Asynchronous Pulsing as a Means of Unplugging Pipelines

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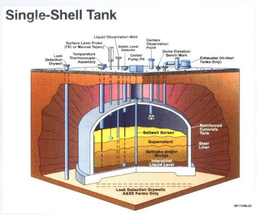
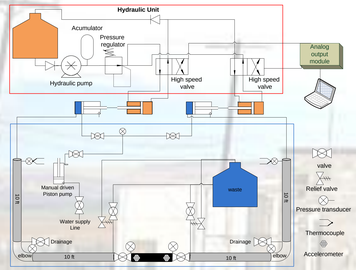
Background:

The U.S. DOE Hanford Site currently contains 177 underground tanks filled with high-level radioactive waste. These tanks contain 53 million gallons of this highly toxic waste. The waste in these tanks is composed primarily of bi-product from the Manhattan Project. The original tanks are beginning to corrode and so new double-wall tanks are being brought in to replace them. The problem occurs when the nuclear slurry is pumped from the old tanks to the new ones. Since the slurry contains solids, the pipes used to transfer it can end up getting plugged and so arises the need for a way to unplug them.



Introduction:

Asynchronous pulsing is a method by which cyclical transient pressure waves are created in a pipeline filled with water on both ends of a plugged section in order to dislodge the material causing the blockage. The waves are created out-of-phase in order to create unsteady forces within the pipe. When they reach a plugged area, the waves cause sufficient vibrations to dislodge the plug. The objective of this project is to use a hydraulic pressure unit to drive two water single-piston pumps. The pistons will actuate as hydraulic pressure is pumped in and out of them by means of fast-acting control valves. The piston motion will then generate cyclical pressure waves with a period related to the valve switching frequency. The control valves along with the piston positions are controlled and monitored via a CompactRIO® programmable automation controller from National Instruments. This controller sends and receives commands based on a program on a laptop implemented in Labview. This program will allow the user to choose the amplitude, frequency, and even type of wave to be generated within the allowable limits.

