EXPERIMENTAL VALIDATION OF CFD HYDRODYNAMIC MODELS FOR CATALYTIC FAST PYROLYSIS (CFP)

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Catalytic Fast Pyrolysis (CFP) is a means of producing renewable fuels and chemicals from lignocellulosic biomass. KiOR, a world leader in this area, has developed a CFP technology along the lines of the FCC process.

In early 2015, KiOR engaged with CPFD Software to develop a new, parallel path for developing and optimizing its CFP technology. Emphasis was placed on hydrodynamics predictions, since that is one key area where KiOR's CFP differs significantly from FCC. The KiOR-CPFD team reduced the hydrodynamics validation problem to four key milestones. Each milestone needs independent experimental validation, and must build on the previous ones:

1. Fixed-fluid-bed (FFB) fluidization of catalyst only;
2. FFB mixing of catalyst and biomass;
3. Circulating-fluid-bed (CFB) fluidization & de-fluidization of catalyst only;
4. CFB mixing of catalyst and biomass.

At the time of this writing, the first two milestones are essentially complete, and the results published (1,2). All efforts are now focused on milestone 3. To this end, a simple lab-scale cold-flow CFB unit has been constructed (Figure 1) that provides for detailed study of important phenomena in circulating systems, like: pneumatic transport; choke point; defluidization and bed-building; powder flow; bubbling and jetting; and transport disengagement height (TDH). This new cold-flow unit can circulate catalyst through test chambers of varying sizes and shapes, over wide ranges of catalyst and gas flows. Existing measurement capabilities include mass holdup, pressure profile, and visual observations.

Figure 2 shows the very first data ever produced by this unit, compared to CFD predictions. Mass holdups were measured gravimetrically, using the isolation valves. These tests already prove the unit is up to the challenge of providing the necessary validation data, with all the discrimination and repeatability needed for CFD model tuning. At this early stage, it appears the CFD predictions are high by roughly a factor of 2. It also seems some fine structure is missing from the predictions. Note that at present, we do not have gas flow capability to explore the sharp drop seen in the CFP predictions. There is much more to come!

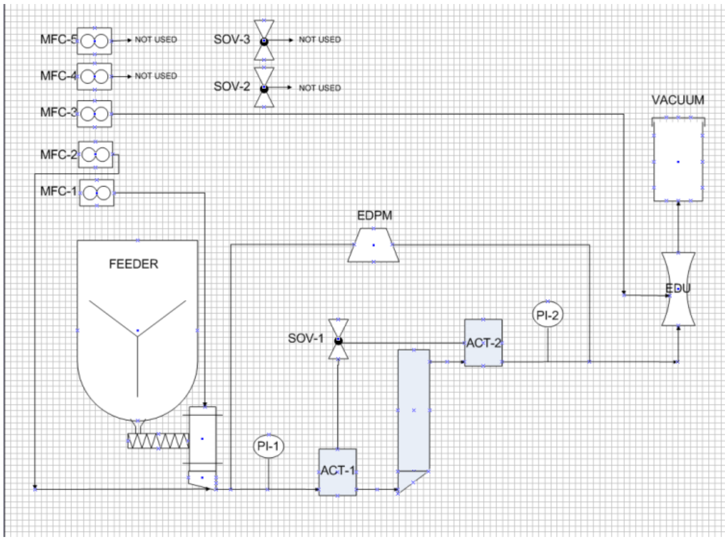

Figure 1. PFD of CFB validation unit. MFC = mass flow controller; PI = pressure transducer; EDU = venture flow eductor; SOV = solenoid valve; ACT = actuator; EDPM = electronic delta-P monitor. The feeder is a Coperion K20 twin-screw with digital motor. The test chamber lies between ACT-1 and ACT-2.

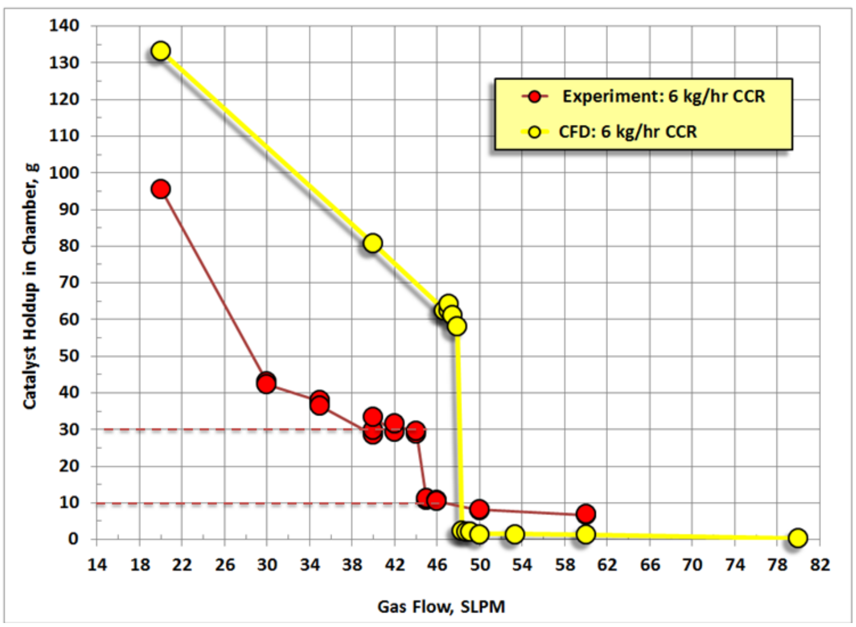

Figure 2. Very first comparison of experimental data from new CFB unit with CFD-predicted catalyst holdup as a function of gas flow and catalyst circulation rate (CCR)

REFERENCES

1. B. Adkins, N. Kapur, J. Pendergrass, J. Parker and P. Blaser, “KiOR Update: Incorporating Barracuda in our CFP Development Process”, tcBiomass Conference, Nov 3-5 2015, Chicago Illinois
2. J. Parker, P. Blaser, J. Pendergrass, B. Adkins, N. Kapur, “Project Update: Incorporating CFD in Our CFP Development Process”, AIChE Annual Meeting, Nov 8-13 2015, Salt Lake City, Utah