

Title

Applying 'Ice Pigging' to the Nuclear Industry

18 November 2009

Ice Pigging for SafeSpur Forum 18.11.09

Content

Brief Overview

Pigging

Ice pigging

Historical context of nuclear application

Update, Excitement, Applications, Imagination

What has been achieved to date

Nuclear applications:

Open pipe, Grout removal, Distances, Storage ponds,

Deployment vehicle

Next?

Conclusions

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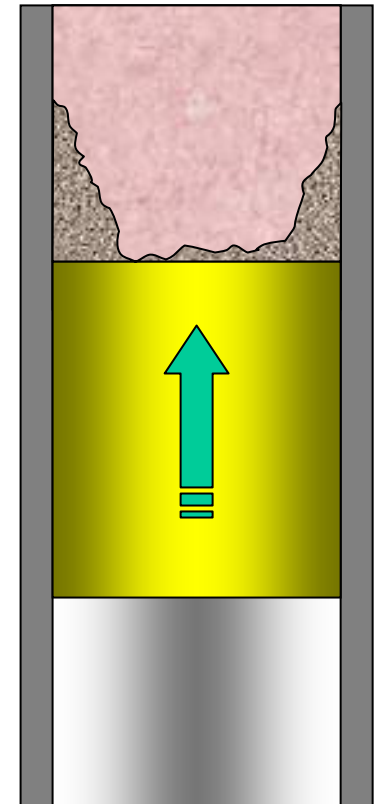
Background; What is pigging?

The process of passing an object through a duct in order to clear/clean it.

Brilliantly developed in the hydrocarbon recovery industry; because:

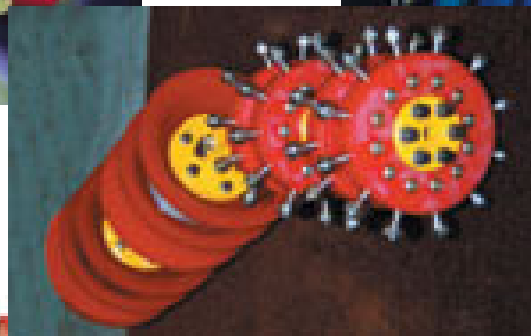
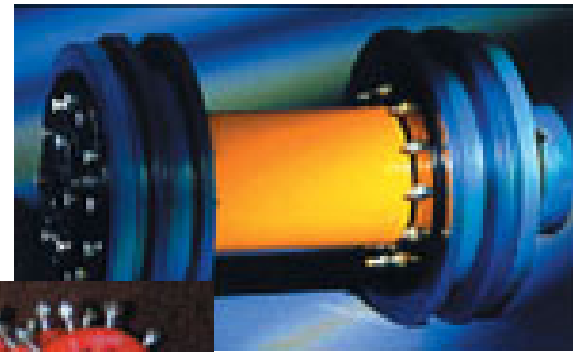
The industry had to, and,

