Virtual Reality Technology Extends McCabe-Thiele Into Higher Dimensional Space

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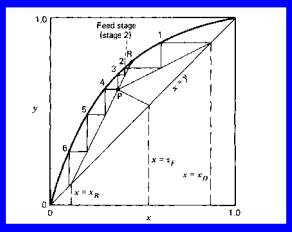
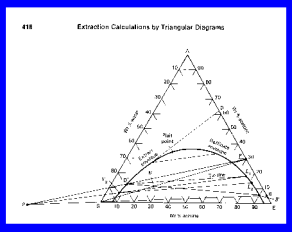
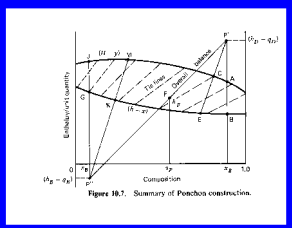
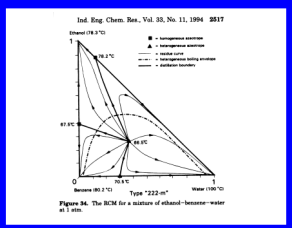
Graphical Methods in Chemical Engineering









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Features of Virtual Reality

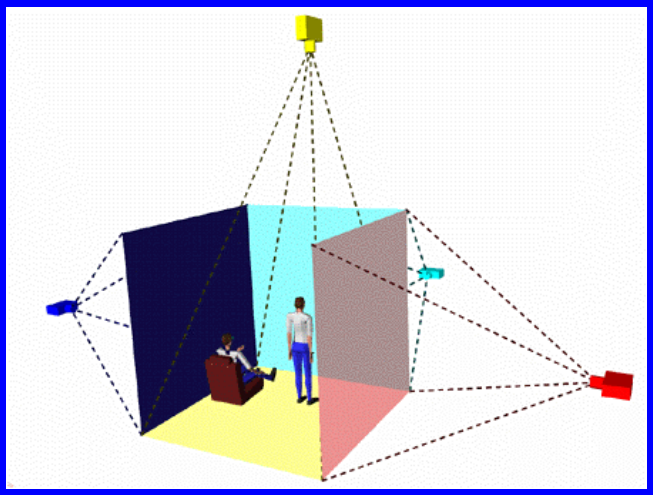
- Immersive, Interactive Experience
- Highly Realistic and Believable
- Multisensory Three-Dimensional Environment

★ High-speed 3D Graphics and (3D) Audio

? Head-Mounted Displays, BOOM, CAVE, . . .

? Trackers, Wired Gloves, Wands, Treadmills, . . .

CAVE® - Cave Augmented Virtual Environment



Early Work - 4 Dimensional Azeotropic Residue Curves, ...

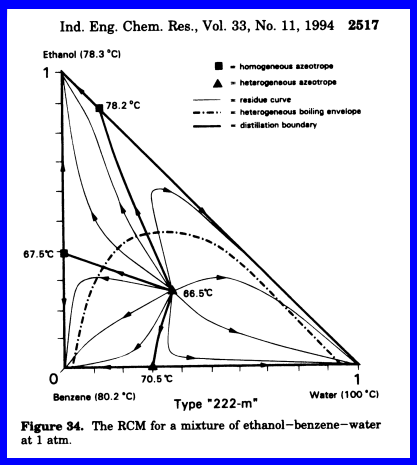
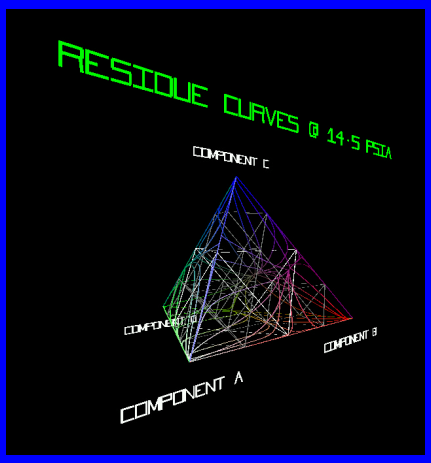


Figure 34. The RCM for a mixture of ethanol–benzene–water at 1 atm.



