Advanced Training: Drag Calibration

Sam Clark
CFPD, LLC

2018 European User Group Meeting
Düsseldorf, Germany · 09 April, 2018

Outline

Empirical models in Virtual Reactor

Drag Models in Virtual Reactor

- Built-in drag models
- User-defined drag models
- Multipliers and multiplier tables

Calibration of Drag Models

- Using operational and experimental data
- Guidelines for applying calibrated drag models

Empirical Models in Virtual Reactor

All CFD tools are based on a mix of fundamentals and empirical models

Fundamentals

- Conservation of mass
- Conservation of momentum
- Conservation of energy

Empirical models

- Particle collision and bounce
- Fluid-particle drag models
- Turbulence models
- Chemical reactions and rates

Fluid-Particle Drag Models

Fluid-particle drag is an important empirical model in Virtual Reactor

Some aspects of drag are well-known

- Drag for a single particle (Schiller-Nauman Correlation)
- Drag for a group of particles at close-pack (Ergun)

Other aspects are not well-known

- Drag for volume fractions between single particle and close-pack (Wen-Yu, Wen-Yu/Ergun blend, EMMS)
- Drag for very small particles (< 44 microns diameter, i.e. fines)
    - Agglomeration
    - Hindrance effects

Audience Question

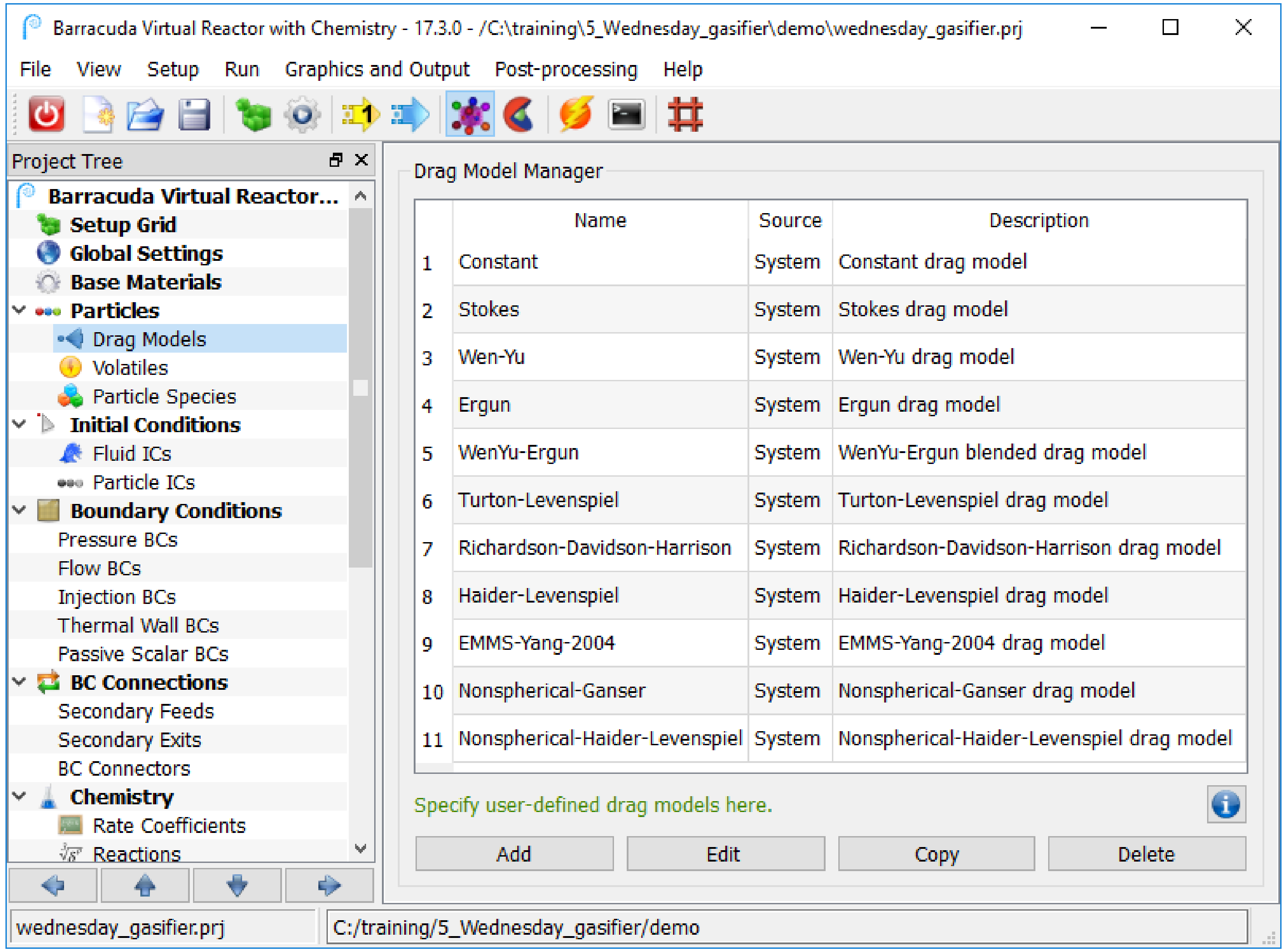
Which drag model do you usually use?

