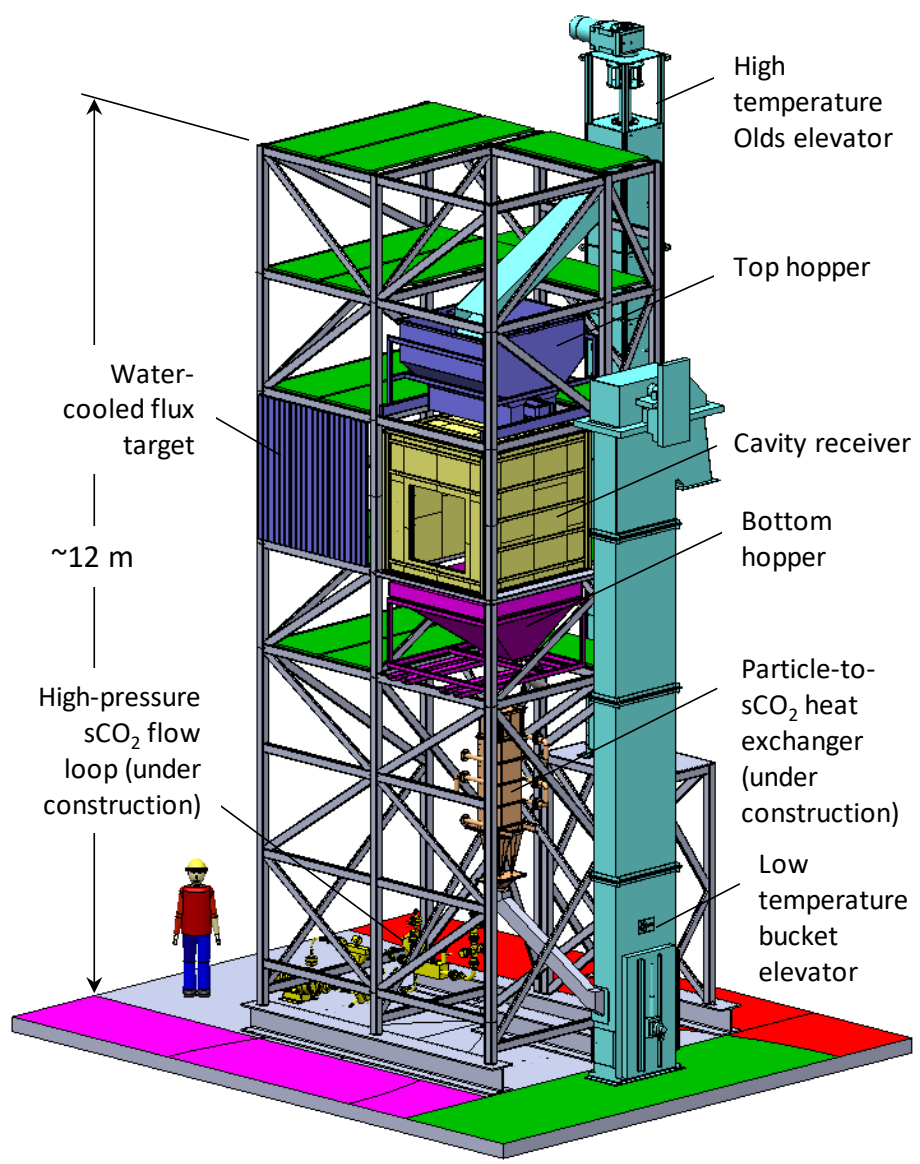
Exceptional service in the national interest

Sandia National Laboratories



Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Introduction



- Lift systems provide the critical function of transporting particles to get heated
- Three main types:
  - Screw-type
  - Bucket
  - Skip Hoist
- Testing has been performed at Sandia Labs for evaluation of lift performance

