Direct heating of chemical catalysts for hydrogen and fertilizer production using Microreactors

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Direct heating of chemical catalysts for hydrogen and fertilizer production using Microreactors

- Team members

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- Students

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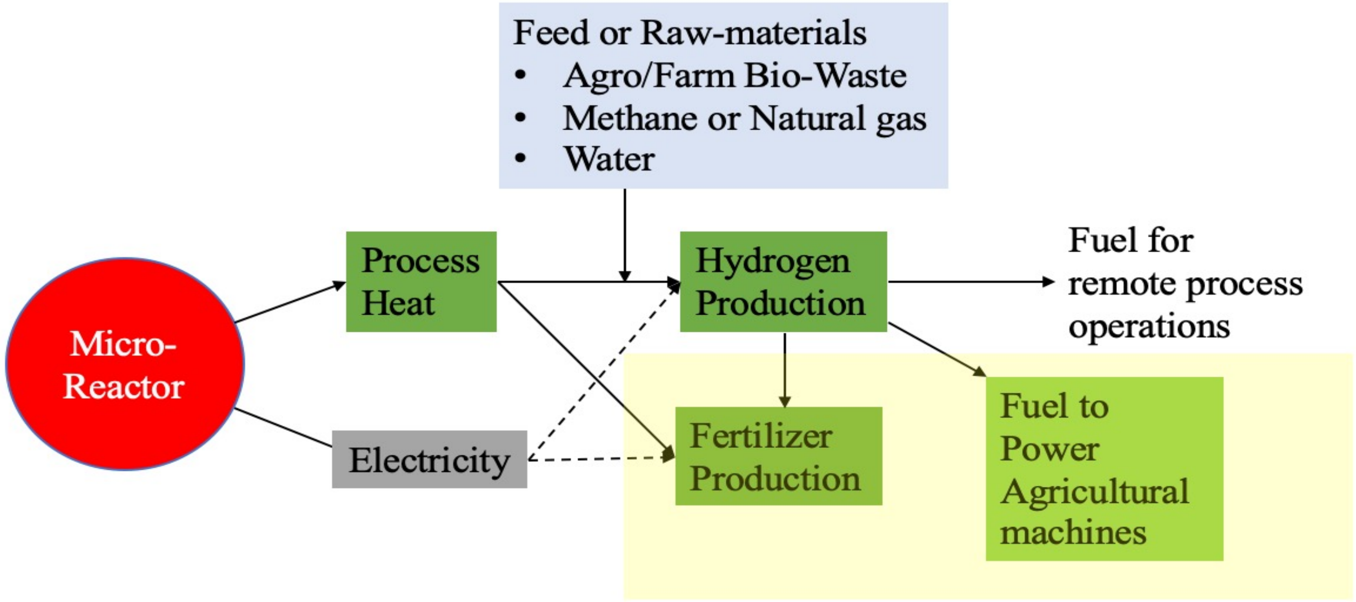
Anshuman Chaube (Graduate student)



