

Spring 6-10-2013

Novel ICFAR solids feeder for pyrolysis and other applications - Experimental results, characterization, sequential modelling and optimization

Federico Berruti
Western University

Follow this and additional works at: http://dc.engconfintl.org/bioenergy_iv

 Part of the [Chemical Engineering Commons](#)

Recommended Citation

Federico Berruti, "Novel ICFAR solids feeder for pyrolysis and other applications - Experimental results, characterization, sequential modelling and optimization" in "BioEnergy IV: Innovations in Biomass Conversion for Heat, Power, Fuels and Chemicals", Manuel Garcia-Perez, Washington State University, USA Dietrich Meier, Thünen Institute of Wood Research, Germany Raffaella Ocone, Heriot-Watt University, United Kingdom Paul de Wild, Biomass & Energy Efficiency, ECN, The Netherlands Eds, ECI Symposium Series, (2013). http://dc.engconfintl.org/bioenergy_iv/8

This Conference Proceeding is brought to you for free and open access by the Proceedings at ECI Digital Archives. It has been accepted for inclusion in BioEnergy IV: Innovations in Biomass Conversion for Heat, Power, Fuels and Chemicals by an authorized administrator of ECI Digital Archives. For more information, please contact franco@bepress.com.

ICFAR Feeding Technology: Fundamentals & Modelling

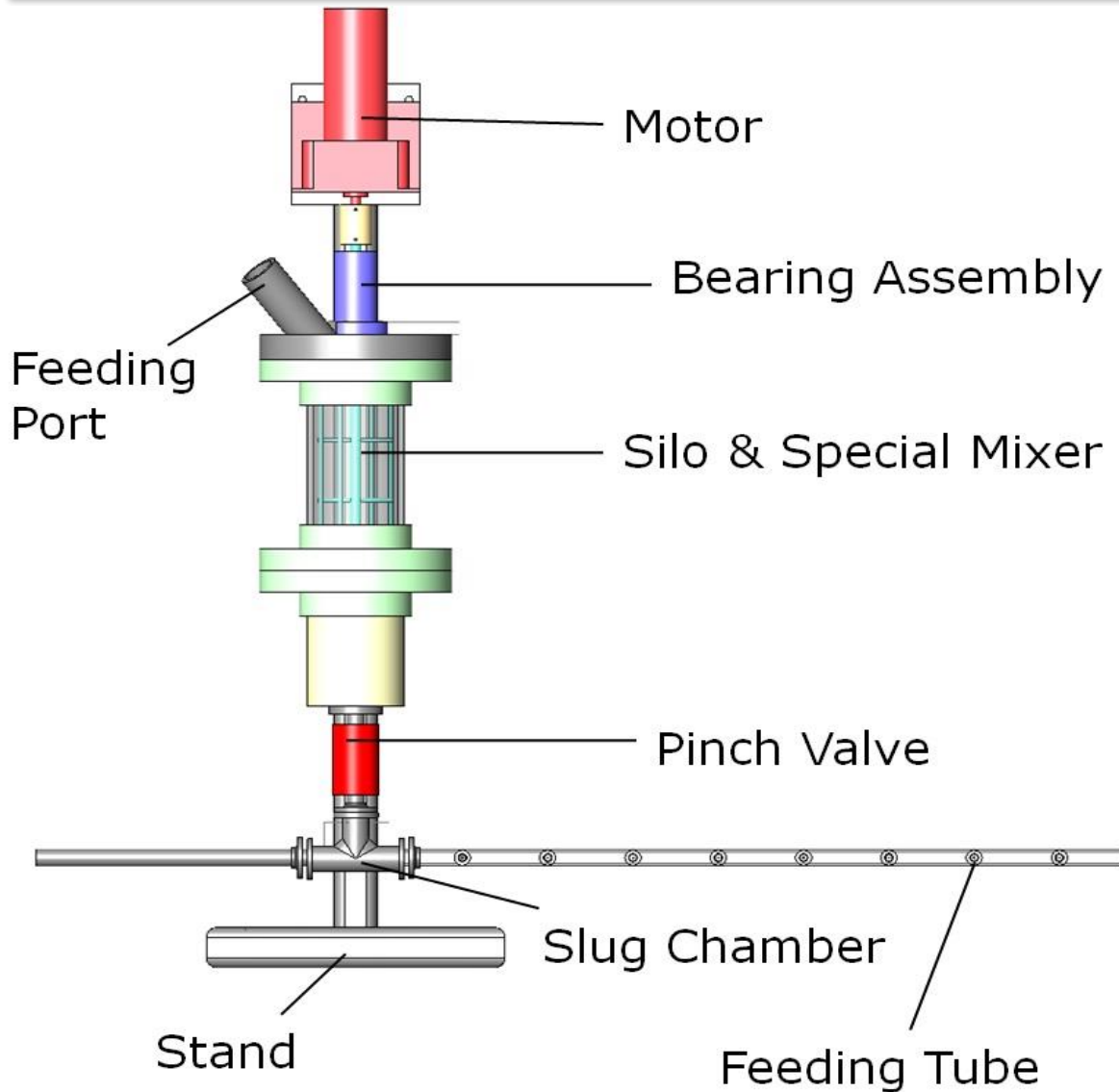
**BioEnergy IV
Otranto, Italy
June 9-14, 2013**