Presentation Overview

- Objectives
- Lift Analysis
- Discussion
- Conclusion

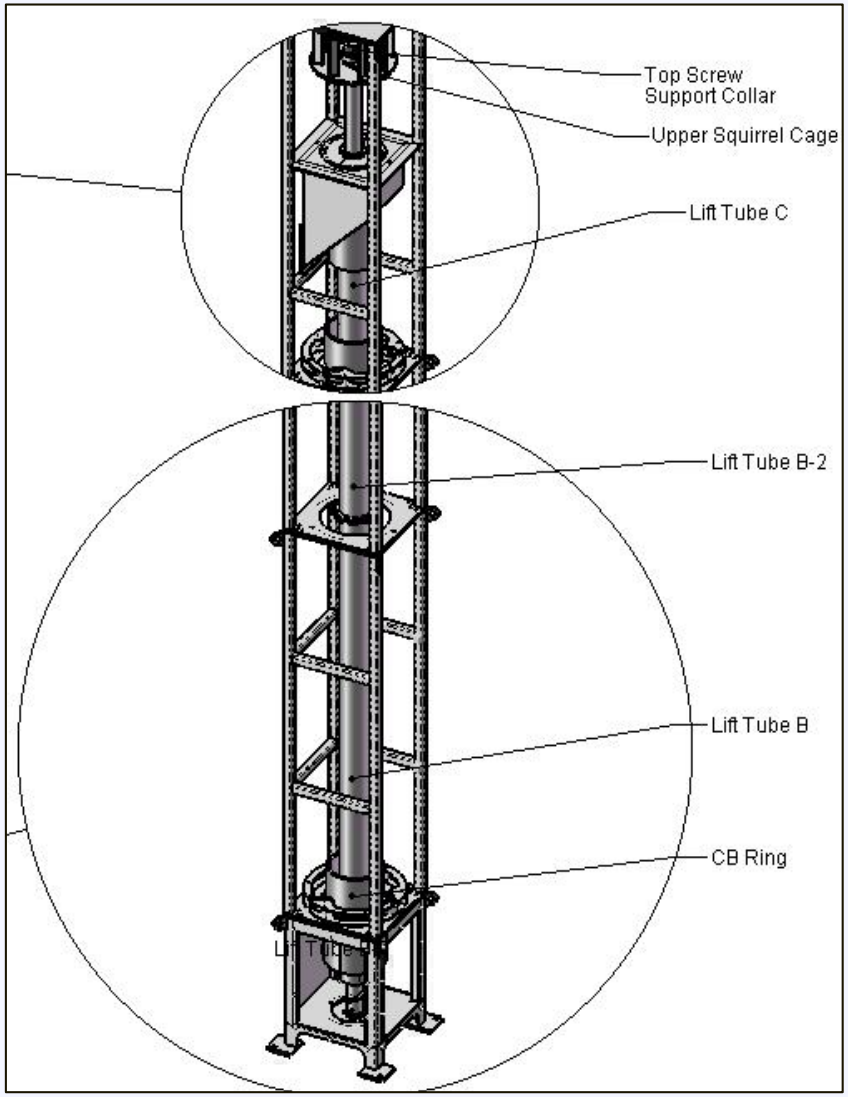
Objectives

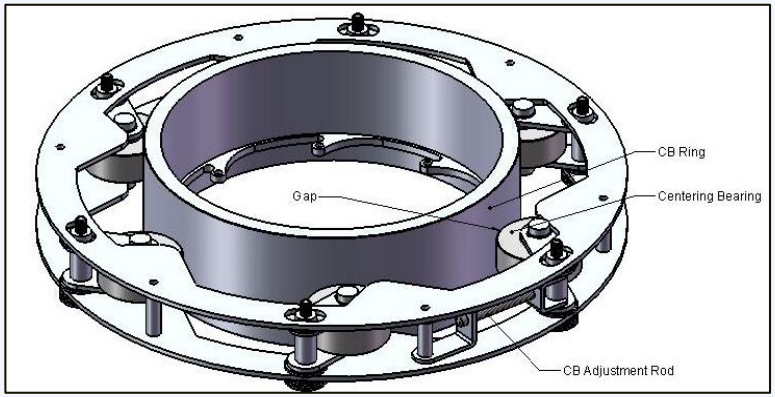
- Evaluate options for lifts needed for future generation particle receiver systems
  1. Compare the performance results from elevators tested at the National Solar Thermal Test Facility
  2. Determine feasibility for future systems
  3. Evaluate possible control systems