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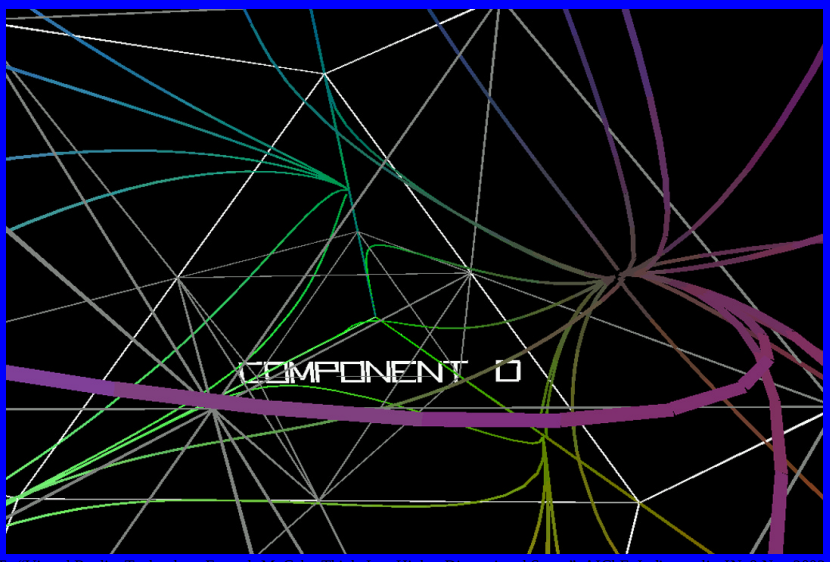
And an Interior View :



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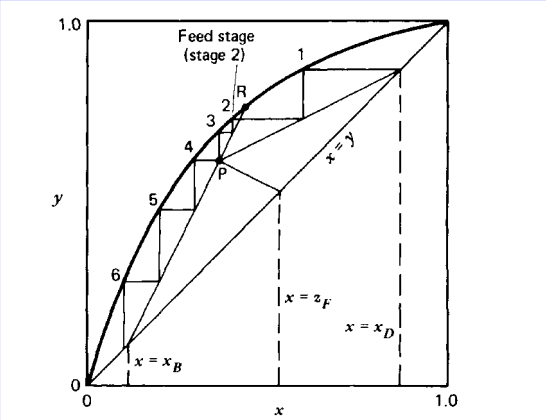
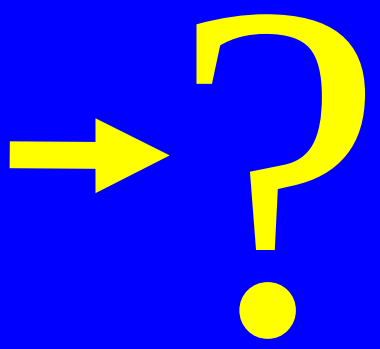
How Can We Extend McCabe-Thiele ?





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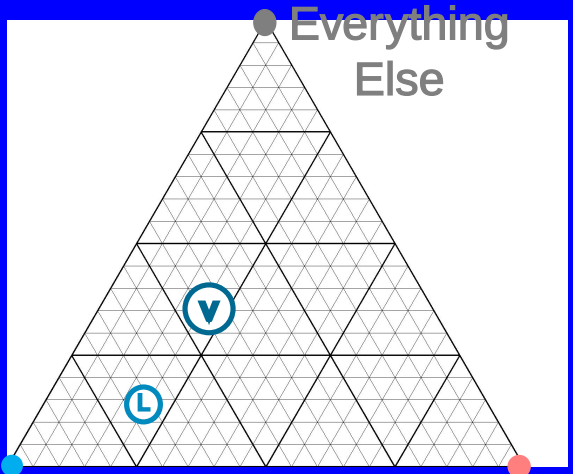
First Consider a Single Stage



