Visualizations of a Physically Coupled System

J. Leng, L. Margetts, I. M. Smith from the University of Manchester

Simulation discussed in this paper is that of a finite element analysis of a magnetohydrodynamic problem; the 3D steady state flow of a charged fluid in an insulated duct to which magnets are applied. Magnetohydrodynamics studies the behaviour of electrically conducting fluids under the influence of magnetic fields. Examples include metal forming processes, measurements of coolants in nuclear reactors, plasma containment for fusion research and astrophysics.

Here the flow of the charged particles in the fluid is affected by the magnetic field while at the same time the magnetic field is affected by the flow of charged particles. It is important that the visualizations show both of the coupled physical processes, the expected features of the model and any that were not expected. As far as the authors were aware this was the first time that this system has been solved in 3D using finite element methods. Although the physical results of this type of system is discussed in the literature there are no images of this process, probably because of the hostile environments involved. In aircraft design photos can be taken of aircraft in wind tunnels and compared to visualizations of wind tunnel simulations but this was not possible.

The important features of the visualizations for this work were:
1. The images in Figure 6, 7 and 8 a are all from the same or very similar view points so that they can be easily compared and thus the physical systems can be compared.
2. 3D simulations are rare in this field and even when 3D models are used 2D visualization techniques like cut planes tend to dominate. Familiar 2D visualization techniques were used but with a high frequency LIC pattern. These showed the complexity of the magnitude of the magnetic field and fluid flow that a normal colour map could not.
3. Figure 7 shows the formation of two jets after the magnet that has never before been shown in a simulation.
4. Figure 8 b and c show the data from a different angle to emphasise the 3D nature of the flow. This flow path had not been expected and can be best seen when the view point is in the middle of the data.
5. The results were to be published in proceedings that are not colour so that the images should convey all the necessary information in grey scale.
6. The template for the paper was in word which does not rescale text in images well so colour legends and labels were not used but descriptions were given in the text.