**Federico M. Berruti
BESc, HBA, PhD Candidate
NSERC Vanier CGS Scholar 2010-2013
Vice-President, Agri-Therm Inc.
fberrut@uwo.ca
www.agri-therm.com**

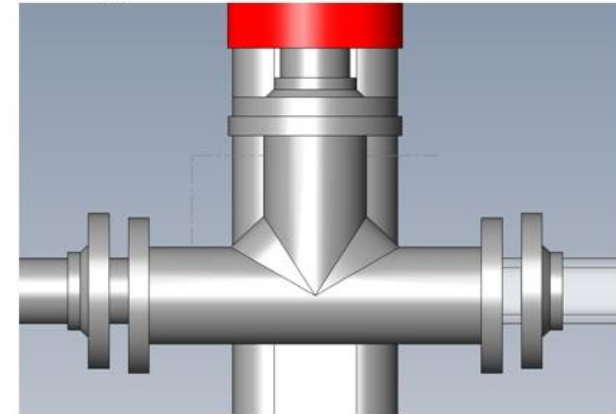
Introduction

- **Conventional feeders for fluid bed reactors:**
 - ❖ *SCREW/AUGER FEEDERS*: plug when attempting to convey temperature-sensitive and cohesive feedstocks.
 - ❖ *DILUTE-PHASE PNEUMATIC FEEDER*: require extensive carrier gas (increased compression energy requirements, condensation train challenges).
- **ICFAR INTERMITTENT SOLID SLUG FEEDER:**
 - ❖ Works with temperature-sensitive feedstocks.
 - ❖ Moderate gas consumption ($F_s/F_g > 50$).
 - ❖ Enhances initial mixing of feedstock with hot bed.

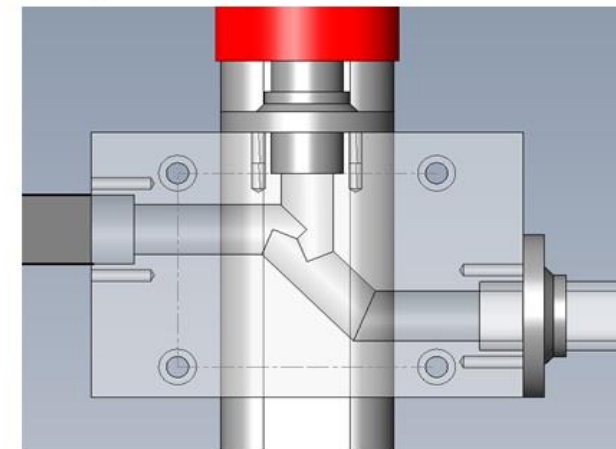
ICFAR Feeding Technology



Slug Chamber Ex.# 1:



Slug Chamber Ex. #2:

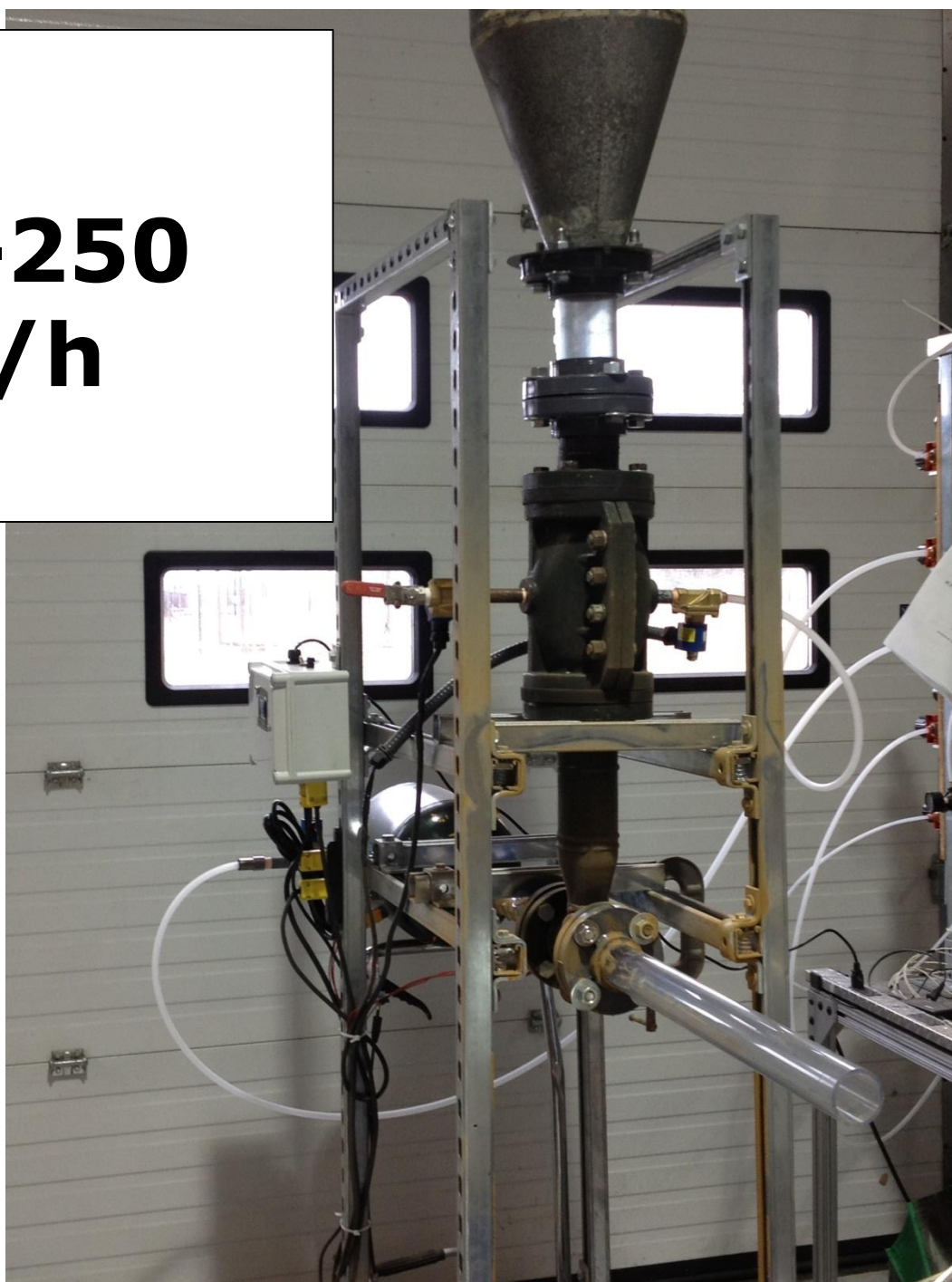






1-20 kg/h