- How well does it work? How do you know?
- Do you ever perform calibration of the drag model?

Built-In Drag Models

Virtual Reactor includes several built-in drag models

- Wen-Yu/Ergun is a reasonable starting point for many Geldart Group A particles
- Nonspherical drag models are helpful when particles are very non-spherical in shape



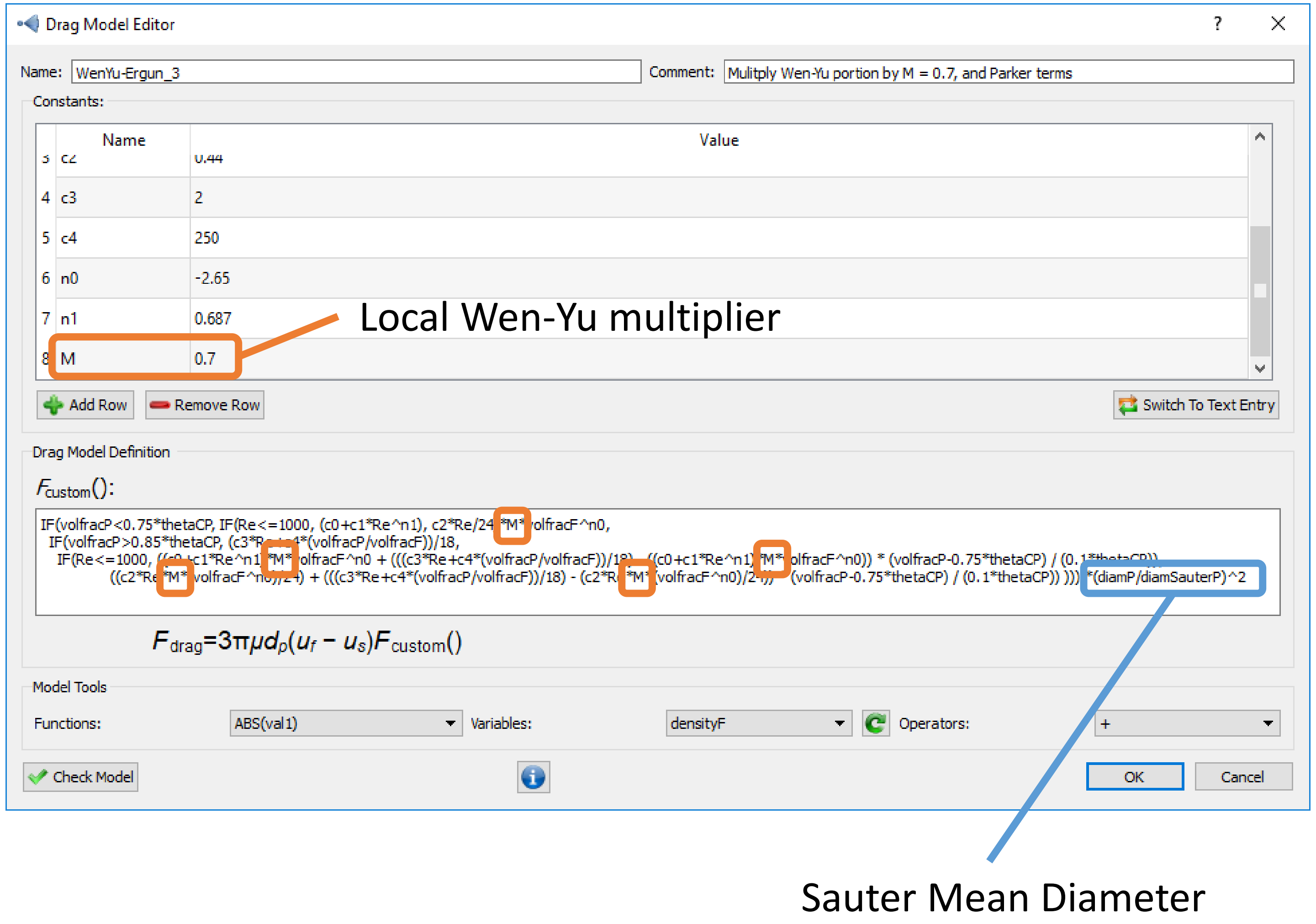
User-Defined Drag Models

Can be based on built-in drag models

- Copy an existing model
