

Design of a Lab-Scale Torrefaction Reactor

In-Situ Conversion of Agricultural Waste to Solid Biofuel

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Opportunity

- Growth of rice, wheat, sugarcane, & cotton produces 500 MT of crop residues/year¹
- Crop residue burning causes nutrient loss, pollution, and poor air quality



- Bioenergy potential from surplus residues = 17% of India's total primary energy

Proposed Solution

- Mobile torrefaction system to process agricultural residues in-situ
- Torrefaction: a mild pyrolysis process carried out in a limited-oxygen environment



Increasing severity of torrefaction⁴

Functional Requirements

| | |
|----------------------------|--------------------|
| Residence Time | 10 – 30 Minutes |
| Torrefaction Temperature | 240 – 300 °C |
| Mass Throughput | 2.5 kg/hr @ 20 min |
| Transfer Heat to Biomass | ≥ 100 kJ/kg·s |
| Feedstock Type | Sawdust, < 40% MC |
| Oxygen-Limited Environment | Yes/No |
| Homogeneous Torrefaction | Yes/No |
| Volatile Combustion | Yes/No |
| Emergency Shutdown | Yes/No |

Next Steps

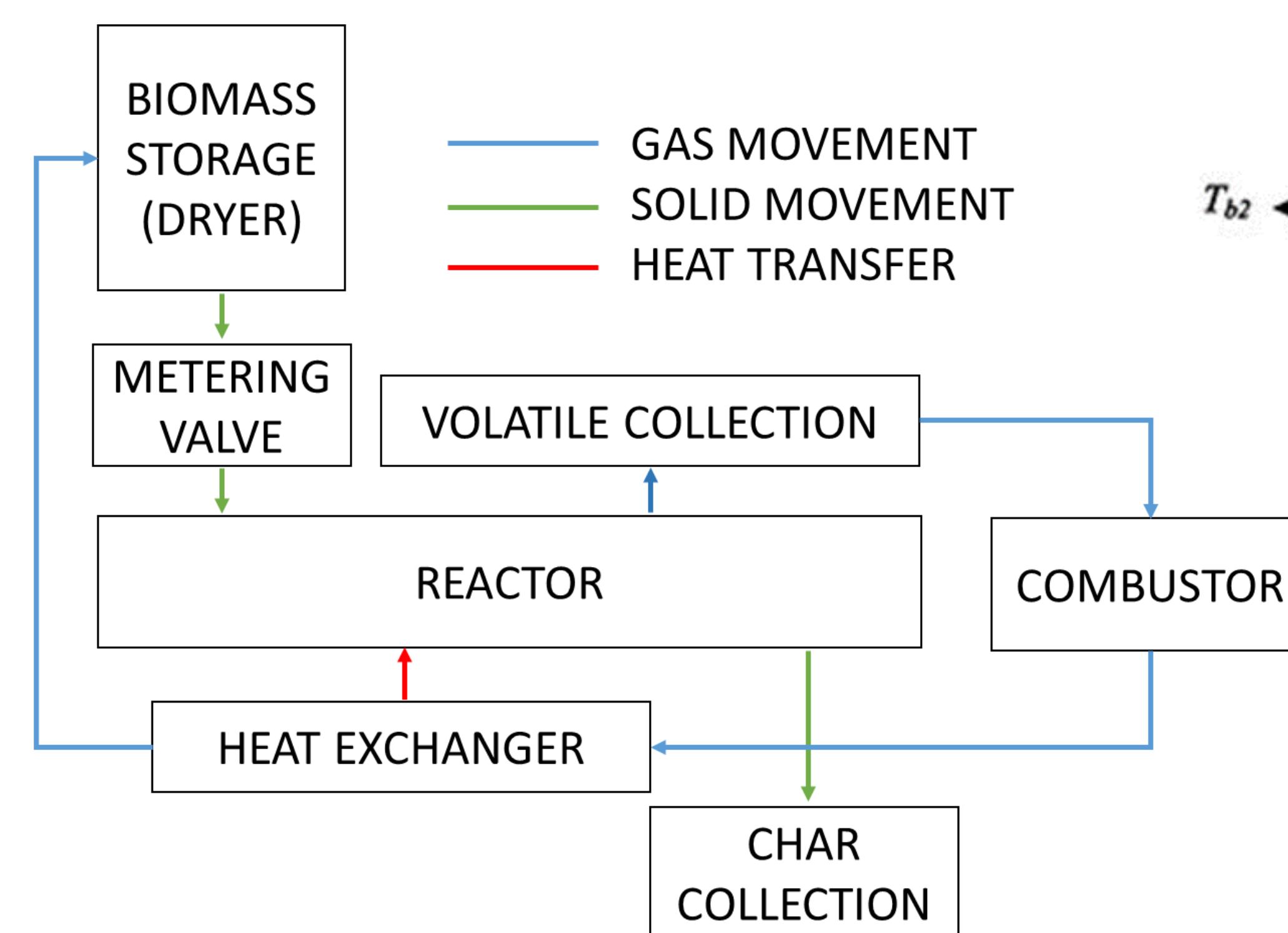
- Fabrication & Assembly
- Testing: Cold Flow, Gas Leakage, Hot Flow
- Heat Exchanger Analysis
- Proposal for Full-Scale Design