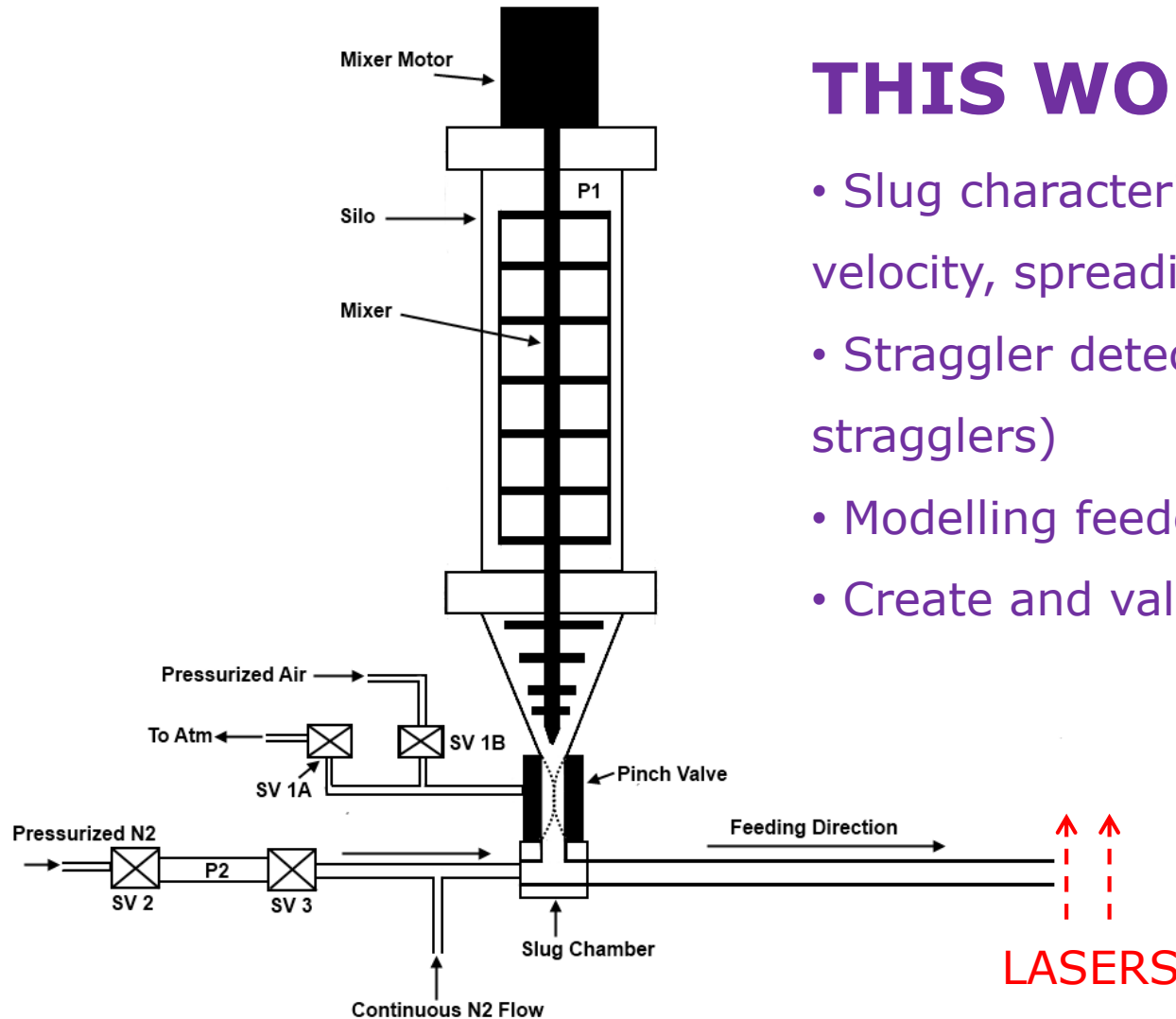
**180-250
kg/h**



ICFAR Feeding Technology

THIS WORK:

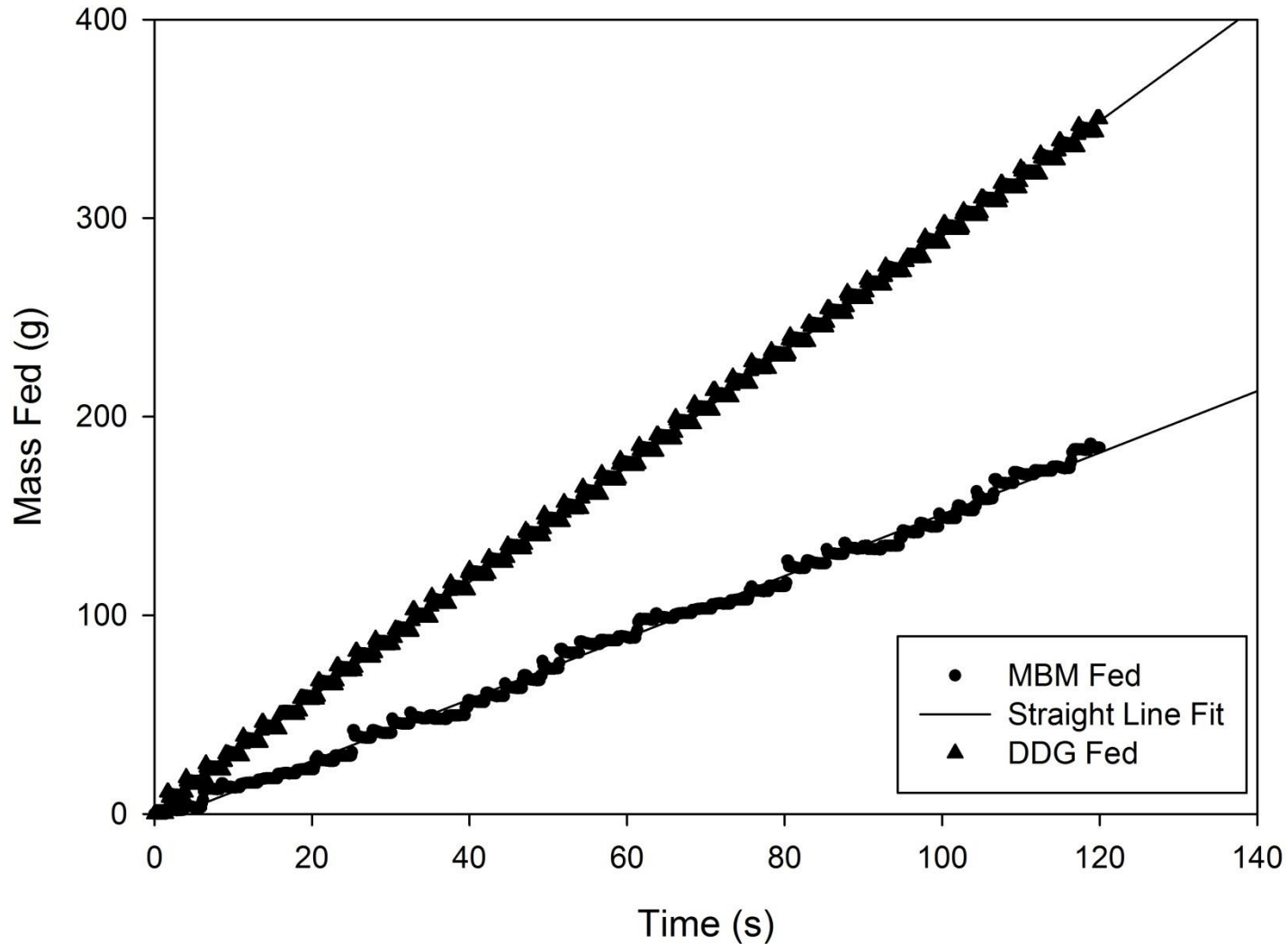
- Slug characterization (length, mass, velocity, spreading) – using **lasers**
- Straggler detection (mass of stragglers)
- Modelling feeder slug flow
- Create and validate predictive model



Selected Feedstocks

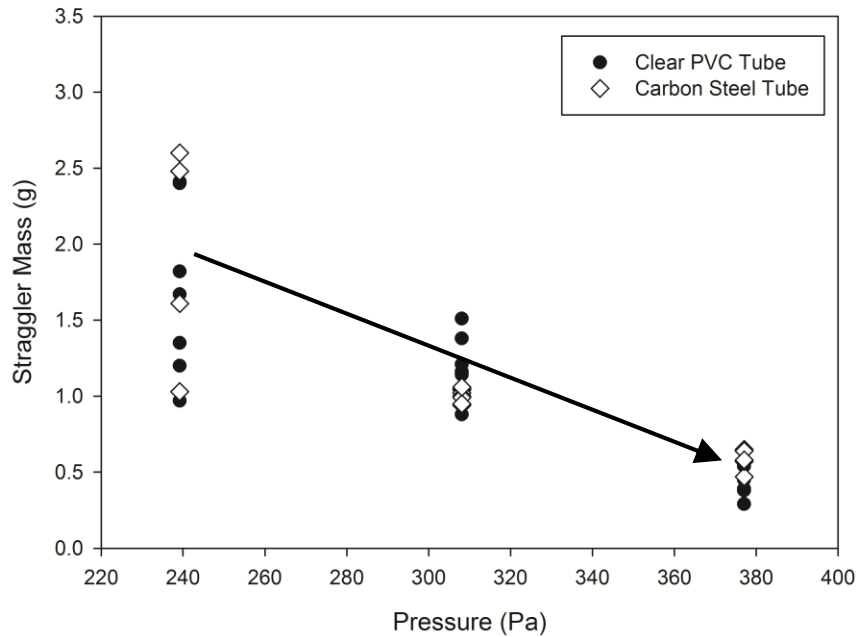
Property	Units/Reference	DDG	MBM	BALL
Sauter mean diameter	μm	577	25.14	15290
Bulk density	kg/m ³	503	467	1229
Particle density	kg/m ³	915	778	1229
Hausner ratio	–	1.26	>1.35	1
Revolution Powder Analyzer:				
Avalanche time	s	4.06	6.03	–
Avalanche median	s	4.29	6.50	–
Avalanche energy	kJ/kg	19.77	27.80	–
Energy std. deviation	kJ/kg	16.10	24.40	–
Avalanche angle	°	56.6	72.4	–
Rest angle	°	44.4	50.3	–
Flow Characterization:				
Flow Type	Shah, 2008 Bhadra, 2009	Passable	Poor	Excellent