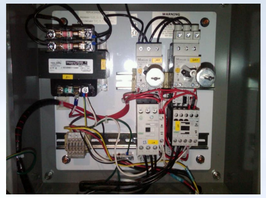


HPU Circuit

Control Enclosure

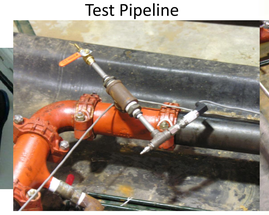
Control Circuitry

HPU Contactors

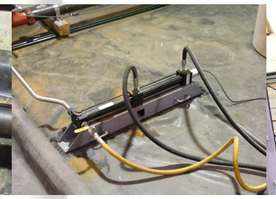


NI Control Module

Test Pipeline

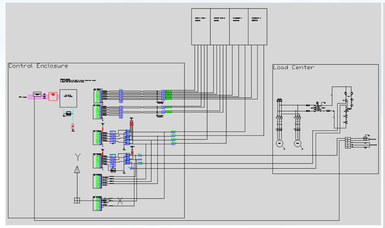


Linear Transducer

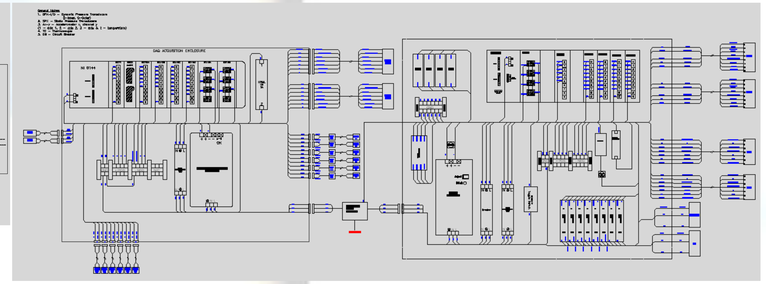


Hydraulic Pressure Unit

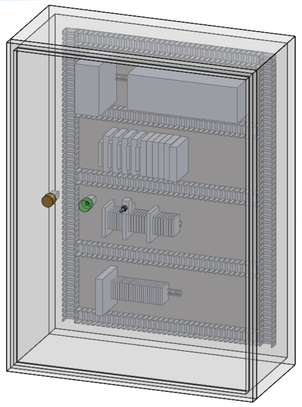
Wiring Diagram Including Hydraulic Unit



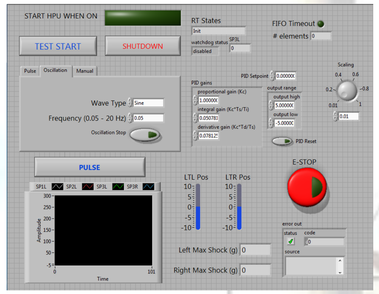
Wiring Diagram



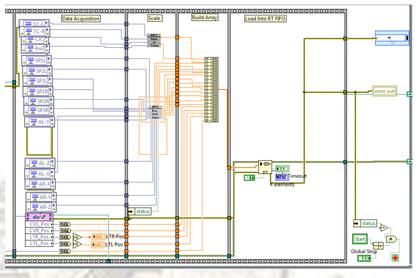
3D Model of control Enclosure



Labview Front Panel Display



Labview Block Diagram



Data

Pulse Time (Sec)	1											
Hydraulic Pressure (PSI)	500				400				300			
Amplitude	0.25	0.5	0.75	1	0.25	0.5	0.75	1	0.25	0.5	0.75	1
Max Water Pressure (PSI)	40	41	48	53	40	41	45	47	40	41	45	46
Min Water Pressure (PSI)	40	29	24	20	40	32	25	22	40	33	30	24

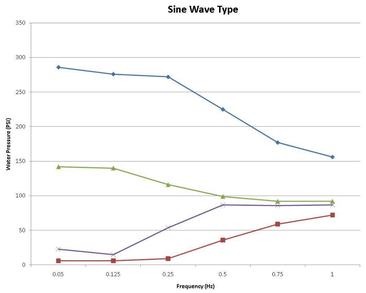
Pulse Time (Sec)	5											
Hydraulic Pressure (PSI)	500				400				300			
Amplitude	0.25	0.5	0.75	1	0.25	0.5	0.75	1	0.25	0.5	0.75	1
Max Water Pressure (PSI)	40	54	172	300	40	51	93	214	40	52	67	104
Min Water Pressure (PSI)	24	10	10	8	26	12	8	8	31	19	11	8

Pulse Time (Sec)	10											
Hydraulic Pressure (PSI)	500				400				300			
Amplitude	0.25	0.5	0.75	1	0.25	0.5	0.75	1	0.25	0.5	0.75	1
Max Water Pressure (PSI)	43	212	293	294	42	97	241	256	48	69	115	141
Min Water Pressure (PSI)	18	8	8	7	20	8	8	7	35	13	8	7

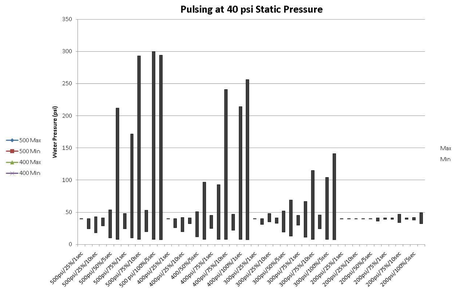
Wave Type	Sine											
Hydraulic Pressure (PSI)	500					400						
Frequency (Hz)	0.05	0.125	0.25	0.5	0.75	1	0.05	0.125	0.25	0.5	0.75	1
Max Water Pressure (PSI)	286	276	272	225	177	156	142	140	114	99	92	92
Min Water Pressure (PSI)	6	6	9	36	59	72	23	13	54	87	86	87

Wave Type	Square											
Hydraulic Pressure (PSI)	500					400						
Frequency (Hz)	0.05	0.125	0.25	0.5	0.75	1	0.05	0.125	0.25	0.5	0.75	1
Max Water Pressure (PSI)	230	213	169	130	128	124	40	114	103	97	120	203
Min Water Pressure (PSI)	24	20	34	48	51	67	40	46	93	86	61	24

Sine Wave Type



Pulsing at 40 psi Static Pressure

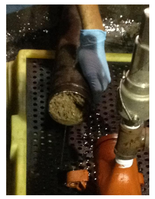


Contribution:

- Completed various AutoCAD drawings of the various components and the wiring diagrams for each, as well as the wiring diagram for their interconnections within the control enclosure.
- Created CAD drawings using Solidworks for both the control enclosure and the power enclosure in order to determine the correct placement of the components within the enclosure based on their individual dimensions and overall heat dissipation.
- Calculated the current consumptions of each of the components and helped determine the proper fusing and surge protection in order to protect the sensitive components in the event of a short circuit.
- Wired the components within the enclosure and wired all the external components such as the control valves and the linear transducers.
- Ran various tests in order to determine effectiveness of the technology.

Results:

Various tests were performed at different pipeline hydrostatic pressures, hydraulic power unit operating pressures, and pulse times. The results show a correlation between higher transient pressure spikes at the plug face, and a higher static pressure at the hydraulic pressure unit. It was also noted that the distinct pulse times were also associated with higher transient pressure spikes. Simulated plugs were created out of K-MAG material and the unplugging capabilities of this technology were tested. The results showed favorable unplugging capability at certain pressures, and pulse durations/frequencies. In the near future, a larger test bed with a 260 foot pipeline will be used for further unplugging tests.



Acknowledgements:

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