**Streamline Visualization in ParaView for a Stationary Mixer**

**Introduction**

The goal of this study was to determine whether the stationary mixer effectively mixes by generating streamlines in ParaView using vector field data from the SMRX.vtk dataset. Streamlines help visualize fluid flow by tracing the movement of particles within the vector field. To enhance the visualization, a contour filter was applied to highlight scalar values, and a vector field adjustment was performed using a Calculator filter to amplify the data. This report outlines the methodology and justifies each step.

The central question driving this analysis is: **Does this stationary mixer actually mix?**

**Methodology**

The dataset SMRX.vtk was loaded into ParaView. The information tab was used to inspect the scalar and vector field ranges, ensuring that appropriate visualization techniques could be applied.

A contour filter was applied to SMRX.vtk to visualize surfaces of constant scalar values. The contour was generated using scalar values with a range of 5. The representation was set to surface, with solid red coloring to highlight the structure clearly, and opacity was kept at 1 to maintain full visibility of the surface. The contour filter helped visualize boundaries where the scalar values are uniform, providing context for the streamline visualization.

A Calculator filter was applied to SMRX.vtk to scale the vector field. The attribute type was set to point data, and the expression used was vectors \* 100. The original vector field values were too small, resulting in short or invisible streamlines. Multiplying by 100 increased the vector magnitudes, making the streamlines more prominent without altering their relative directions.

A Stream Tracer filter was applied to the Calculator Result to generate streamlines from a specific seed line. The vectors used were from the Calculator output, the integration direction was set to both to track both forward and backward flow, and the integrator type was Runge-Kutta 4-5, chosen for accuracy in solving ODEs. The seed type was line, with the first point at (30, 40, 5) and the second point at (30, 40, 50). The resolution was set to 100, determining the number of streamline seeds along the line. The coloring was set to solid blue. This tracer captured streamline behavior in a specific flow region.

A second Stream Tracer filter was applied using a different seed line. The vectors used were again from the Calculator output, with integration direction set to both and the integrator type remaining Runge-Kutta 4-5. The seed type was line, with the first point at (30, 15, 5) and the second point at (30, 15, 50). The resolution was again set to 100, and the coloring was set to solid yellow. This second tracer provided another perspective on the flow structure, revealing differences in streamline behavior at different locations.

**Results**

The first image presents an angled perspective, providing a clearer view of how the internal geometry influences the streamline paths. The flow structure indicates significant redirection and stretching of the streams, which are critical for enhancing mixing. While there is evident deformation in the flow, the presence of unmerged blue and yellow regions suggests that further elements, such as turbulence or additional mixing stages, may be required for thorough homogenization.

A computer generated image of a wooden structure

Description automatically generated with medium confidence

A red and blue striped object with different colored lines

Description automatically generated with medium confidence1a: image from the assignment

1b: replicated image

The streamline visualizations provide key insights into the mixing performance of the stationary mixer. The second image shows a side view where blue and yellow flow regions enter the mixer from distinct inlets. As they progress through the mixer, there is clear interaction between the two streams, with some degree of interweaving. However, distinct regions of blue and yellow remain visible, suggesting that complete mixing is not achieved within the observed domain.

A red cross with blue and yellow lines

Description automatically generated

The third image, which provides a top-down view, reinforces these observations. It highlights how the stationary elements disrupt the initial streamlines, causing some cross-stream motion. However, there are still segments where the original colors remain largely unmixed, indicating that while interaction occurs, the effectiveness of the mixer in achieving uniform blending remains in question.

A red and yellow tubes with yellow lines

Description automatically generated

**Conclusion**

The streamlines show interaction between the blue and yellow flow regions, indicating some level of blending. However, there are still regions where the two streams remain somewhat distinct, suggesting incomplete mixing. This methodology successfully generated meaningful streamline visualizations from SMRX.vtk. The contour filter provided structure to the dataset, the calculator filter enhanced the vector field for better visibility, and the two stream tracers highlighted different flow regions. The approach effectively captures the flow characteristics and improves interpretability within ParaView.

To answer the central question, further analysis is required to determine whether the observed flow patterns indicate effective mixing. The distribution and behavior of streamlines suggest areas of recirculation and interaction, but additional scalar mixing metrics should be analyzed to confirm the extent of mixing within the stationary mixer.