- Modify as desired

Can be completely new

- Use the Drag Model Editor
- Define any constants
- Define $F_{custom}()$



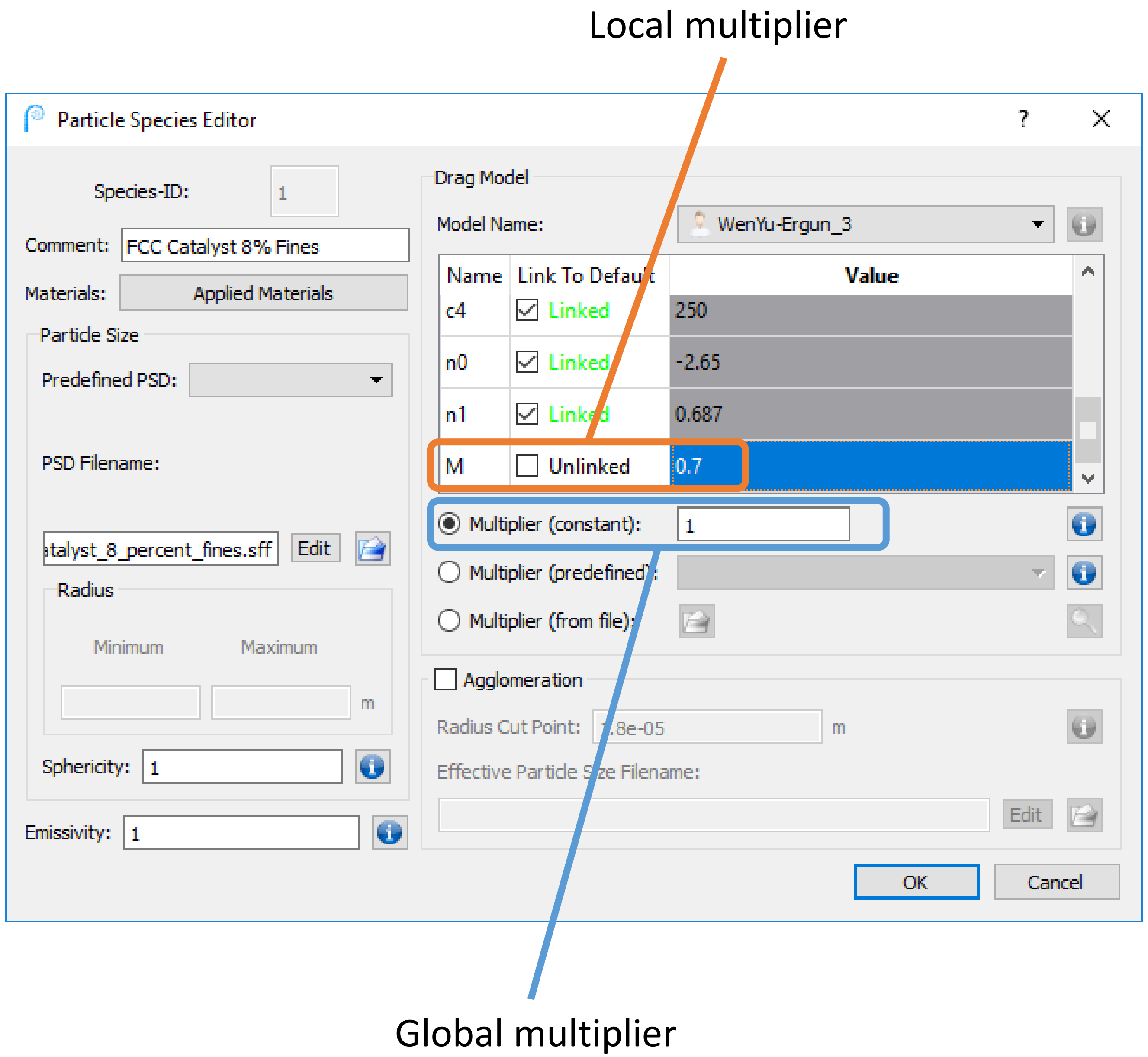
Multipliers: Global and Local

A global multiplier affects the entire drag model

- Use *Multiplier (constant)* in Particle Species Editor

A local multiplier can be defined to affect just a portion of the drag model

- Define a custom drag model
- Define a constant that affects just the desired portion



