Improved Third Generation Peristaltic Crawler for Removal of High-Level Waste Plugs in Hanford Site Pipelines

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Introduction
The retrieval of radioactive material at the Hanford Site produced vast quantities of high level waste (H/LW). The later double-shell tanks (DSTs) consist of a first tank surrounded by a secondary containment tank as an additional barrier. It is estimated that up to 2 m³ of radioactive waste might have leaked from the inner shell of a DSTs. The retrieval and containment of these materials will be a significant part of the Hanford Nuclear Reservation’s mission to secure the site and remove the waste in place, including the removal of high level waste plugs.

System Explanation and Components
• Pneumatically operated tool propelled by a sequence of pressurizations/depressurizations of its inner shell
• Omron programmable logic controller (PLC) program inflates and deflates the bellows in sequence causing worm-like motion
• Frontal attachment has a hydraulically powered unpluging tool
• 500 foot long tether reel assembly: 3 pneumatic lines, 1 hydraulic line, and 1 multi-conductor cable jacketed together.

Bellows
• As the tether length increases so will the weight. It is important that the crawler is able to carry its own weight as well as that of the tether.
• Set up:
  - Spring (F=kx)
  - Force exerted = 1.21 kN
  - Spring rate = compresses 23.3 kN/m
  - Maximum displacement = 0.052 m

Bellows Force Test

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<thead>
<tr>
<th>Pressure (kPa)</th>
<th>Displacement (cm)</th>
<th>Force Exerted (N)</th>
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<tbody>
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<td>68.95</td>
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Third Prototype
• Hydroformed outer bellow for relatively high internal pressure
• Edge welded inner bellow to decrease the stiffness
• 316 stainless steel rims used for HLW environment durability
• Parts welded together eliminating potential leak points
• Hydraulic and pneumatic lines jacketed together
• Pneumatic valves located behind the crawler unit to significantly reduce cycle time
• Outer Bellow wall thickness: 0.15 mm

Improved Third Prototype
• Outer bellow wall thickness was reduced to allow superior flexibility
• Water proof camera installed for viewing capabilities while in the pipe
• 15° water nozzle mounted as unpluging tool
• Front rim was re-sized to a diameter of 5.715 cm and an inner diameter of 4.31 cm for better packaging
• Frontal helmet was redesigned to hold the camera and water nozzle into place and allow space for waste to travel back through after unpluging

Maneuverability
3rd generation:
• Bells set to 345 kPa and rims at 414 kPa
• The crawler successfully travelled through a 10.795 cm radius elbow in ▲ 10 min

Improved 3rd generation:
• Bells set to 138 kPa and rims at 621 kPa
• The crawler successfully travelled through a 10.795 cm radius elbow in ▲ 6 min

Speed
3rd generation:
• Bells set to 345 kPa and rims at 414 kPa
• Straight line navigational speed: ▲ 5.8 m/hr

Improved 3rd generation:
• Bells set to 69 kPa and rims at 621 kPa
• Straight line navigational speed: ▲ 11.6 m/hr

Bellow Response
• Time needed for bells to reach a set air pressure
• Measured by gauge at base of bells
• Testing for each pressure performed three times

Future Work
The Peristaltic Crawler is a versatile platform that can improve DOE’s unpluging toolbox
• Large scale pipeline testing
• Manufacture a radioactive resistant and waterproof container for pneumatic valves
• Bellow fatigue testing
• Additional unpluging tools for new nozzle

Design Metrics
Based on Hanford pipelines, the crawler and its components must:
• Fit within 7.62 cm inner diameter pipes
• Be able to pull to own weight including weight of tether
• Operate below 2.07 MPa
• Be capable of removing plugs that exist in pipelines
• Maneuver through a 90° elbow with a 10.795 cm turning radius
• Survive in a radioactive environment

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