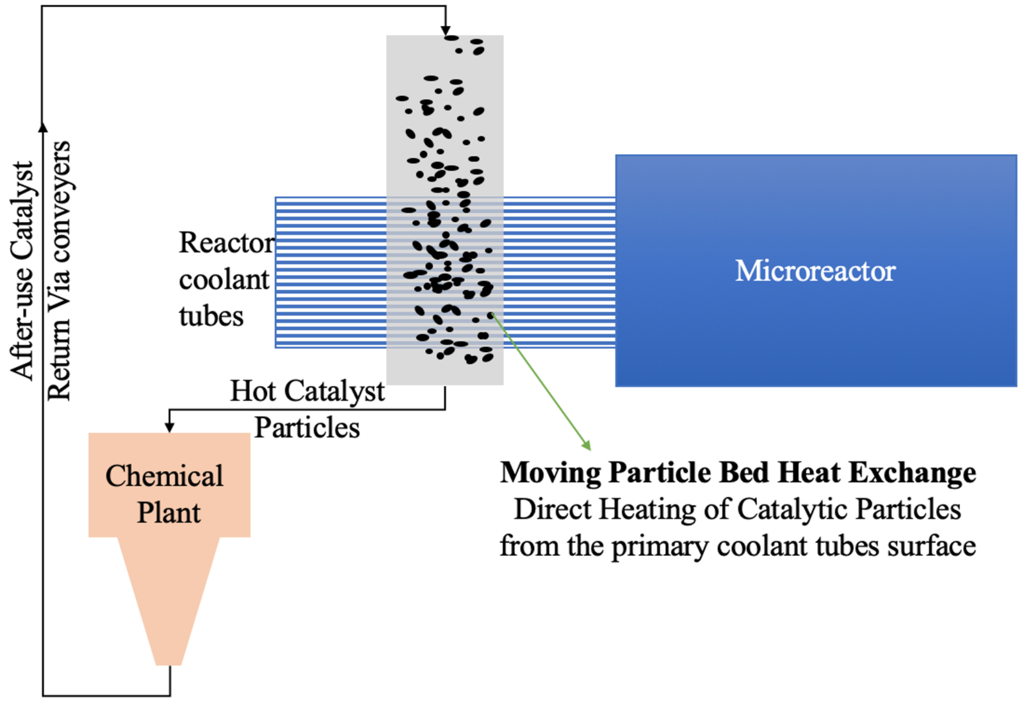
Start Date: Oct. 2021

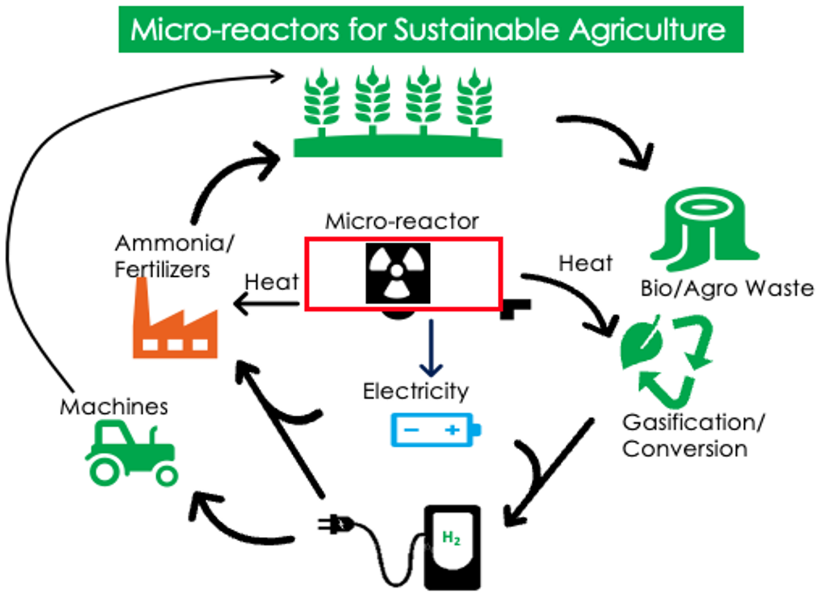
MRP Microreactor Program

Direct heating of chemical catalysts for hydrogen and fertilizer production using Microreactors

Project Objectives

1) Design MPBHX and compare other IHX alternatives for microreactor integration.
2) Exergy and techno-economic feasibility of microreactor integration for hydrogen production and ammonia/fertilizer production.
3) Investigate feasibility of microreactors for achieving sustainable agriculture.





- Moving ceramic particles have high volumetric heat density.
- Store heat for later use.
- Catalyst carriers to sustain thermochemical reactions

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Project Timeline

Milestone	End Date
MPBHX concept design with calculations	9/30/22
Microreactor end-use compatibility	9/30/22
Design matrix and comparative analysis for different microreactor integration concepts	6/30/23
Hydrogen production potential	9/30/23
Overall MPBHX integration economic assessment	4/30/24
MAGNET demonstration guidelines	5/30/24
Sustainable agriculture-case study report	6/30/24

In-Progress

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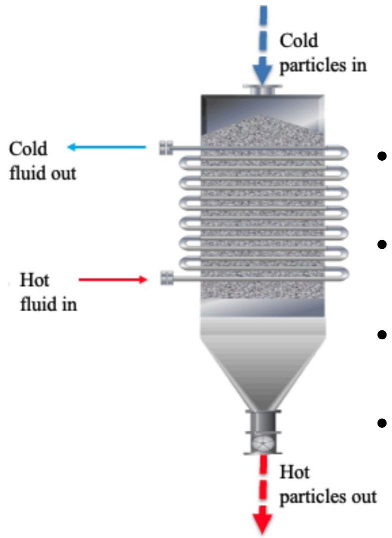
Moving Packed Bed Heat Exchanger (Design and Evaluation)



- Gaseous coolants-High Pressure drop-High parasitic Losses.
- Not too many liquid coolants compatible
- Ceramic granular flow – simple design
- Compare options