Acknowledgments

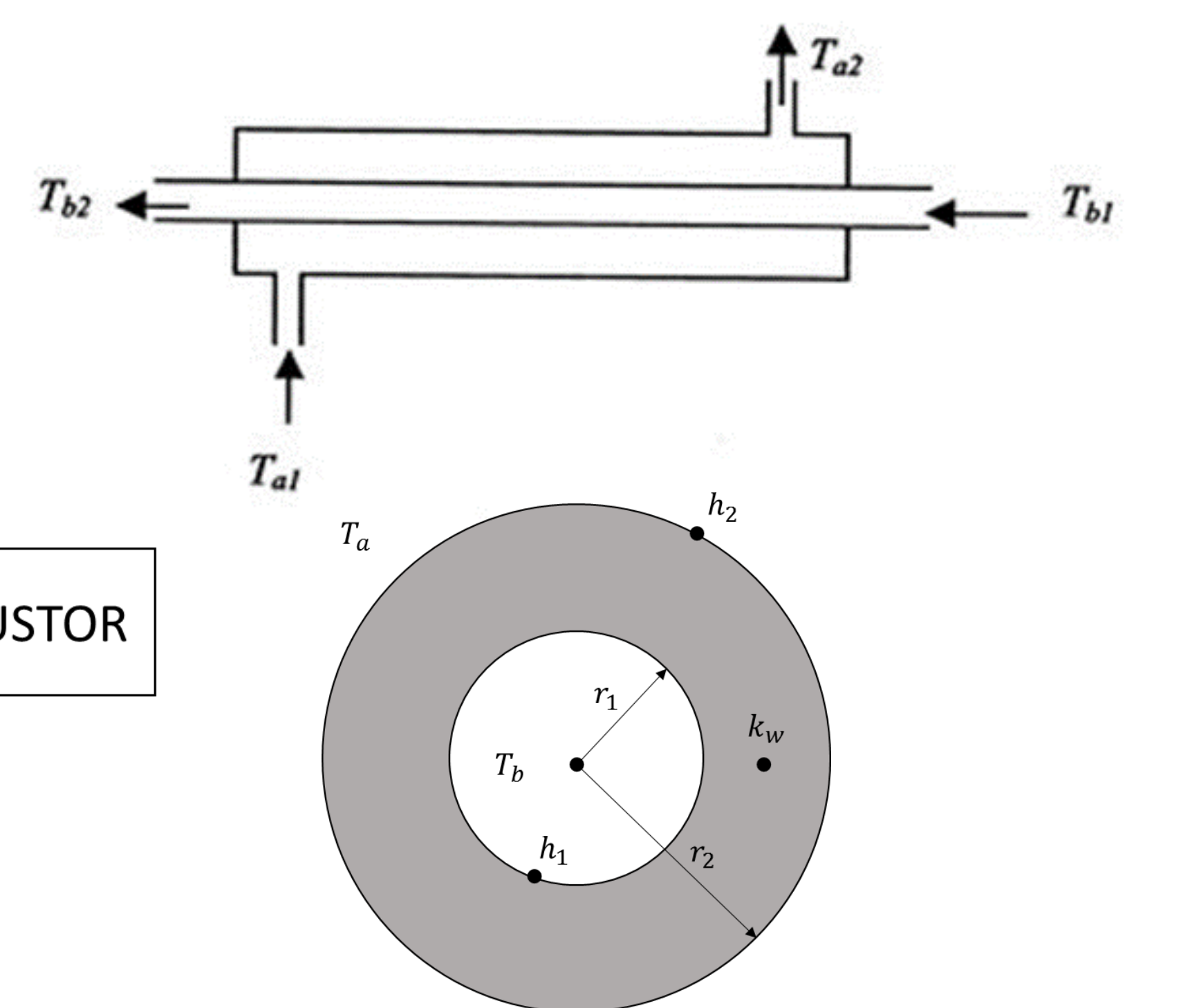
This work is supported by the Tata Trusts.