Feeder Performance

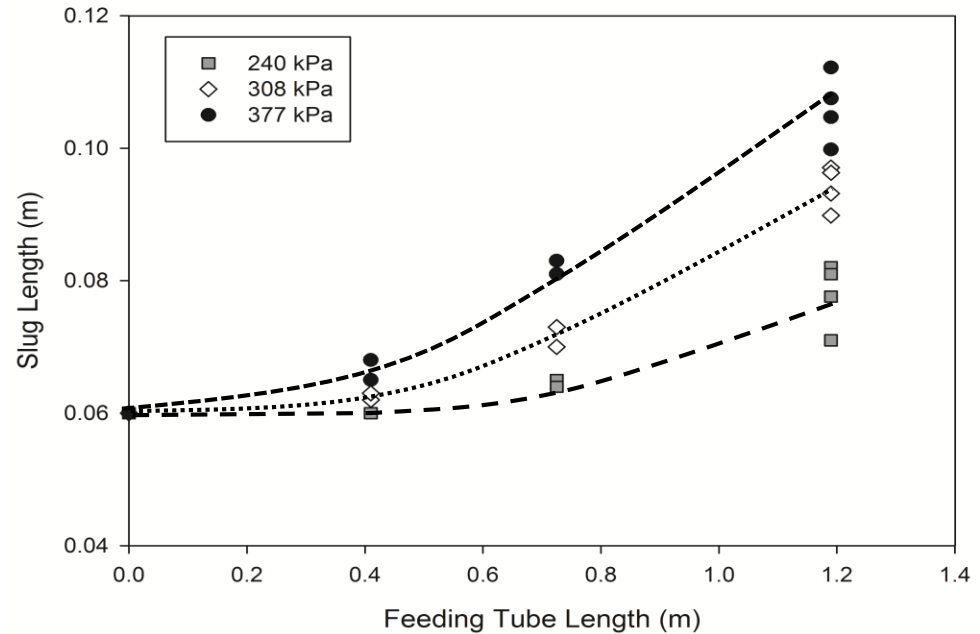


Feeder Performance

Straggler Accumulation vs. P

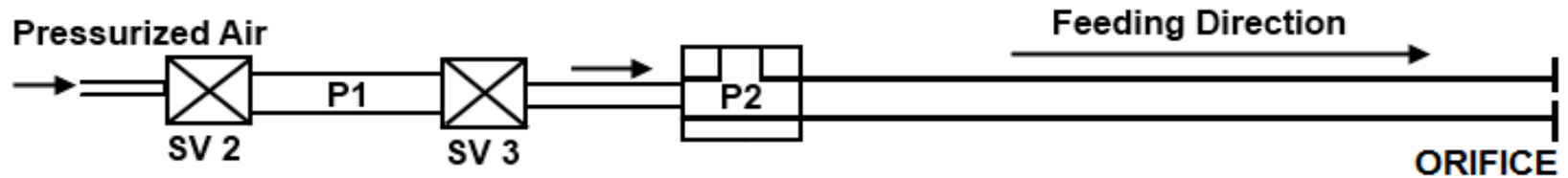


