The future of pipeline maintenance

ICE PIGGING

www.inpipeproducts.com
Introduction

International Pipeline Products Limited

*iNPIPE PRODUCTS™* -
A global leader in the supply of pipeline maintenance and isolation equipment to the Oil, Gas, Petro-Chemical, Food, Water and Sewerage industries

Established 32 years ago
Based North East of England
80 Employees
Turnover £7.5m
Operating throughout 6 continents
Technology Overview

The inspiration came from nature!

- Glaciers forcibly shape landscapes
  a clever semi solid that cleans valley floors carrying vast amounts of sediment
  then disappears

- Using an ice slurry we can recreate this phenomenon inside a closed system

- Ice pigs are not constrained
  by topology or geometry (within reason) result:
  a pig that cleans the parts other pigs cannot reach

- If the ice pig gets stuck... it melts
The Evolution of Ice Pigging

2001 – Patent granted to University of Bristol
2005 – Lab tests at University of Bristol
2008 – First live network trials at Bristol Water
2010 – Commercial service launched in UK Water Industry by Suez Aqualogy
2011 – Ice Pigging introduced into Spain, USA, Chile, Japan, Australia, Netherlands
2011 – First contact with Shell
2012 – Sponsored project in Shell GameChanger program
2014 – Full Patent purchased by Suez Aqualogy
2015 – Successful wax removal tests and demonstrations for Shell
2016 – iNPIPE Agreement to partner deploy technology in Oil and Gas sector

• Potential decommissioning application
• Contact for demonstration of technology in Jan 2015

1st commercial deployment?
How Ice Pigging Works

https://www.youtube.com/watch?v=DMcoVsyBDp4
Complexity Becomes Trivial

Drastic changes in diameter

Sudden changes of direction

Tees

Plate heat exchangers
Preventative Maintenance

Preventative maintenance in food/beverage industry

Plate heat exchanger
Shell Collaboration

1. Agree design of a test rig to test Proof of Concept
2. Specification of a suitable safe model contaminant
3. Constructing of the test rig
4. The proof of concept
5. Testing
6. Results
7. Conclusions
Proof of Concept

- To demonstrate that an ice pig can convincingly, repeatably remove 95% of sand and wax at 15% by volume from a 3m test section of 24” diameter pipe
**The contaminants**

**TEST 1**: Soft Paraffin wax selected as an analogous contaminant

**TEST 1**: Wax Smeared evenly around circumference of test spool  

107kg

**TEST 1**: Soft Paraffin wax mixed with black dye

**TEST 2**: sharp sand in bottom of test spool  

250kg
Small scale testing

Paraffin wax mixed with black dye and placed in 8” Perspex pipe for scaled down qualification tests.
Wax Removal Test Rig

- Break Tank
- 6” Acrylic Spool Pieces
- 6” Acrylic Viewing Windows
- Eccentric Reducer 24” > 20” > 8”
- 2” Fill Duct
- Acrylic Blind Flange
Testing Methodology

- Sharp diameter reduction from 24” to 8”
- Thick ice will flow around this restriction
- But hydraulically unusual and creates unusual situations
- Represents a quasi blocking point
- Not representative of real world
- Has caused us problems with very thick ice
Test Video

https://www.youtube.com/watch?v=nJ01tqPfZm0
In Depth Characterisation

<table>
<thead>
<tr>
<th>Greater liquid content</th>
<th>Fine Sediment</th>
<th>Sand</th>
<th>Biofilm</th>
<th>Pet food</th>
<th>Shampoo</th>
<th>Paint</th>
<th>Hair conditioner</th>
<th>Mayonnaise</th>
<th>Paraffin Wax</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 Pa @ 5m3/h</td>
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- Viscous contaminants can only be removed with ice that has a high effective shear rate
- Ice thickness can be measured in relation to head loss (friction) induced in a pipe - Pa
- Loose and light material can be removed with ice with low ice fraction
- We can make and use ice slurries up to a theoretical limit of 2000 Pa

This has necessitated various equipment and technique adaptions
Results Achieved

Before

After
Conclusions

1. Ice Pigging can remove sand and wax from previously ‘unpiggable’ lines
2. Ice Pigging can restore hydraulic capacity where soft wax has accumulated
3. Ice Pigging will eliminate the risk of a pig getting stuck
4. Ice Pigging would raise the bar for sub-sea decommissioning where water flushing is the currently the only option
5. Ice Pigging has real potential beyond pipelines, such as clearing heat exchangers
6. Technology now described as ‘technically credible’ by Shell Global Solutions
Proposed Oil Industry Service

- Only 2 x 20’ containers to mobilise anywhere in the world
- Equipment fully designed and tested
- Capable of making 400 Pa ice (for wax removal)
- Continuous flow of ice into pipe to be cleaned – delivery capacity of 10 tonnes of ice per hour
- Potential to marinise for off-shore projects and or deliver from vessel
2. Crushing Method

Add crushed ice to a brine solution and fly mix and grind until the required ice quality is achieved. thick ice in large quantities possible.