Design Process

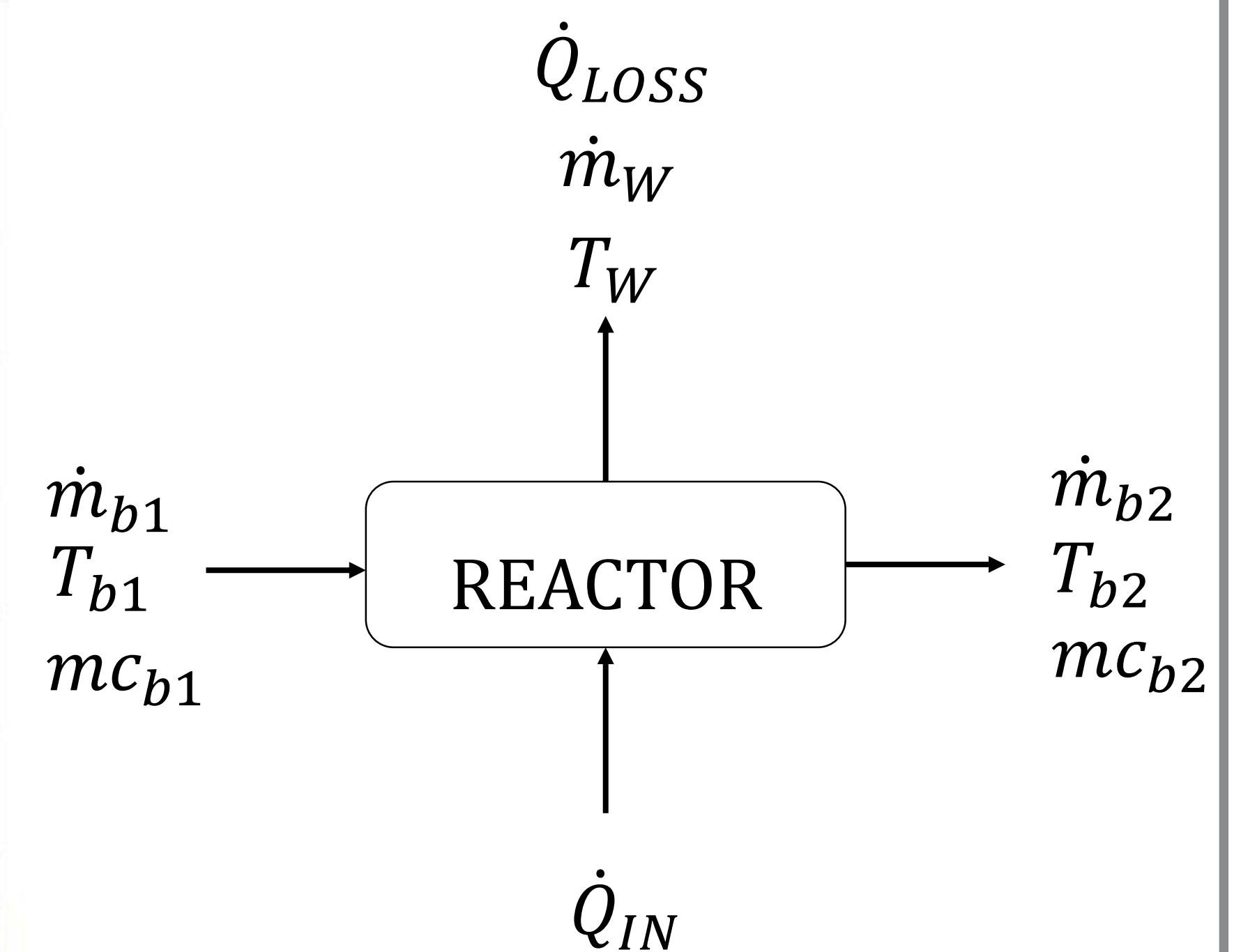
