Modelling Double-Riser Fluid Catalytic Cracking Units

Lante Carbognani, M.Sc., P.Eng.
VMG, A Schlumberger Technology

Background

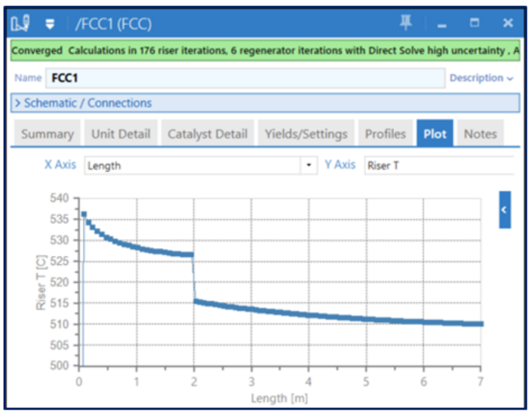
Fluid Catalytic Cracking (FCC) is a key process in refineries as it cracks high molecular weight hydrocarbons in the presence of a catalyst and heat, producing gasoline and lighter, higher-value fluids. To add to the importance of this unit, recent forecasts for gasoline and other fuels indicate that the FCC will remain one of the most important heavy oil conversion units in the refining industry [1].

On the oil availability and quality side, unconventional oil has been playing an increasingly important role in world oil supply. This translates to a gradual quality decrease in the feed to the different units in a refinery [2]. To answer these changes, FCC technologies are constantly pushing the boundaries, developing more efficient and flexible units such as the RFCC (Residue FCC) and more recently a "Two riser FCC" configuration. This last process was developed to be flexible enough to be operated in different modes depending on market demands. [3]

Summary

The Symmetry* Process Software platform allows for fully rigorous double riser configuration (see Figure 1) for both FCC and Residue FCC (RFCC) configurations, allowing you to:

- Predict the reactivity of feeds & blends
- Save time and resources on simulation
- Optimize the reactor's operating conditions considering:
    - Catalyst deactivation
    - Mechanical considerations
    - Chemical additive interactions
    - Pretreatment unit performance



Riser Geometry		
Riser	1	2
Riser Top Height [m]	**3.00**	**4.00**
Riser Top Diameter [m]	**0.65**	**0.65**
Riser Mid Height [m]	**2.00**	**3.00**
Riser Mid Diameter [m]	**0.60**	**0.60**
Riser Bottom Height [m]	**2.00**	**2.00**
Riser Bottom Diameter [m]	**0.50**	**0.50**
Catalyst Recirculation [kg/h]	**0.00**	**0.00**
Catalyst Circulation Rate [kg/h]	447285.45	566266.72
Risers Outlet T [C]	**510.0**	**515.0**

Riser Results		
Riser	1	2
Conversion [%]	51.35	74.08
Riser Inlet T [C]	534.9	566.0
Risers Outlet P [kPa]	287.68	276.81
Riser DP [kPa]	12.32099	23.19181
Bed Void [Fraction]	0.9604	0.9299
WHSV [1/h]	18617.98	24709.75
Gas Residence Time [s]	0.4723	0.3864
Catalyst Residence Time [s]	0.6920	0.5879

Figure 1. Symmetry's Double Riser FCC

Double-Riser FCC in Symmetry

Symmetry's FCC unit previously only supported a "One riser" conventional FCC with both single and two-stage regeneration available (see Figure 2).

However, in order to keep up with constantly changing technologies, an effort to develop a double-riser feature for the FCC was completed in 2020.

This new additional configuration allows the user to model two independent risers, where effluents are stripped off the catalyst on a common stripping section similar to that reported by Wang et.al.[4] (see Figure 3). The catalyst is subsequently regenerated in either a single or a two-stage regenerator (see Figure 2).