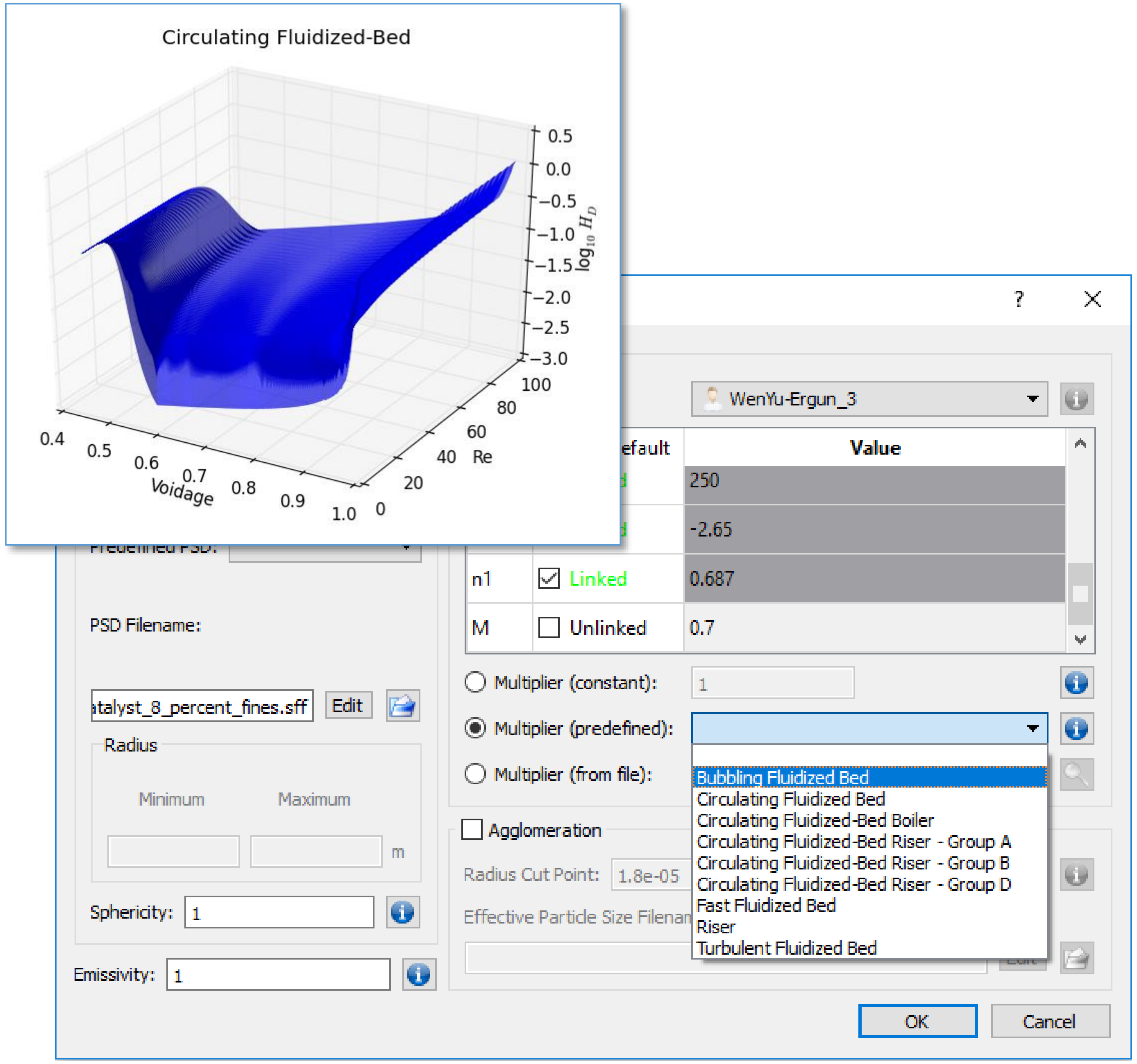
Multiplier Tables: EMMS

2-dimensional tables to adjust drag based on voidage and Re

Virtual Reactor has several predefined tables to choose from

CPFD has the ability to generate [custom EMMS tables]

- Highly recommend to use a custom-generated EMMS table
- Very dependent on particle properties and flow conditions



Drag Model Calibration

What adjustable parameters are available?