Slug Length vs. Tube Length



Modelling Approach

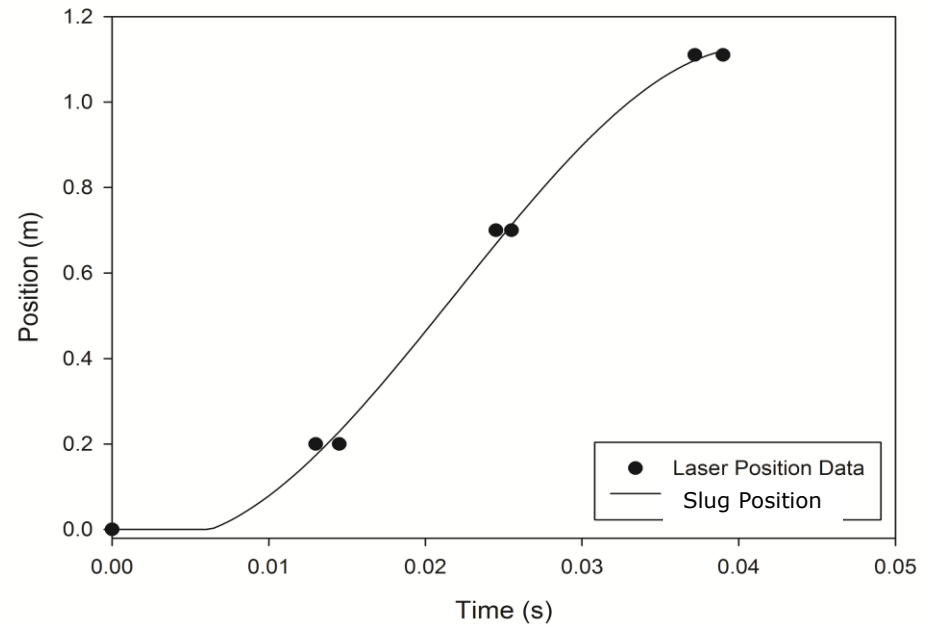
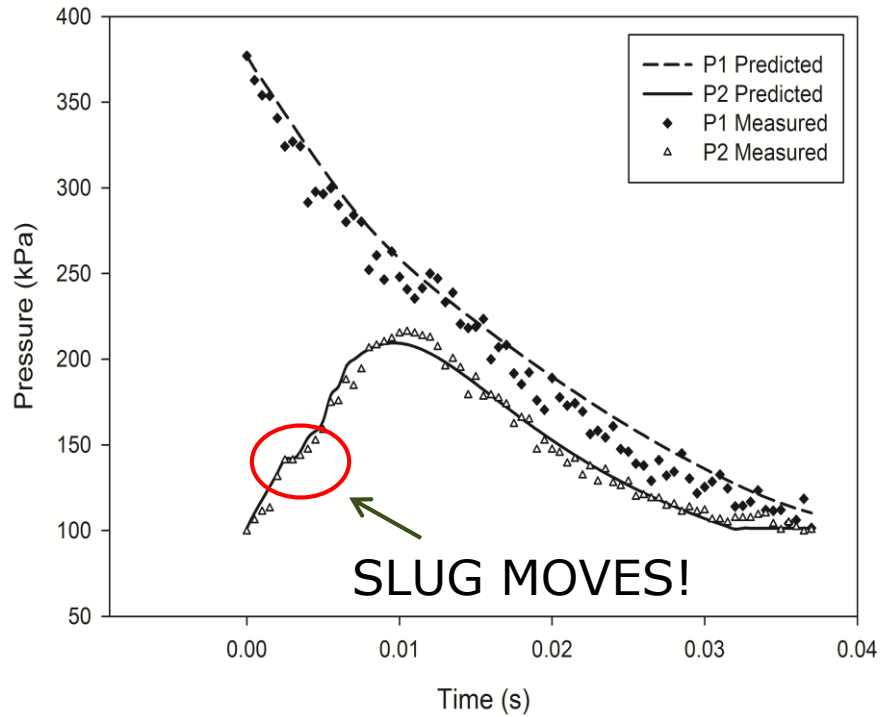
1)