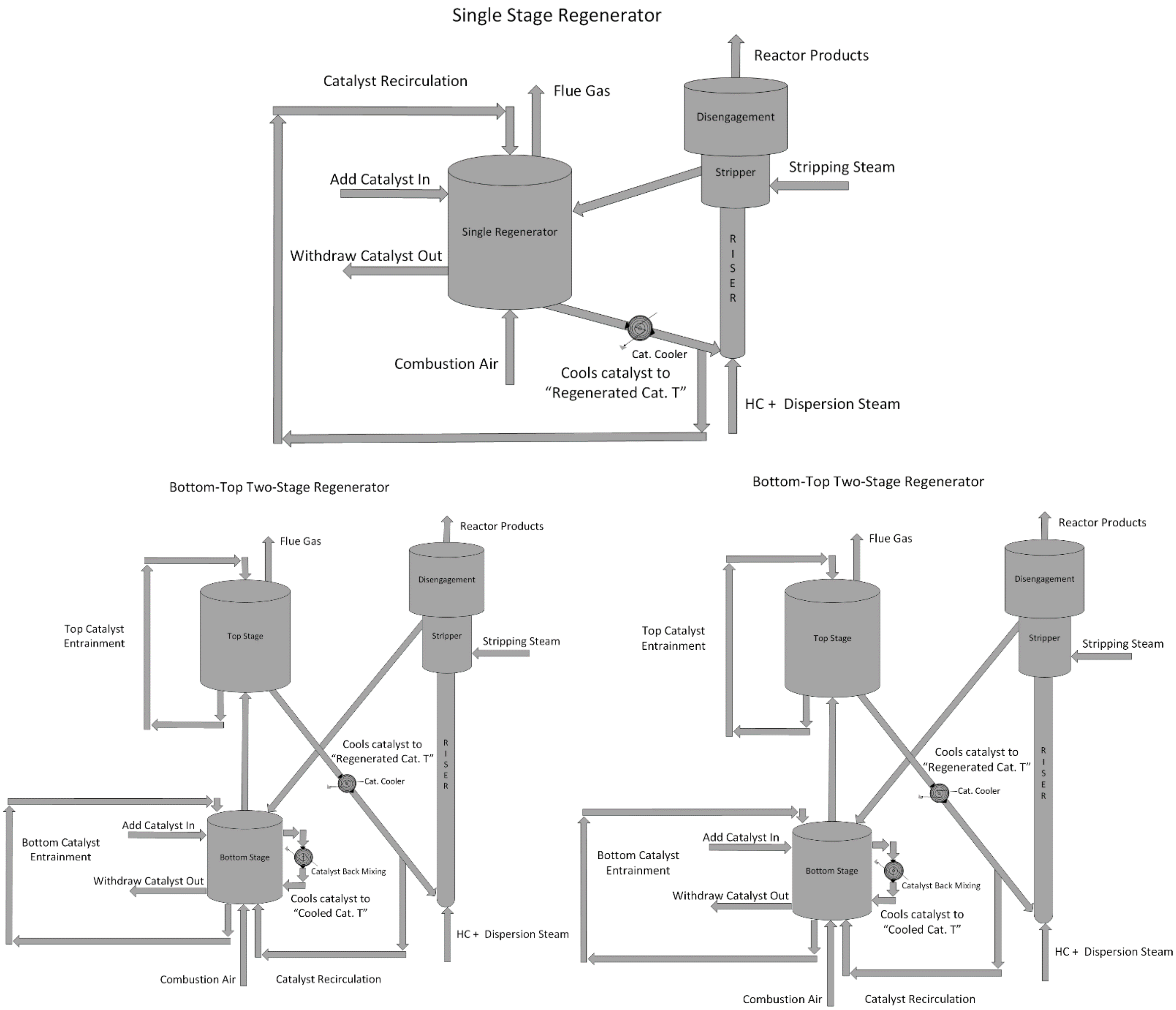


Figure 2. FCC Possible Configurations

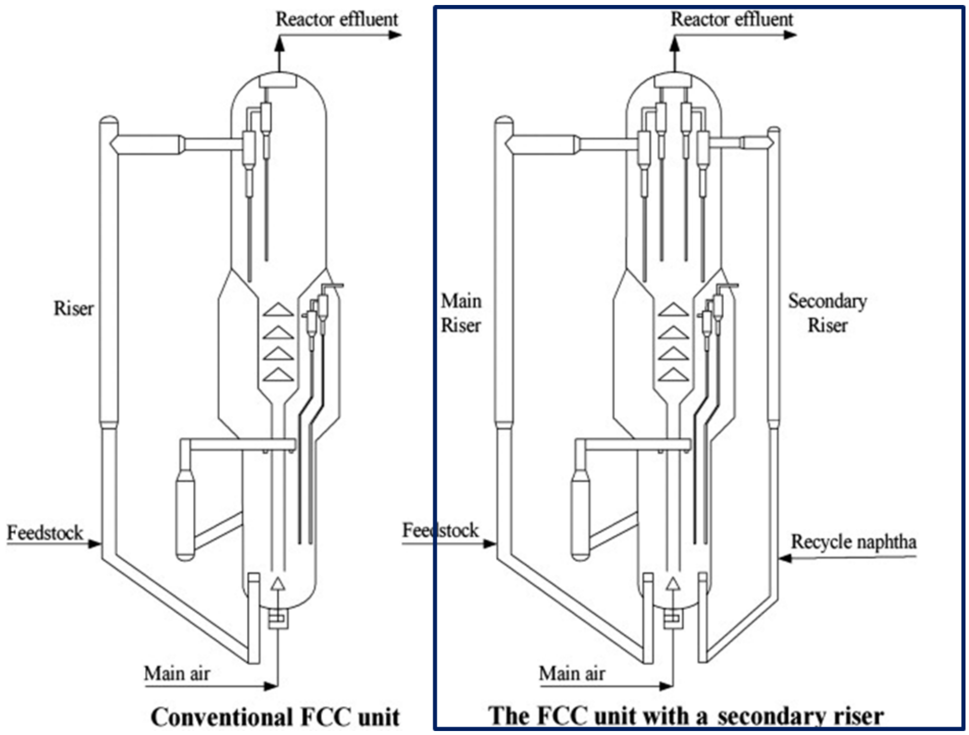


Figure 3. Double riser schematic [4]

Double Riser Features

When selecting the double riser option, a series of features and differences between single and double riser FCC units can be noted.

Mainly, this option allows the user to specify two different riser sections with different feeds, dispersion steam and quench:

- Single Diameter
  - Additional Feed port
  - Additional Dispersion port
- Multi-Diameter
  - Additional Feed port
  - Additional Dispersion port
  - Additional Quench port

In the Summary tab, the "Additional Riser Results" is now going to reflect the two different catalyst to oil ratios, one for each riser (see Figure 4):

Additional Riser Results

Riser	1	2
Catalyst/Oil wt		

Figure 4. Additional riser results

Specifying the RON/MON is still possible. The FCC unit operation will find the catalyst circulation rate (thus riser temperature) in order to achieve this specification. The only difference between single and double riser FCC is that when in double riser mode, the overall catalyst circulation rate (and thus outlet temperature) is going to increase/decrease in order to find the desired RON/MON, all while keeping the risers outlet temperatures (ROT) ratio constant. For example:

	Scenario 1	Scenario 2
Spec RON	No	Yes
RON	91	93
ROT1 (Riser 1)	515	520
ROT2 (Riser 2)	518	523.03
ROT1/ROT2	0.9904	0.9904

When working with a double riser FCC, the geometry for each riser can then be specified, including the possibility of multi-diameter risers (see Figure 5):