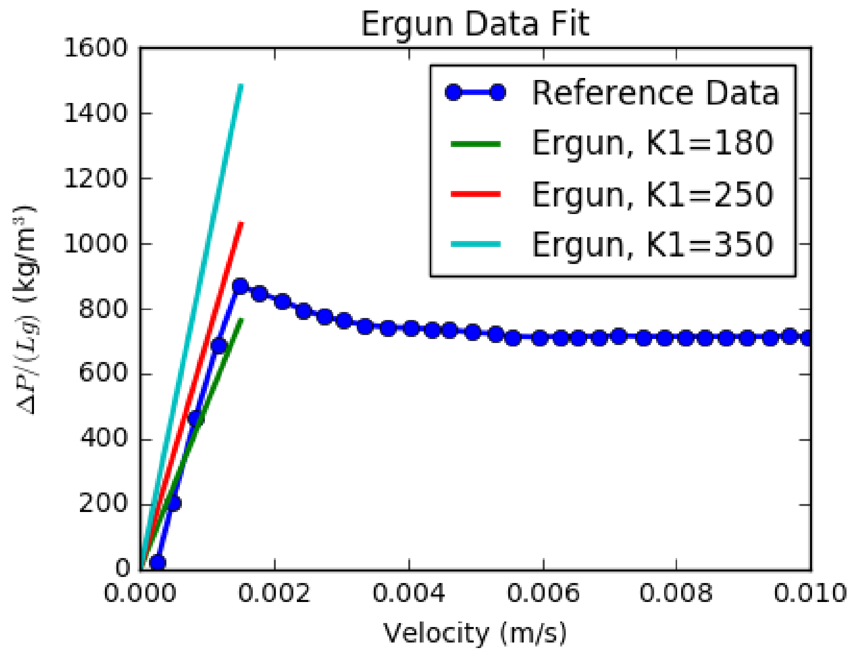
- Depends on which drag model you are using