Presentation Overview

- Objectives
- Lift Analysis
- Discussion
- Conclusion

Screw-Type Elevator





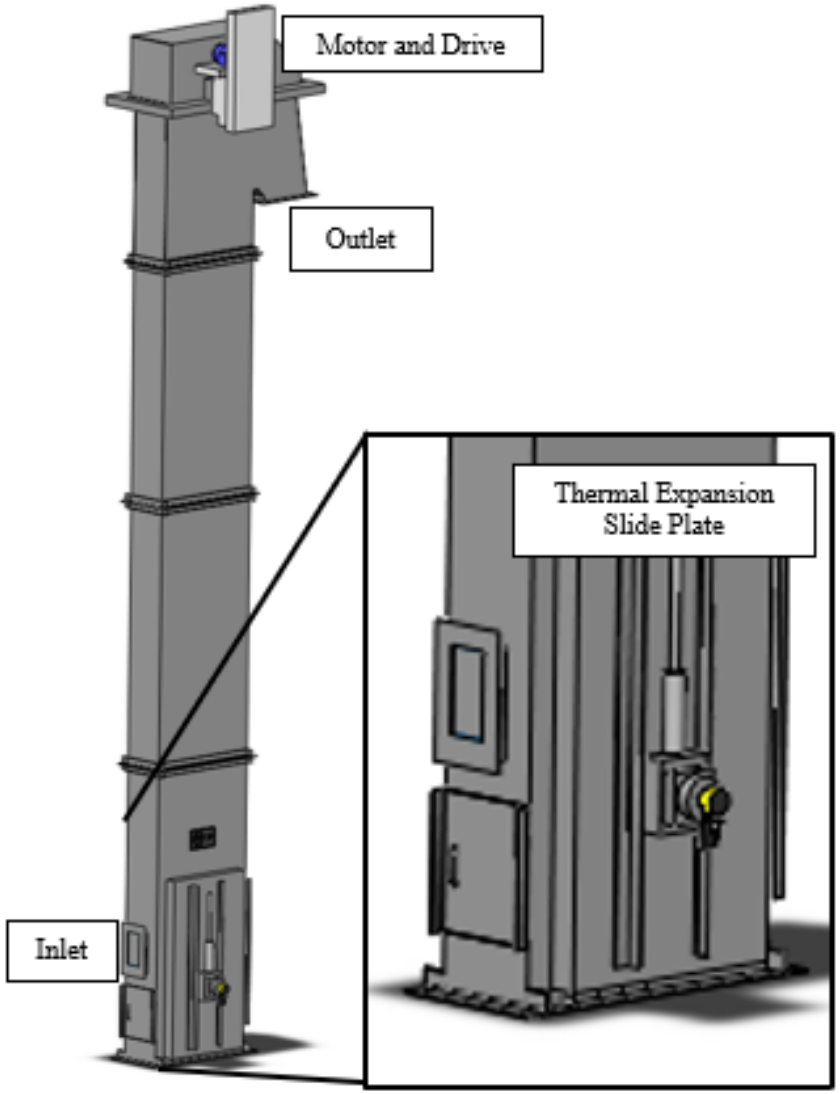
Screw-Type Elevator

- Efficiency: Could not achieve greater than 5%

VFD Frequency (Hz)	Mass flow rate (kg/s)	Power (W)	Efficiency (%)
20	4.14	309.28	1.67
30	6.32	472.56	2.55
40	8.30	620.67	3.35
54	10.77	805.27	4.35

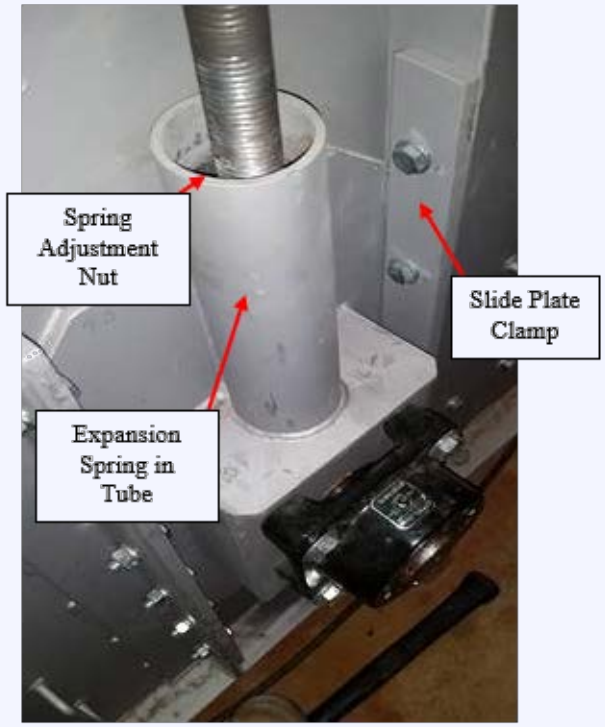
- Inlet particle conditions: particle uniformity and momentum loaded screw casing
- Shaft thermal expansion
- Particle attrition