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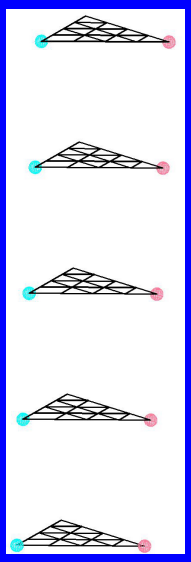
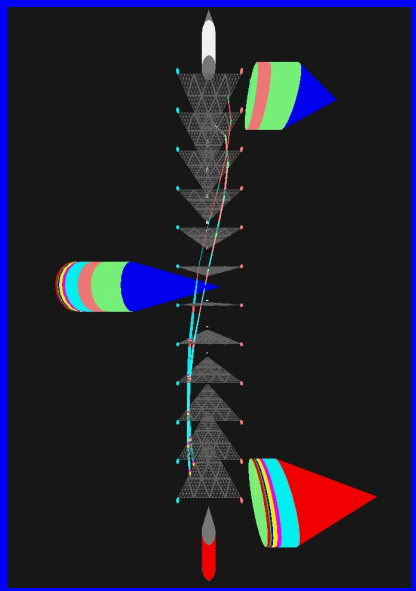
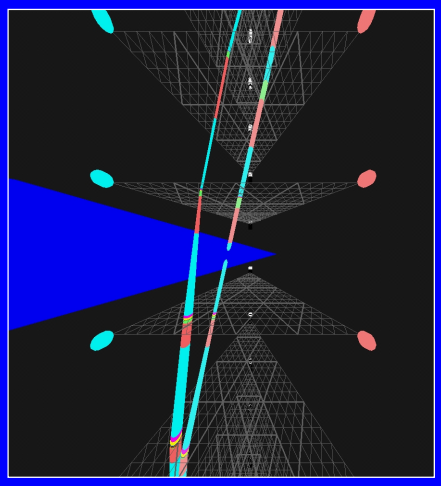
Then Stack Multiple Stages

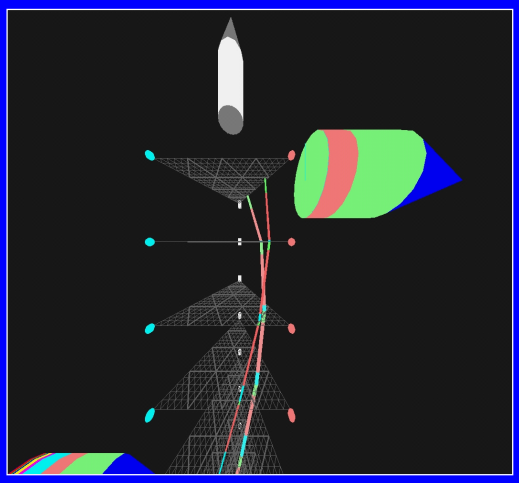


Augment With Color and Detail



Close Ups of Feed and Top Stages





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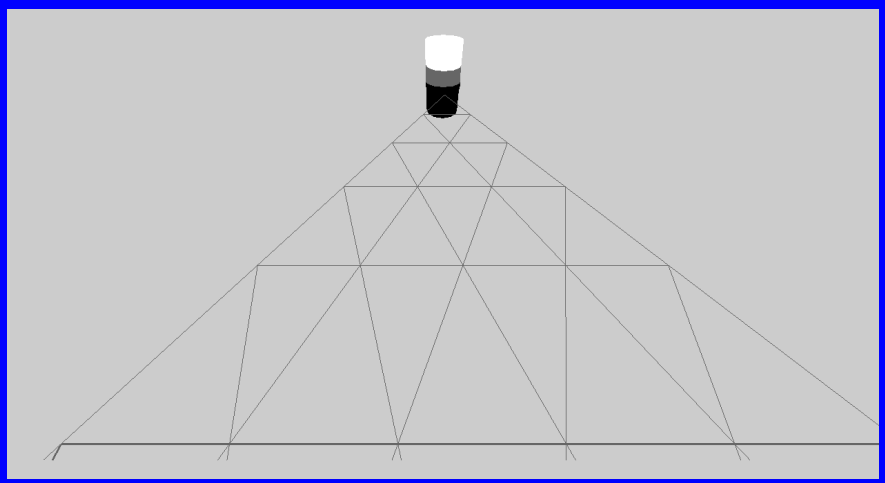
Icon Indicates Light / (Mixed) / Heavy Ratio