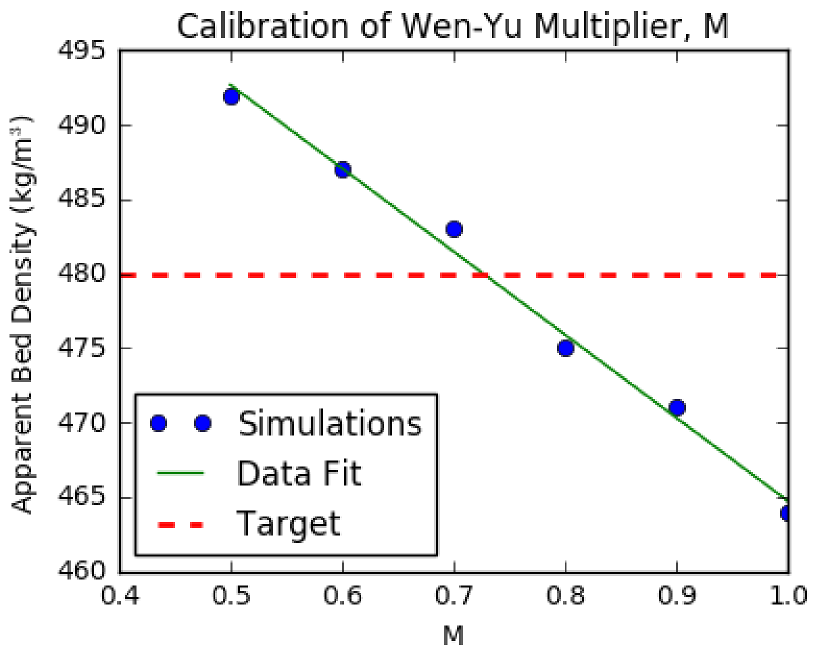
Ergun

- Linear coefficient can be calibrated using minimum fluidization (Umf) data

User-defined Wen-Yu with local multiplier

- Multiplier “M” can be calibrated using operational pressure drop data



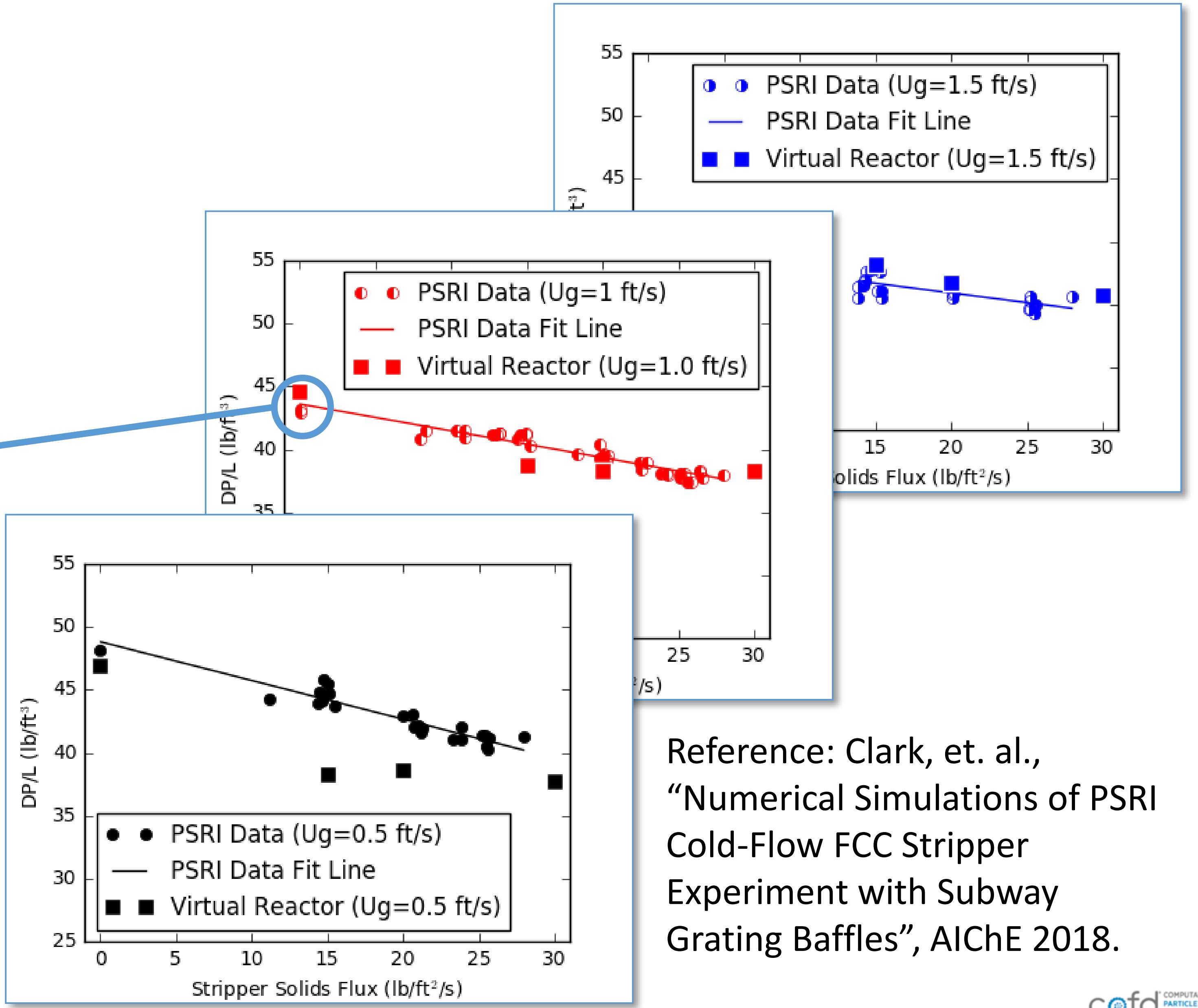


Guidelines for Applying Calibrated Drag Models

Goal: use Virtual Reactor as a reliable predictive tool

Do not “tune” every case

- Determine the calibrated parameters for a baseline case
- Use those parameters in all subsequent simulations of the system



Reference: Clark, et. al., “Numerical Simulations of PSRI Cold-Flow FCC Stripper Experiment with Subway Grating Baffles”, AIChE 2018.

Conclusions

Drag is an important empirical model in Virtual Reactor

- Since it is not "fundamental", calibration is necessary

Virtual Reactor provides several ways to handle drag

- Built-in drag models
- User-defined drag models
- Multipliers and multiplier tables

Guidelines for calibration of drag models

- Use operational and experimental data whenever possible
- Do not tune every case! Tune a base case, and use calibrated parameters.