Bucket Elevator

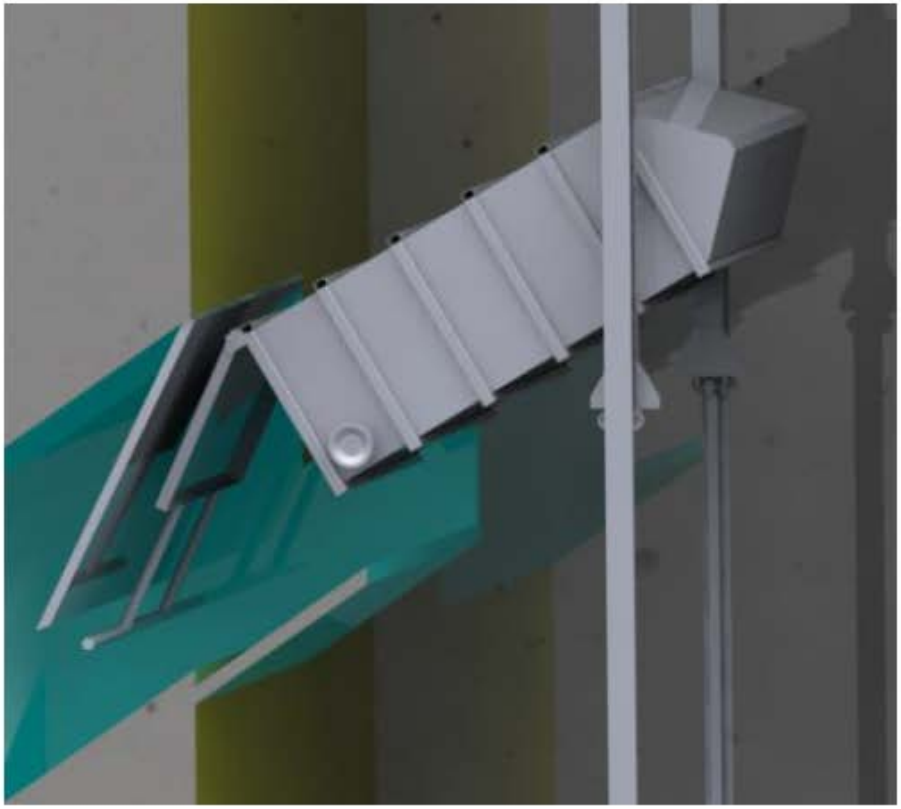


Bucket Elevator

- Efficiency: 15.5%
  - Single mass flow rate of 6 kg/s
  - 8.2 m lift height
- Slide plate thermal expansion: fine tuning required
- Bracing to support structure
  - Careful design required at high temperatures



Skip Hoist Elevator



Skip Hoist Elevator

- Excellent for large inventories necessary at 50-100 MW plants
- Efficiency as high as 80%
- Hot particles separate from drive mechanisms
- Low thermal mass of elevator

Presentation Overview

- Objectives
- Lift Analysis
- Discussion
- Conclusion

Discussion

1. Efficiency
   - Screw-type <5%
   - Bucket <20%
   - Skip hoist <85%
2. Mass flow regulation
   - Not possible with the bucket or skip
3. Installation/Setup
   - Insulation can be difficult to install
   - Alignment is straightforward with all types

Discussion

4. External Bracing
   - Thermal requirements need a more complex design for stability at low and high temperatures
5. Heat Loss
   - Insulation design must be carefully considered
   - Height of elevator results in large surface areas
6. Control algorithms
   - Some elevators can use VFDs to regulate flow rate into hoppers

Conclusion

1. All lifts have advantages/disadvantages
2. Small scale vs. large scale systems will drive lift selection
3. Control algorithms can be used with a VFD to control particle flow in the screw-type elevator
4. Heat loss is a major aspect to lift design

Questions

- This work was funded in part or whole by the U.S. Department of Energy Solar Energy Technologies Office under Award Number 34211; DOE Project Managers: Matthew Bauer, Vijay Rajgopal, Shane Powers