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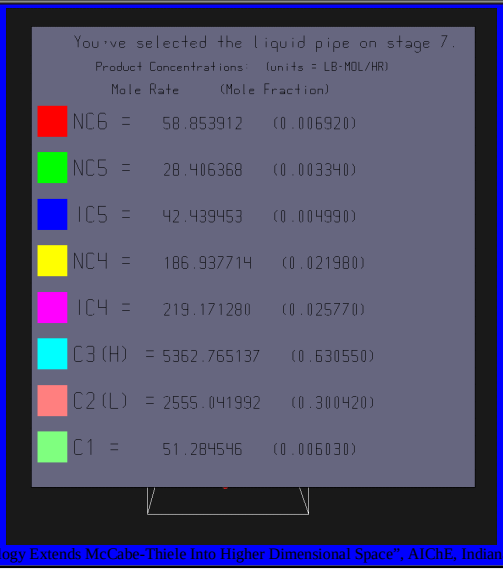
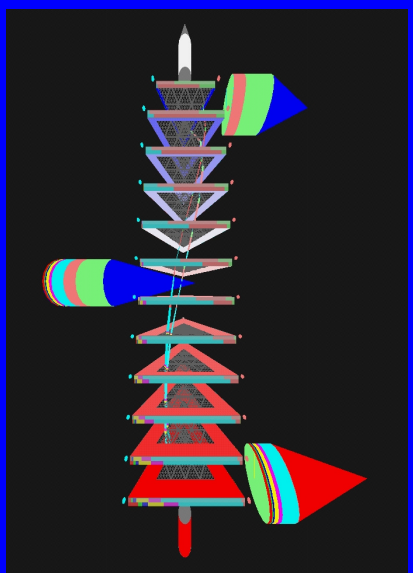
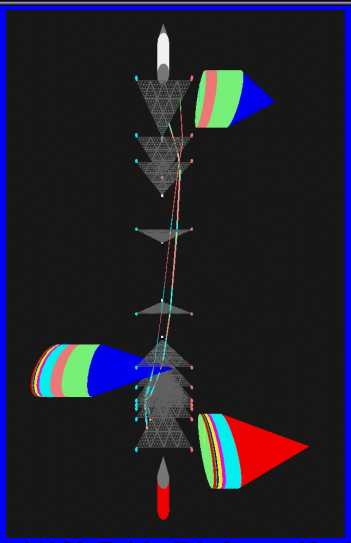
Full Numeric Details Are Available



