Evaluation of Asynchronous Pulsing Unit Pipeline Unplugging Technology

Eric Inclan, DOE Fellow; Amer Awwad, M.S., P.E.; Seckin Gokaltun, Ph.D.

Background

- The US DOE Hanford Site contains High Level Waste (HLW) with diverse composition.
- Transfer pipelines have become clogged with substances that are very difficult to remove.
- Over the past two years Florida International University's Applied Research Center (ARC) has evaluated a method known as Asynchronous Pulsing.
- Asynchronous Pulsing uses high pressure waves to dislodge material in plugged pipelines.

Figure 1: DOE Single-Shell Waste Tanks. *Photo credit: DOE*

Experimental Setup

- The HPU creates the pressure "behind" each pump's piston, compressing the fluid in the pipeline.
- Each pipeline segment has one 90-degree elbow, three pressure transducers, and an accelerometer.
- The pistons can be cycled back and forth at a given range of frequencies.
- The plugs will be made of different materials in order to simulate different field conditions.

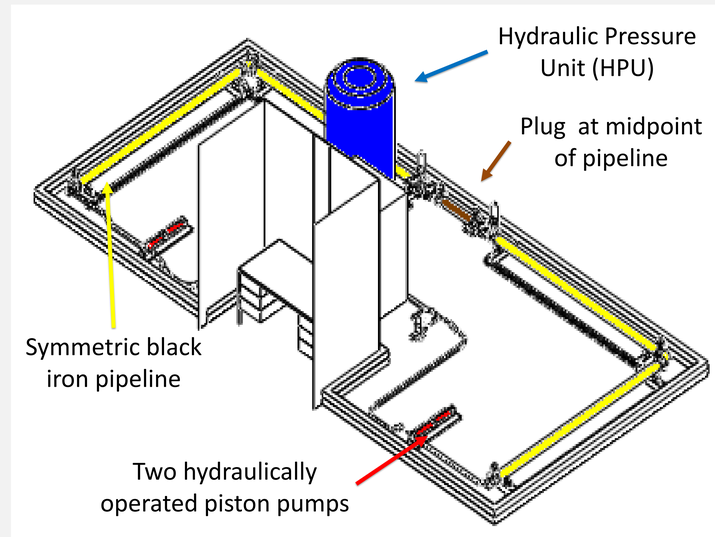


Figure 2: Asynchronous Pulse Unit Solidworks Drawings

Sample Results

- The Asynchronous Pulse Unit performance varies with the pressure and frequencies used.

Figure 3: Various Plugs After Exposure to Asynchronous Pressure Pulses Using APU Experimental Setup

- Maximum safe pressure in real world pipelines is 300psi.
- The results shown in these images correspond to pulses up to 300 psi, cycled at 2 Hz, with HPU pressure of 400 psi.

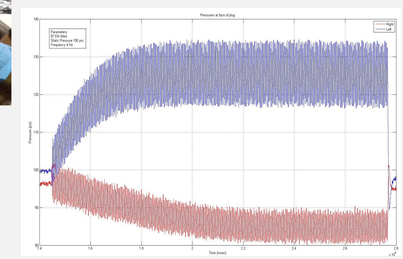


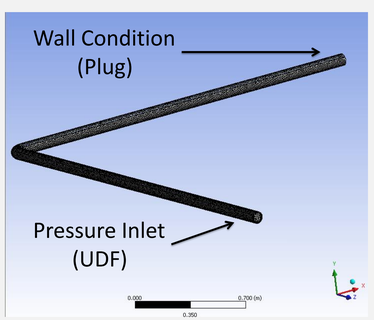
Figure 4: Pressures at Plug Surfaces During Asynchronous Pulsing

Computational Fluid Dynamics Model

- Evaluate the effectiveness of the Asynchronous Pulsing Unit by comparing simulated pressure peaks to the blow-out pressure of plugs.

$$\frac{\partial \rho}{\partial t} + \nabla \bullet \left(\rho \vec{V}\right) = 0 \qquad \rho \frac{d\vec{V}}{dt} = \rho \vec{b} + \nabla \bullet \underline{\underline{T}} - \dot{\rho} \vec{V}$$

Model:
3 Dimensional
Periodic Unsteady
Compressible
Multiphase (VOF)
Viscous (Laminar)
PISO Scheme



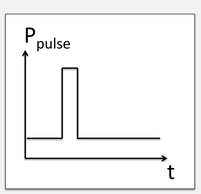


Figure 5: Pipeline Mesh Generated Using ANSYS Fluent 12 (above), Pressure Pulse Profile (left)

Optimization

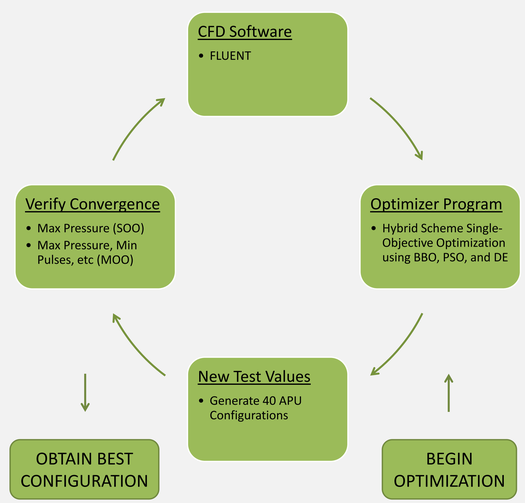


Figure 6: Conceptual Diagram of Optimization Algorithm (major components)

- Over the past thirty years, researchers from various disciplines have come together to develop "evolutionary" optimization algorithms (EA's).
- When coupled with powerful engineering software, EA's are capable of automatically generating optimal designs.
- EA's save time and money, and often produce novel solutions.
- Objective: Maximize Pressure at Plug Surface,

$$P_{plug} = P\left(P_{inlet1}, P_{inlet2}, f_{inlet1}, f_{inlet2}\right)$$

$$\ni \begin{cases} 0 < P_{inlet} < 300\,psi \\ f_{\min} < f_{inlet} < f_{\max} \end{cases}$$

Future Work

- The Optimizer Program and FLUENT model of the pipeline are in development.
- The Optimizer will run simulations (usually at least 50 iterations) in order to obtain the best possible (and feasible) configuration of inlet pressures and pulsation frequencies.
- The results will be validated in order to gauge the effectiveness of the optimizer.
- The Optimizer can be extended to handle multiple objectives including maximizing pressure at plug surface, and minimizing the number of pulses required.

Acknowledgements: Dr. Leonel Lagos, Dr. George Dulikravich
DOE/FIU Science & Technology Workforce Development Initiative, DOE-EM