Model Assumptions

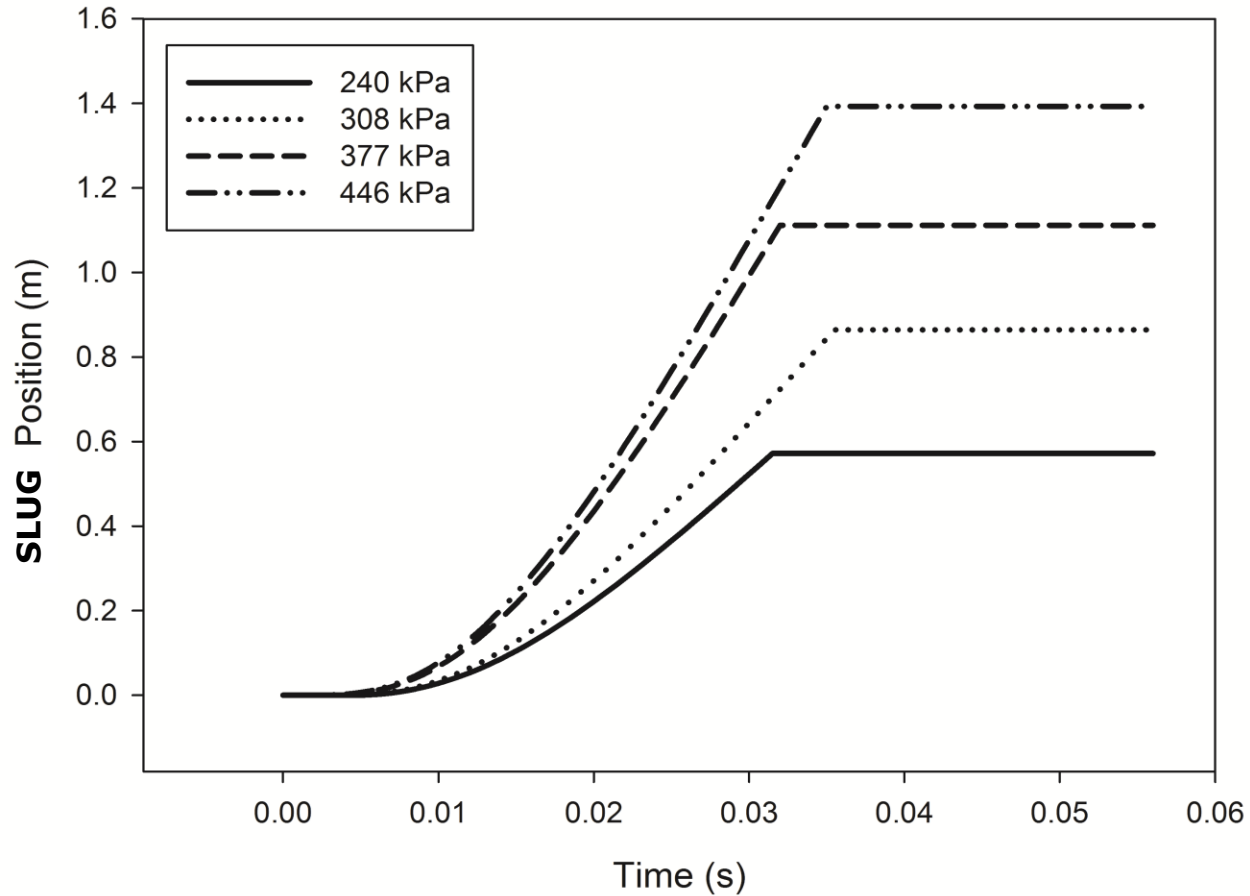
- Ideal gas law
- Delay for initial slug motion/friction (verified)
- No gas leakage through slug (verified)
- Friction factor feedstock index developed:
 - Quick experiments to determine
 - Can be scaled-up (future work)

Model Results for DDG



Predictive Model for DDG

PREDICTED SLUG POSITION BY MODEL



Key Conclusions

- The **ICFAR Intermittent Solid Slug Feeder** can feed temperature-sensitive and cohesive solids into fluidized bed reactors.
- A **predictive model** for the feeder has been successfully developed by utilizing a sequential approach with validation from dedicated experimental data.
- The predictive model can be used as a **design tool** to develop effective feeders for various applications, while considering physical constraints, capital costs and energy efficiencies.
- Recent work has validated the model for the **large scale** feeder and for various **alternate feeder geometries**.

Thank you!

Institute for Chemicals and Fuels
from Alternative Resources
Western University

i  **cfar**

Federico M. Berruti
BESc, HBA, PhD Candidate
NSERC Vanier Canada Scholar 2010-2013
Vice-President, Agri-Therm Inc.
fberrut@uwo.ca
www.agri-therm.com



Government
of Canada

Vanier Canada
Graduate Scholarships

Gouvernement
du Canada

Bourses d'études
supérieures du Canada Vanier

Canada 

AGRI·THERM