Frames Add T, P, X, Y Info



McCabe-Thiele Spacing Shows (In)Efficient Stages



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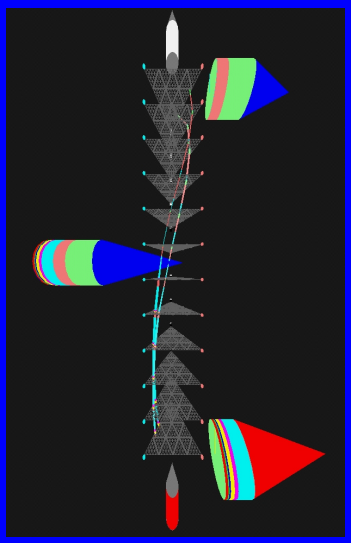
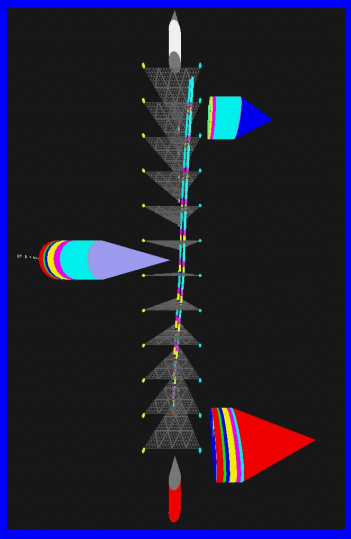
Two Related Towers ...





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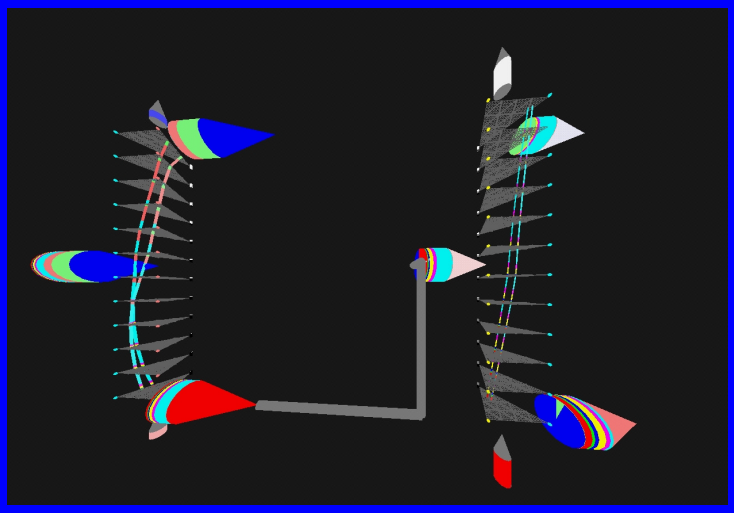
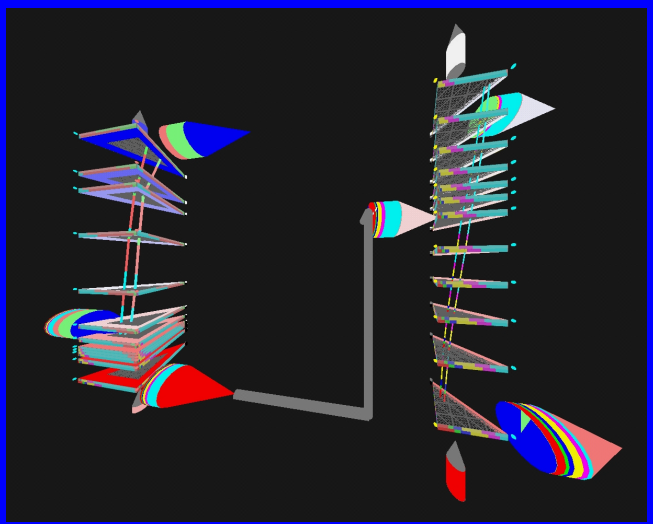
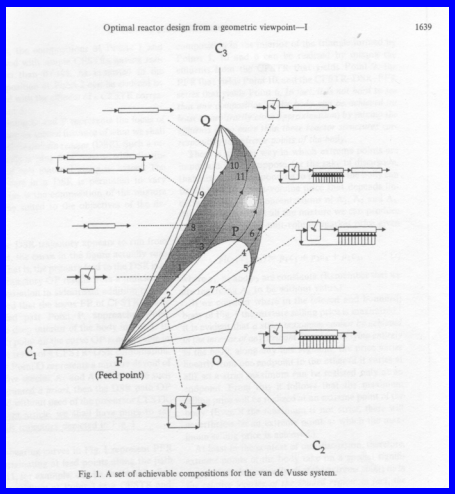
… Can Now Be Combined :