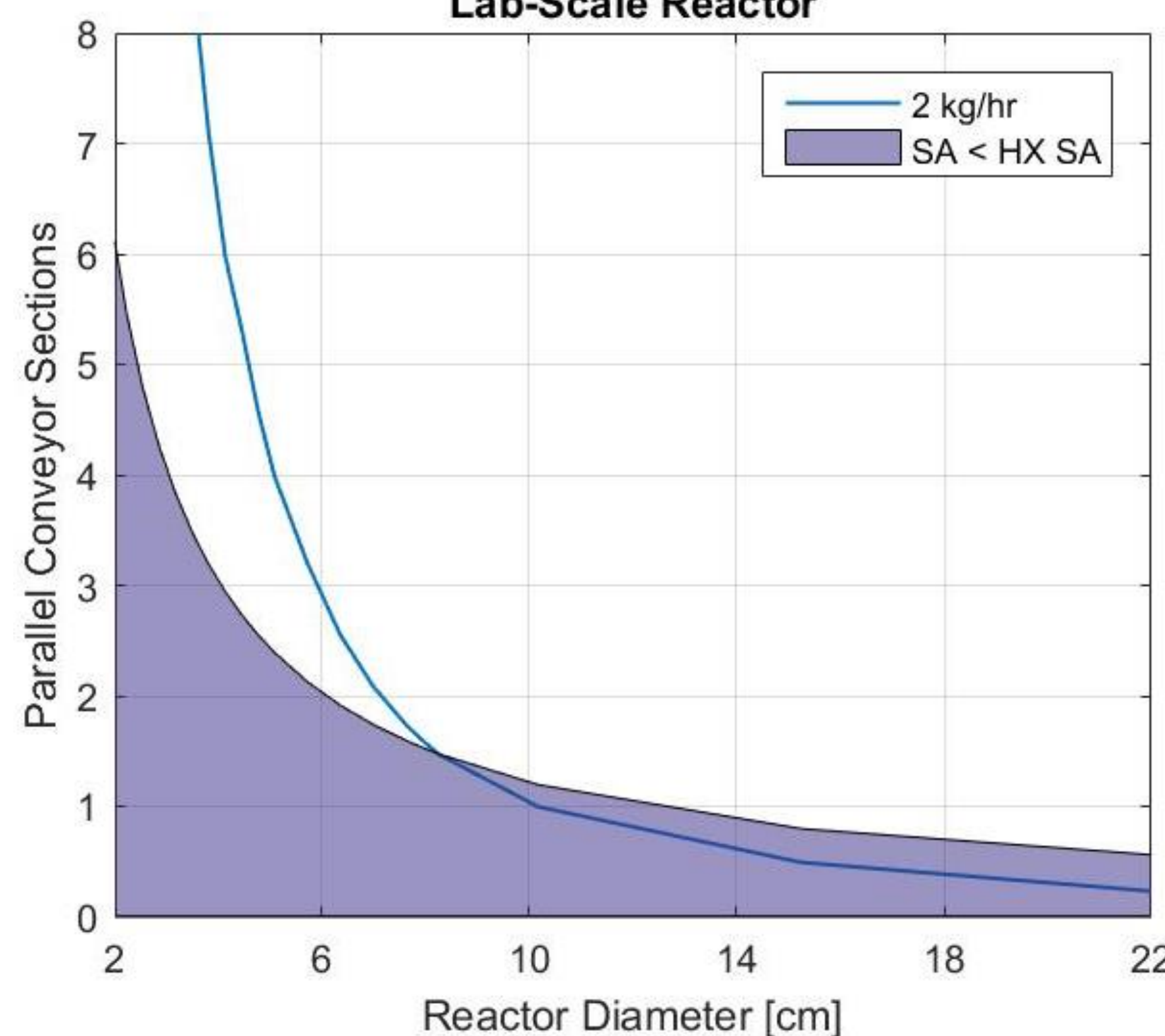
System Architecture:



