Title: Harmonic Analysis – A Tool for Troubleshooting Propagated Disturbances.

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Extended Abstract:

Large process plants, such as oil refineries, power plants and pulp mills, are complex integrated systems, containing thousands of measurements, hundreds or thousands of controllers and many recycle streams. This integration of energy and material flow, required for efficiency, results in the spread of fluctuations throughout a plant. These fluctuations force the plant to be operated further from the economic optimum than would otherwise be possible, and so cause decreased efficiency, lost production and in some cases increased risk. Because of the scale of operation of process plants, a small percentage decrease in productivity has large financial consequences.

It can be extremely difficult to pinpoint the cause of these fluctuations. In the most difficult case, the fluctuations are in the form of oscillations. The problem is that oscillations have no defined beginning and end, and so the cause cannot be isolated by standard techniques. Finding the cause of oscillations is a tedious, labour-intensive, often fruitless task. Once the cause is understood, removal of the oscillations is usually straightforward.

Figure 1 shows time trajectories of 20 refinery variables in the left panel, with the corresponding power spectra in the middle panel. An oscillation in the time trajectory shows up as a spike in the power spectrum. From the power spectrum it is clear that several measurements oscillate at a common frequency of 0.06 (17 samples per cycle). Process engineers must answer the question, ‘What is the source of these oscillations?’

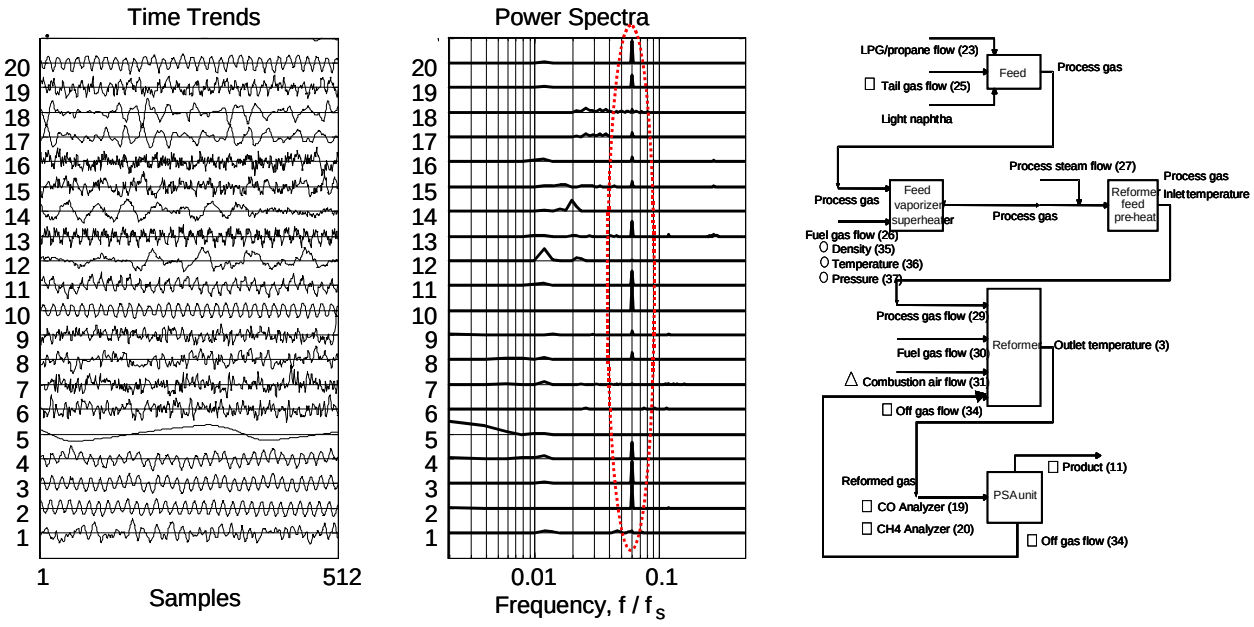

Figure 1: Illustration of plant wide oscillations through an industrial example. Temporal trends (left), Spectral trends (middle), and process schematic (right)

The objective of this study is to identify the root cause of such common oscillations in a plant. Once the root cause is known, the oscillations can be eliminated, and the process can then be operated more efficiently.

Usually oscillations originated in process plants due to various faults such as sensor faults, valve faults, process faults, etc. Many of these faults can be presented as nonlinearities. Faults in the form of nonlinearity may produce oscillations with a fundamental frequency and its harmonics. Faults generated in a control loop or a unit of a process propagates to the adjacent units due to the material or signal connectivity and multivariate nature of the processes. It is well known that the chemical processes are low-pass filters in nature. Therefore, when a fault propagates away from its origin or source, the higher order harmonics get filtered out. This study aimed to present a method to estimate the amplitudes and phases of the fundamental oscillation and its harmonics and use this information to troubleshoot or pinpoint the root-cause of plantwide or unit-wide oscillation. The successful application of the method will be demonstrated on the simulated and industrial data sets.