Abstract

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Title
32-3: DEVELOPMENT OF A TRANSIENT FLUID DYNAMIC SOLVER FOR COMPRESSION SYSTEM PULSATION ANALYSIS

Summary
The Southwest Research Institute® (SwRI®) “Analog Computer” and the newer digital acoustic solver Interactive Pulsation and Performance Simulation (IPPS) have been successfully used in pulsation analysis for slow-speed compression system design for the last fifty years and more recently in the design of the new high-horsepower, highspeed compressor installations. The IPPS solver utilizes a solution algorithm of the transient acoustic wave equation in the frequency domain, which has been demonstrated to provide in most cases accurate results for compression system resonance frequencies and reasonable agreement for pulsation amplitudes. However, the mathematical assumptions associated with solving the acoustic linearized wave equations must lead to discrepancies in amplitude predictions as these equations are only a partial physical model of the actual transient fluid dynamics. A full one-dimensional representation of the governing transient fluid dynamic equations (called the Navier-Stokes equations) can provide a more thorough solution for the pulsating flow field and can provide more accurate pulsation amplitude predictions. This is particularly critical in the design of variable high-speed compressor systems, as for these applications complete resonance avoidance is impossible. Thus, SwRI decided to develop a new one-dimensional timedomain Navier-Stokes solver to improve SwRI’s prediction capabilities for transient compressor station manifold and piping systems. The resulting state-of-the-art piping pulsation analysis tool, called Transient Analysis Pipe Solver (TAPS), will lead to better design optimization capabilities for the pipeline industry. This paper describes

the TAPS solver development and validation testing. TAPS code testing results showed:

- A transient one-dimensional solver of the Navier-Stokes equation can accurately predict frequencies and amplitudes of pulsations in a complex compression piping system.
- The non-linear terms of the governing (Navier-Stokes) equations have a significant influence on the solution of the pulsating flow field and must be considered in high speed compression system analysis.
- Transient and steady-state pressure drops can be accurately modeled using the TAPS solver.
- The TAPS solver predicts acoustic phase cancellation, phase interference, and amplification between compressor cylinders on a common header more accurately than previous analysis tools.

Thus, the new TAPS transient flow solver advances the state-of-the-art in compression system pulsation analysis and is an improvement over existing acoustic wave equation solver technology.