I May Not Be A Genius, But Sometimes CFD Sure Makes Me Feel Like One

Simulating fluid flow using Computational Fluid Dynamics (CFD) enabled me to see things no one has ever seen before, much less imagine.

Before I started doing CFD, whenever we reviewed a design, the forum was pretty much a case of just listening to opinions. Since we really didn't know what was physically happening, we argued about every detail of the design, not knowing what was important and what wasn't. The old school engineers recalled past experiences even though most of those were circumstantial. The young engineers often oversimplified the physics and failed to consider the systemic interactions. Without any way to test our hypotheses, we could only guess what was going to happen until we ran tests on real hardware. This was certainly not the way to optimize the design for our customer.

I got into CFD because we had to find a way to evaluate our design concepts before we built hardware. We needed a final authority. Once I developed my proficiency with CFD (and it was properly validated) we accomplished that. In some sense, I became the final authority by virtue of the fact that I was the one who did the computer simulations. I was the one who could explain why something would or wouldn't work because the CFD told me how the fluid behaved. My colleagues started to ask for my opinion. If I didn't know the answer, they'd ask me if I could model it. I became the one who was really "in the know". I didn't fully realize it at the time, but developing proficiency and embracing computational methods dramatically increased my insight, understanding, and ultimately value as an engineer.

Here are a few of the benefits I experienced once I added CFD to my arsenal of expertise.

1. **My capacity to visualize increased.**

   After studying countless CFD generated velocity vector plots of air flow (the ones where arrows are used to show the path of the fluid flow), I learned to visualize how air behaves. When other people saw an empty room, I saw air entering through the ventilation grills, recirculating around obstacles, and creating dead zones in the room. It was pretty easy to learn to visualize in two dimensions; the real accomplishment was learning to do it in three dimensions. Visualizing was not an end to itself. The real benefit was that the mystery of fluid flow began to dissipate as I learned to visualize (like being an electrical engineer and seeing the electrons) and my level of understanding increased. Once I gained understanding, I could start to see solutions.

2. **I became more inquisitive**.

   Gaining knowledge and understanding has a way of building on themselves. As a result, I began to ask more questions. Why did the air behave like this? And what could I do to alter that behavior? I pulled out my old fluid dynamics and heat transfer text books to more fundamentally understand why things happened as they did. I realized that I needed to understand the physics so I could conceive a better solution.

I also began to think more systemically. The state of a fluid at any instant in time is the result of what happened before (parabolic flow) or what happens all around at that instant (elliptic flow). The point is any change you make in one place will likely affect another place.

Here's an interesting side bar about becoming more inquisitive. Not only did I ask more questions about fluid flows, I found myself asking more questions in general. I was no longer satisfied with doing something just because that was the way it's always been done. Is this work providing real value to the customer? Why do we do it this way? Is there a better way to do it? Sometimes I think I drove my boss crazy.

3. **My confidence increased.**

I always thought the ideal engineering job was one where the engineer simulated (modeled) the situation, used the simulation to design a better mousetrap, and then verified that the solution actually worked as predicted. In the simulation world we always have to be mindful that we're not just doing it to create pretty color pictures and simulating for the sake of simulating. The ultimate goal is to produce better designs and processes. When we simulate correctly (indicating we understand what's happening) and the test data matches (within reason) the predicted performance, our confidence grows in a big way.

I remember one situation where we were simulating the air flow in automotive paint spray booths. We proposed some changes to a production facility based on what we observed in the models. Plant management thought it would be a huge risk to make the changes we proposed. In the past they tried to make changes to the facility and totally messed up production. So from their viewpoint, paint booth air flow was a mysterious black box that you didn't tamper with. But we were very confident about what we proposed because we did our modeling and verification work up front. Indeed, when we implemented the changes, we got most of the results we expected. Risk diminishes greatly when you understand what you're doing.

4. **My value to the company increased.**

When I was younger I used to think it must be difficult to get a patent for something. But the more modeling and simulation work I did the more things I saw that other people never saw. New ideas and novel solutions came to me much more easily. The company I worked for patented many of these, and we implemented several of them at our facilities as well. As a result, my value to the company increased, and I was rewarded for this. Could we have achieved this much without CFD? Quite frankly, I believe we would have achieved something (just because we had a team of competent engineers who put forth an effort), but I know we wouldn't have achieved nearly as much as we did or been nearly as successful.