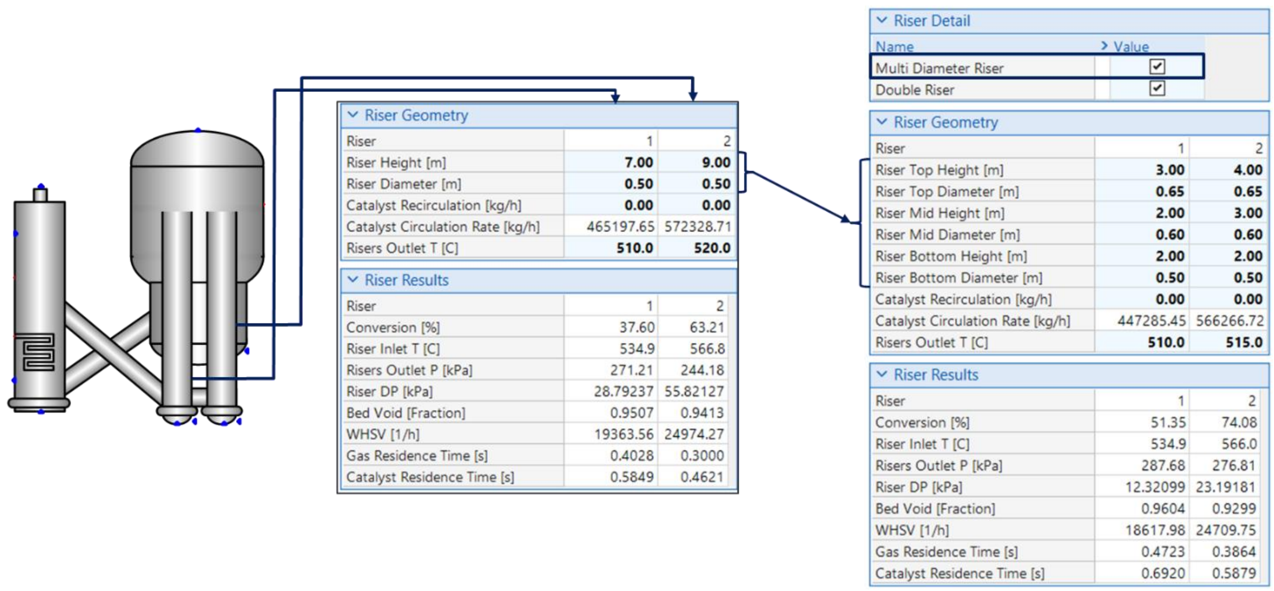


Figure 5. Double-Riser Geometry inputs

Additionally, profiles for each riser are available in both table & plot format (see Figure 6):

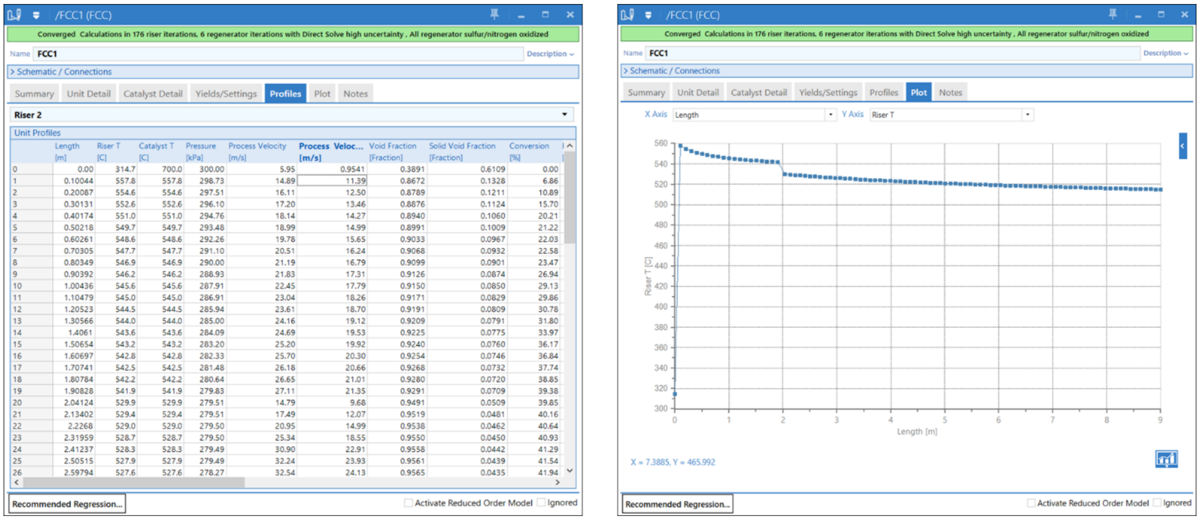


Figure 6. Double Riser Profiles & Plots

How to Add a Double-Riser FCC

The FCC double riser feature can be accessed in two ways:

1. By dragging and dropping the new “FCC 2R” stencil directly into the flowsheet (see Figure 7):

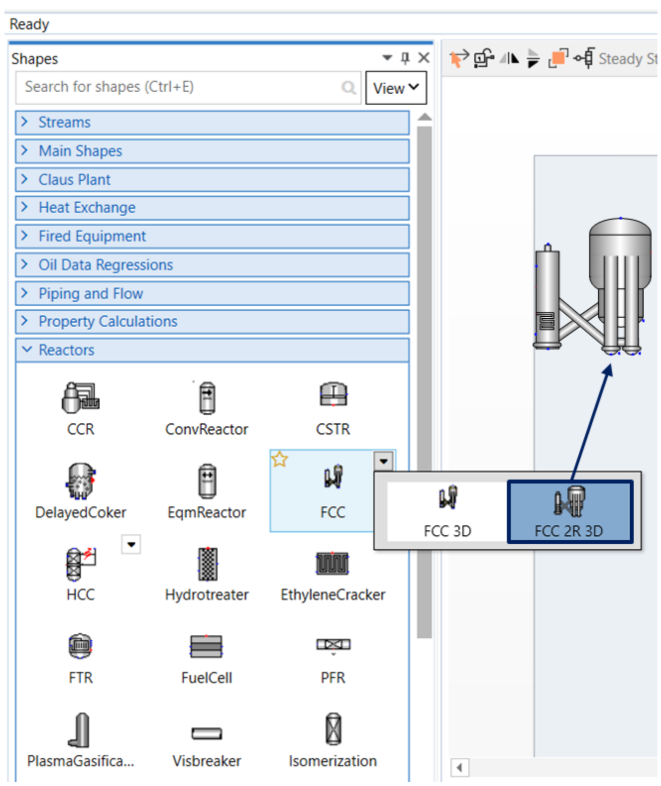


Figure 7. Adding an FCC 2R unit

2. By clicking on the “Double Riser” checkbox located in the Unit Detail Tab (see Figure 8):

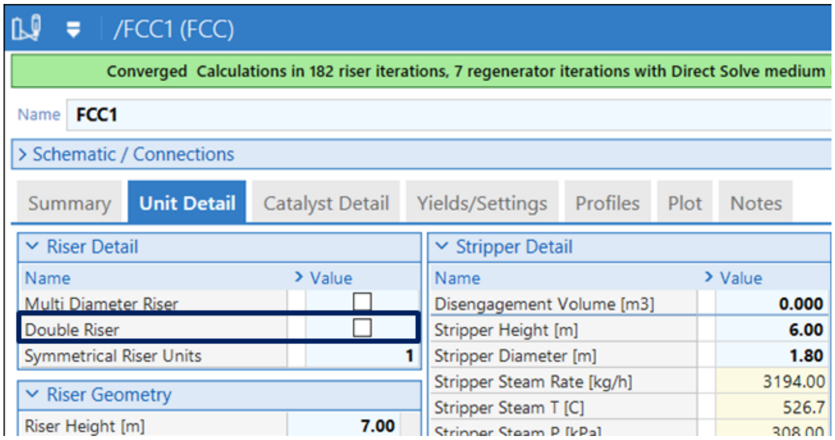


Figure 8. Switching between single and double riser

References

[1] Shan, Hong-hong, et al. "Experimental study of two-stage riser FCC reactions." Fuel 80.8 (2001): 1179-1185.
[2] WEO, IEA. "International Energy Agency, World Energy Outlook 2012." Paris Google Scholar (2012).
[3] Zhang, Jinhong, et al. "Multifunctional two-stage riser fluid catalytic cracking process." Applied petrochemical research 4.4 (2014): 395-400.
[4] Wang, Gang, Chunming Xu, and Jinsen Gao. "Study of cracking FCC naphtha in a secondary riser of the FCC unit for maximum propylene production." Fuel Processing Technology" 89.9 (2008): 864-873.

To learn more about the Symmetry Process Software Platform please contact your local Schlumberger office.

*Mark of Schlumberger