Design and Development of Innovative High-Level Waste Pipeline Unplugging Technologies

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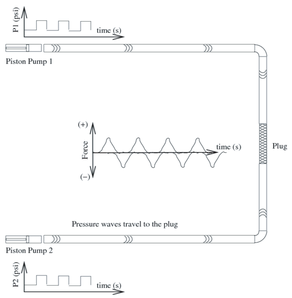
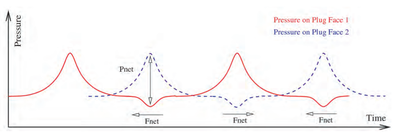
Asynchronous Pulsing Method

Concept:

The Asynchronous Pulsing method is based on the idea of creating pressure waves in the pipeline filled with water from both ends of the blocked section. The waves are created asynchronously in order to break the mechanical bonds between the blockage and the pipe walls as a result of vibration caused by the unsteady forces created by the wave.





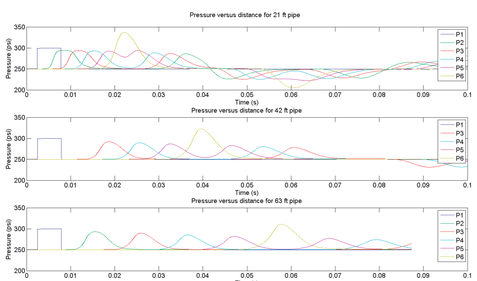
Modeling:

-Three pipes (21 42 and 63 ft) with a fix percentage of air, were used to investigate the effect of the pressure pulses at the plug (rigid wall) at the end of the pipe.

-Pressure variations in the pipe were tracked in time at various axial locations.

-As the first pressure pulse moves down the pipe, the pulse is reduced until the pressure wave reaches the end and compresses increasing the pressure.

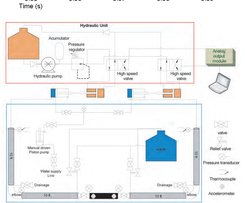
-The timing of pressure pulses can be applied such that the maximum effect on the plug can be achieved when approached from both sides.

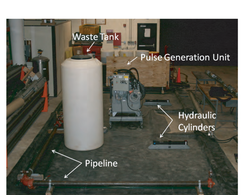


Experimental Set-up:

The bench-scale test bed is assembled using four 10 ft straight sections and two 90° elbows. The pipes used for the test bed are 3 in diameter schedule 10 carbon steel pipes. A blockage will be placed at the center of the 20 ft straight section to emulate a plug in the pipeline. The pipeline will be instrumented with accelerometers, pressure transducers and thermocouples located at strategic locations to capture the changes of the induced disturbances inside the pipeline.

The hydraulic unit is powered by a 7.5 HP/213 TC 3 phase electric motor which drives a hydraulic pump that will generate pressure waves by combining pressurized oil and rapid acting proportional valves to activate the tandem hydraulic cylinders.