Of Course Too Much Data Can Still Be Overwhelming :



A New Direction Involves Attainable Regions :



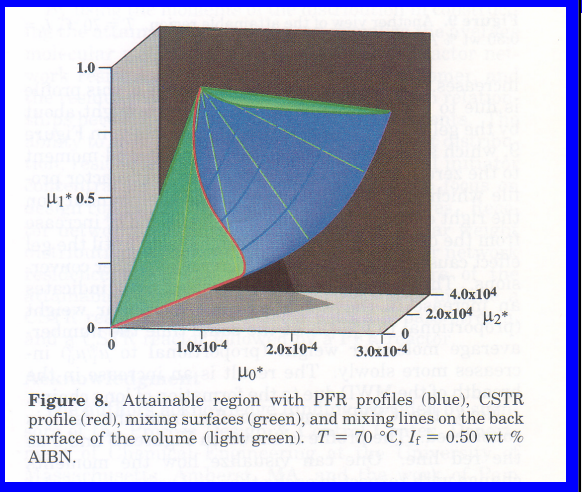


Figure 8. Attainable region with PFR profiles (blue), CSTR profile (red), mixing surfaces (green), and mixing lines on the back surface of the volume (light green). $T = 70$ °C, $I_f = 0.50$ wt % AIBN.

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Van de Vusse System

$$A_1 \xrightarrow{1} A_2 \xrightarrow{1} A_4$$

$$2\,A_1 \xrightarrow{10} A_3$$

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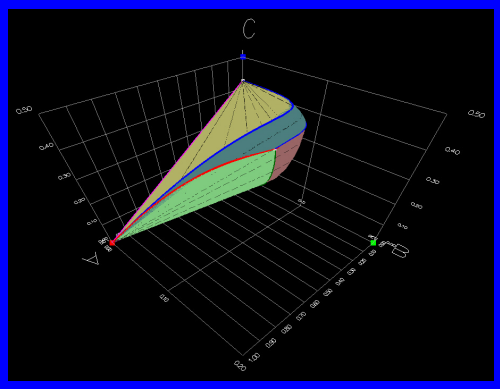
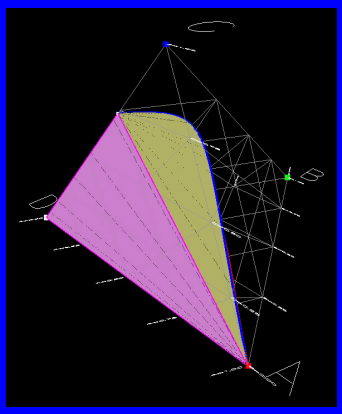
Live Demos of Preliminary Attainable Region Application





Future Work

- Attainable Regions in 5, 6, 7, … ? Dimensions
- Real-Time Interactivity
  (Interprocess Communication to PD Simulators)
- Shared Virtual Environments - Multiple Participants
- Additional Graphical Methods
  - Ponchon Savarit
  - Liquid-Liquid Extraction
  - Revisit Residue Curves
  - Others ?

Conclusions

- A visualization has been shown that uses interactive, immersive, three-dimensional computer graphics to extend the key concepts of the McCabe-Thiele diagram into higher dimensional space.
- Preliminary efforts have also been shown regarding the extension of attainable region graphs into higher dimensions.

References

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- Fien, Gert, A.F. Jan, and Y.A. Liu, "Heuristic Synthesis and Shortcut Design of Separation Processes Using Residue Curve Maps: A Review", *Industrial & Engineering Chemistry Research*, **33(11)**, pp 2505-2522, 1994.
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- Daniel Harms - Original McCabe Thiele Work
- Kunal Gandhi - Enhancements to Above
- Tom Peterka - Commencing Attainable Regions

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