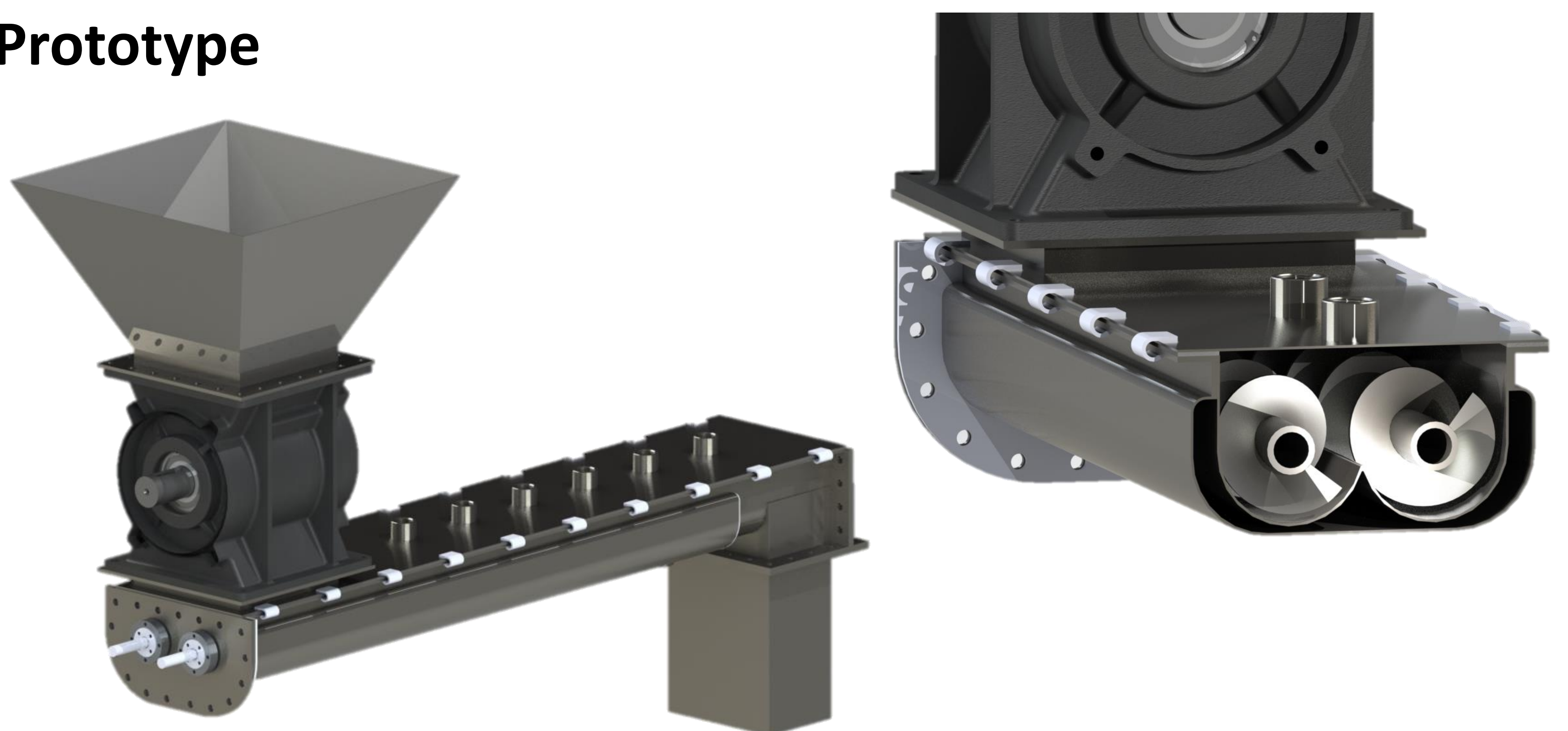
1st-Order HXer Model:



Lab-Scale Reactor



Prototype



References

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- <https://www.engineering.leeds.ac.uk/eri/research/renewable-energy-systems-future-fuels/current-research/torrefaction.shtml>

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