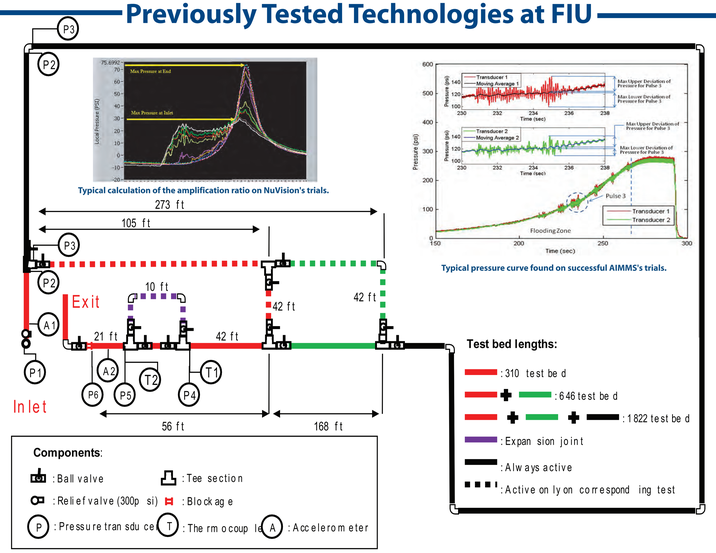




Background

- As Hanford moves into a more active retrieval and disposal program, site engineers will encounter increasing cross-site pipeline transfers with a corresponding increase in probability of a pipeline getting plugged.
- In order to ensure smooth operation of the waste transfers and to ensure tank farm cleanup milestones are met, pipeline unplugging tools/technologies are crucial.
-FIU has evaluated numerous commercially available technologies for their ability to remove various blockages in a number of pipeline configurations.
- It was observed that most of the technologies evaluated, excluding NuVision's wave-action technology and AIMM's Hydrokinetics™ process, could not negotiate the large number of elbows in the pipeline which reduced the effectiveness of the methods for long pipelines.
-NuVision's and AIMM's methods were subsequently tested at FIU. Data from the experiments was used to provide an understanding of the fudamental physics of the techologies.
-Lessons learned from the evaluation of the commercially available technologies have led to the development of two novel approaches for pipeline unplugging:
+Asynchronous Pulsing Method
+Peristaltic Crawler

Previously Tested Technologies at FIU

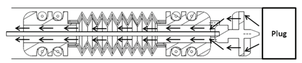


-Although the testing demonstrated that the NuVision technology could remove certain type of blockages, additional phases of testing are needed to determine the operational control parameters as a function of pipe configuration and distance to the plug.
- AIMM's technology was able to remove sludge-based plugs effectively but had difficulty removing the chemical and salt based plugs.
- Significant reduction in the amplitude of the pressure pulsations at the blockage section was observed for AIMM's technology.

Peristaltic Crawler

Concept:

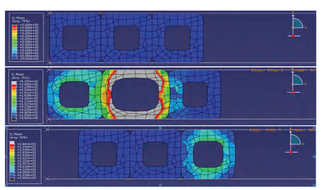
The Peristaltic Crawler is a pneumatic/hydraulic operated crawler that propels itself by a sequence of pressurization and depressurization of flexible cavities. The unit uses a flexible skeleton to allow it to turn around elbows.



The Peristaltic Crawler has the capability of having different attachments depending on the type of blockage to be unplugged. For all the attachments, the power source used is a pressurized water line that passes thru the crawler. The crawler is hollow, and as the plug is removed, it is driven from the front to the back of the unit.

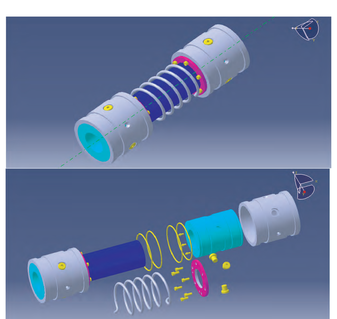
Proof-of-Concept Modeling:

The device propels itself by the pressurization /depressurization sequence of the flexible cavities (balloons) located at the font, center, and back of the unit. Individual pressurization of the front or back cavities results in anchoring the system to the pipeline. This is a result of the linear relationship between the normal force imposed by the balloon on the inner surface of the pipeline and the resulting friction force.



First Generation Crawler:

The first prototype was manufactured, assembled and successfully tested, demostrating potential for pipeline unplugging operations.
The crawler was able to navigate thru two 90 degree elbows and a vertical pipe.
The unplugging attachment used was a high pressure water nozzle.
First experimental trials were performed using Bentonite plugs in 3 in diamter PVC pipes.

Second Generation Crawler:

Improvements to the first generaton crawler include:
-Components rated for higher pressures (300 psi).
-Stainless steel bellows will replace rubber bellows providing a higher pulling strength.
-Clamping mechanisms will be replaced by high pressure flanges providing more reliable seals.
-Interchangeable assembly parts: The design was improved to allow future implementation of extra passages for in board electronics and other inspection devices.
-Automated operation: pressurization / depressurization sequences will be implemented to create an optimal navigation motion sequence for different scenarios.