PROPER ORTHOGONAL DECOMPOSITION (POD) TO EXTRACT FLOW INFORMATION

APPLICATION NOTE (A4)

What is Proper Orthogonal Decomposition (POD)?

Proper Orthogonal Decomposition was introduced to the fluid mechanics community over 30 years ago. It is also known as Principal Component Analysis and Karhunen-Loeve Decomposition in fields such as computer vision and pattern recognition. POD is a robust, unambiguous technique used for recognizing or identifying key dominant features in data sets.

In fluid mechanics, POD has gained recognition as a powerful tool for examining turbulence and understanding the underlying mechanisms. When applied to flows, the technique has the ability to identify structures that contribute most to the energy of the flow. The decomposition of the flow by this technique provides a set of modes that represent flow structures containing most of the energy. Thus, POD has gained a wide spread reputation for identifying dominant or coherent features in a flow. The POD is generally used for the following:

- Identification of coherent and energetic events
- Spatial and temporal characterization of the flow
- Spatial characteristics of the flow field using the respective POD modes
- Properties of the reconstructed flow-from velocity and vorticity fields to advanced statistical property fields

How to Apply POD to Analyze your Fluid Flow Results

Insight™ 4G Global Imaging, Analysis, and Display Software Platform includes the POD Analysis Toolbox to quantify the flow properties of interest with the desired detail.

PIV measurements provide instantaneous velocity fields with high spatial resolution over a period of time. This type of large data set is ideally suited for POD analysis. The analysis of the fields provides a powerful tool for identifying dominant structures and events in the flow.

Two methods for calculating the POD modes are the Direct method and the Snapshots method, both of which are incorporated into the software. The selection of which method to use depends upon the size of the input data matrix. The contribution of the different modes to the total energy can be graphically displayed. This provides the relative energy level as a function of the number of POD modes. All these are provided as user selectable functions. Detailed displays from the analysis are provided as part of the package.

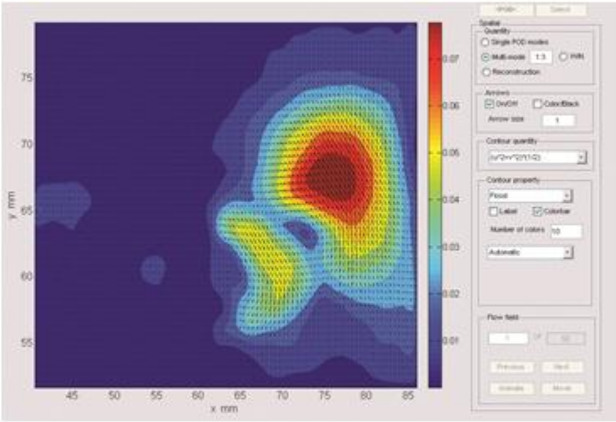

Figure 1: Control Screen in Insight 4G Software for POD Analysis

For PIV data, POD is an useful tool for:

- Identifying coherent structures and energetic events in the flow
- Extracting dominant structures and hidden events in the random or incoherent turbulent motion
- Reconstructing the flow field using the minimum number of modes that account for the most amount of energy

The plot shown in figure 2 is the different levels of energies in each mode of the flow structure. Figure 3 provides the details of one of the modes, with contours giving different energy levels of the flow.

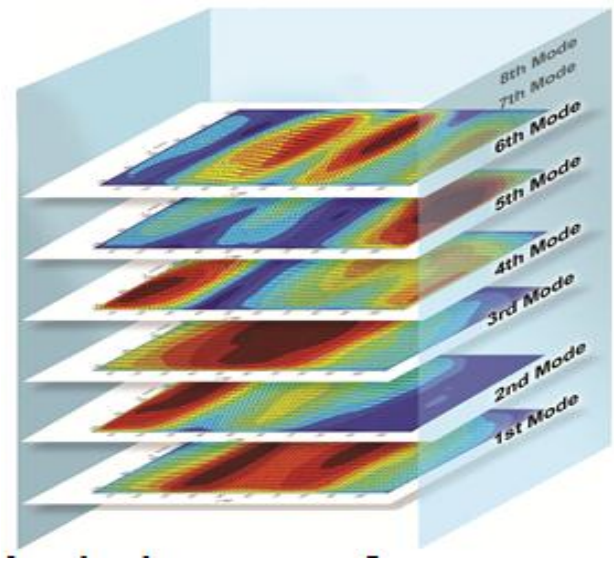

Figure 2: Energy Distribution at Different Modes Analyzed using POD

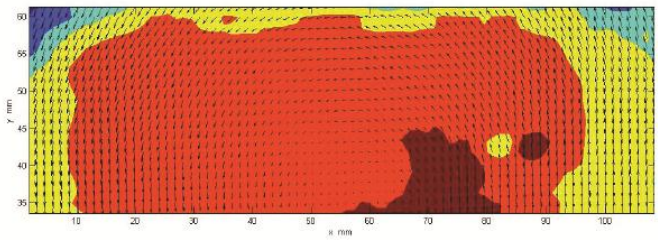

Figure 3: Detailed Energy Distribution for the Primary Mode in the Flow Field

UNDERSTANDING, ACCELERATED

TSI Incorporated – Visit our website www.tsi.com for more information.

USA	**Tel:** +1 800 874 2811	**India**	**Tel:** +91 80 67877200
UK	**Tel:** +44 149 4 459200	**China**	**Tel:** +86 10 8219 7688
France	**Tel:** +33 4 91 11 87 64	**Singapore**	**Tel:** +65 6595 6388
Germany	**Tel:** +49 241 523030		

P/N 5001642 Rev. B (A4) Printed in U.S.A.