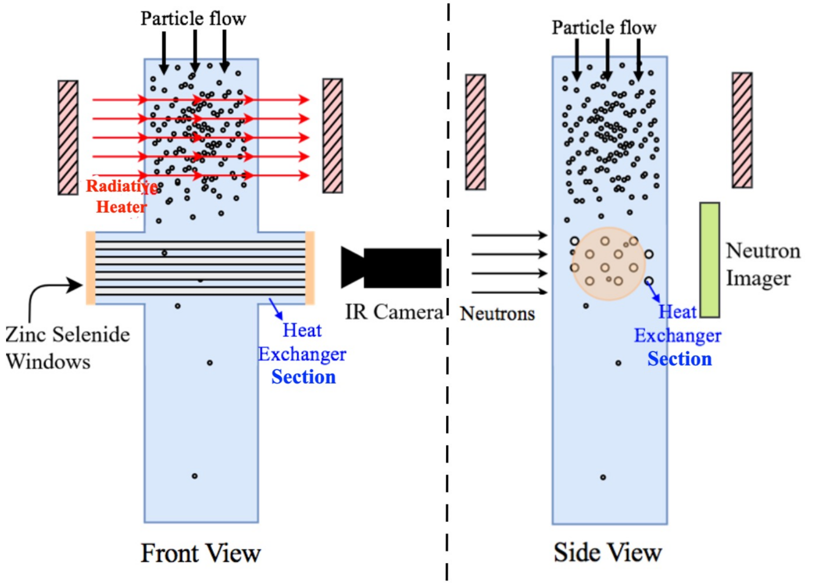
	FOM_ht[1]	FOM_pumping
Air	0.07	40,000
Helium	0.12	25,000
Molten-Salt (Chloride)	0.55	15
Packed bed	0.31	12.5

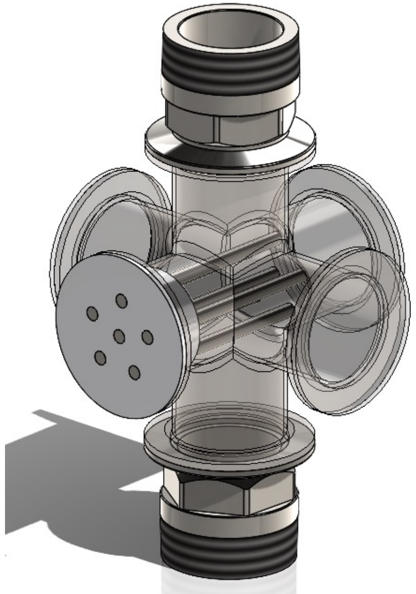
Evaluation Plan

Particles will be flown over electrical heater bank

Thermal imaging response via IR transparent windows

X-ray imaging of particle distribution





[1] Sabharwall et al., INL/EXT-11-21584

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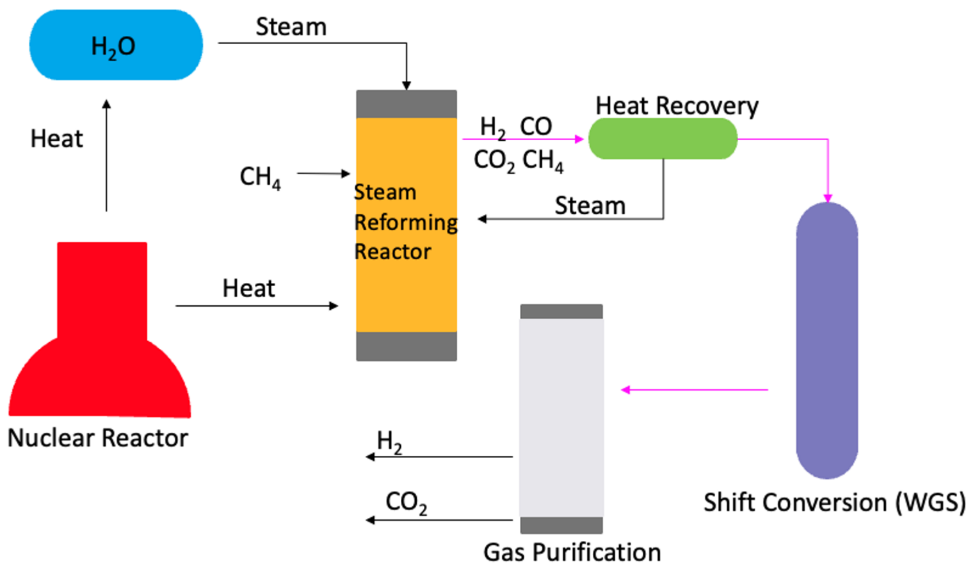
Hydrogen production using Microreactors



Replacing the standard Methane fueled heat supply with microreactor heat

JAEA HTTR (10 MW th) is used for baseline analysis

Steam Methane Reforming-
Thermochemical process at 700- 800ºC

Source of Emissions	**CO_2 emissions (Standard)**	**CO_2 emissions (Nuclear)**
Conversion of feed to hydrogen	0.75 kg/s	0.75 kg/s
Combustion for reforming reaction	0.19 kg/s	N/A
Combustion for steam production	0.28 kg/s	N/A
Total Emissions	**1.22 kg/s**	**0.75 kg/s**

Just replacing the heat component with Nuclear heat can reduce carbon emissions by 38%

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