The pipes are straight and simple



Conventional pigs

Some 'clever' pigs



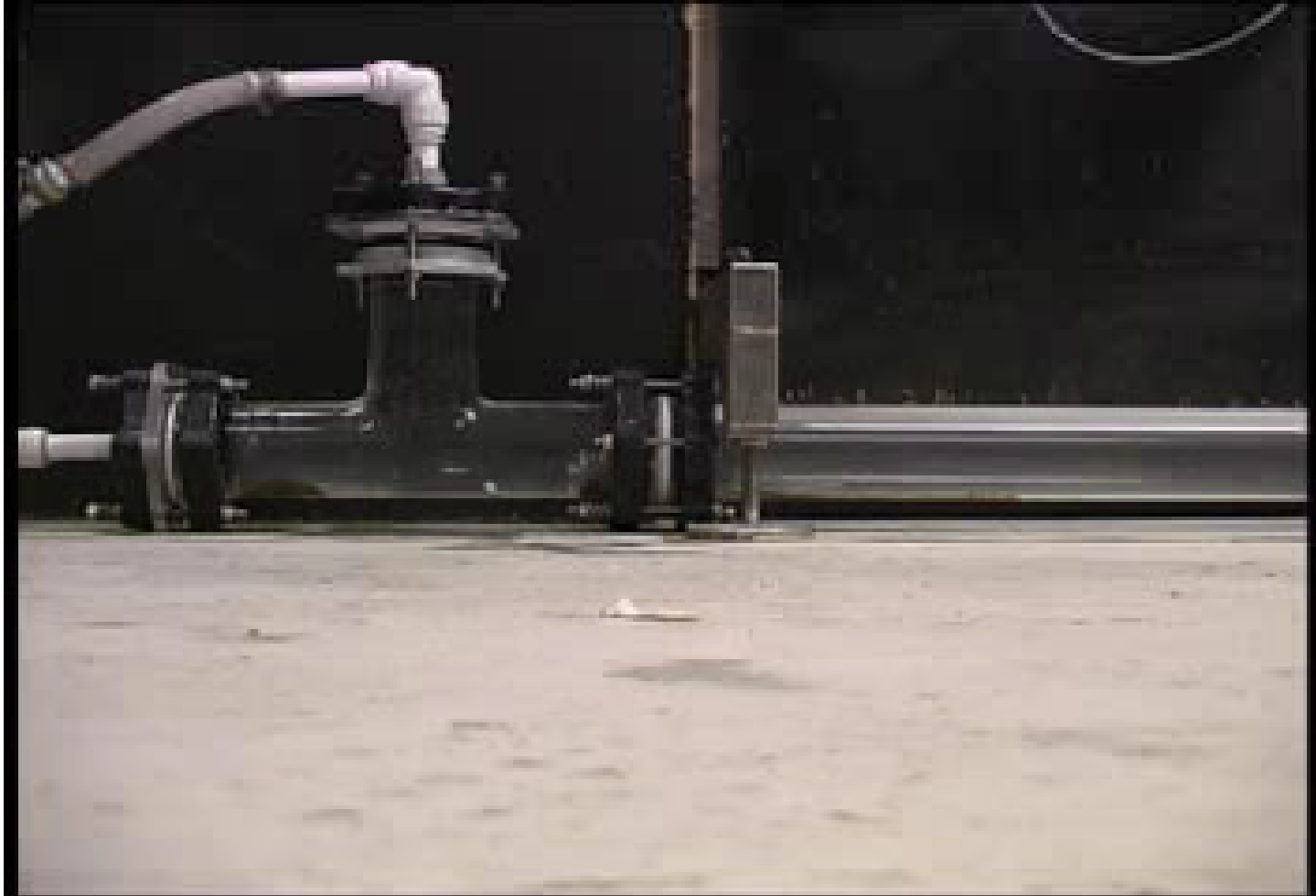
Quick history of what happened

- Everyone sort of interested; but show me for my problem/challenge
- We thought that the biggest beneficiary would be the food manufacturing
- Over the past 6 years, the water industry (specifically Bristol Water) has committed the most, and has benefited the most...more about this at the end.
- Nuclear application really starts with NDA (2006/2007) ...and ...lots more to come.

So...with the water sector

- Good relationship between University and Bristol Water..but
- Simple demos generate polite interest..but
- Demos indicate potential for:
 - Actually doing the job,
 - Doing it ‘better’ (cheaper, faster, friendlier..)
- Regulatory environment conducive

What can be achieved; the persuaders video



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Gutsy Feel for Technology

In its very simplest description, ice pigging is Water Flushing with very very thick water, this 'water' is capable of:

- Giving 10 to 100 to 1000 times the wall shear.
- 'holding' sediments in suspension.
- being handled by usual water techniques

Achievements to date

November 2009

- 58 real trials, 54 on 'live' mains.
- AC pipes diameters 8" to 18", longest successful distance 3.3km (12")
- Plastic 2.7km in 6" diameter
- Iron pipes 60m to 1600m, (6" to 10")
- Mostly within BW territory, plus, Cornwall (5hr and 200miles away), and Wessex Water. All very pleased
- On 01 to 03 November we did pigging in Barcelona!!!!
- 'Pushing the limits' Large 24 to 30inch diameter trial experiments ongoing

Nuclear Applications

- NDA
- Sellafield Sites
- MagnoxNorth
- British Energy
- Start of interest from contactors

NDA

- Real initiation of work and start of connectivities, especially Sam Moore Sellafield Sites
- NDA's input was 'seed-corn' and alignment. Keen for the industry to take a view of the potential value of the technology.
- One of the important aspects identified was whether it was able to help with the magnox 'silts'.

Magnox Sludge

Investigation of the ability of ice pigs to move magnesium oxide sludges and deposits

Figure of merit, M

$$M = \frac{\text{(mass of sediment picked up(g)/mass of ice pig (g))}_{\text{for ice pig}}}{\text{(mass of sediment picked up(g)/mass of water used to flush (g))}_{\text{for water}}}$$

Worked out at 100 to over 200 for Versamag and Britamag, respectively

Sellafield Sites

Interests in generics, but in demonstrating potential for real challenges:

- Freezing point depressants
- Open pipes and half filled pipes
- Grouts

Demo at Sellafield

- Outside security fence, but on Sellafield designed loop to demo potential of different techniques (Whirlwind-by-Air and later Ice Pigging)

Freezing Point depressants 1

Needed to 'buffer' system (range of freezing temperatures), reduced agglomeration, slowed Oswald ripening.

Number of ions or molecules per unit volume of water controls the effectiveness of the FPD; NaCl is great, NaOH is better, HCl is brilliant on a percentage weight basis. All work very well; physical attributes of slurry seem identical

EXTRA: Transport of sediment(s)

- Follow on from original NDA work
- Move to more civil-engineering sizes
- Start with sand, then gravel to bricks
- Start horizontal, move to upward facing slopes (11 to 12 degree examined)

Grout removal

- Follow on from freezing point depressant work, use HCl solution to achieve FPD, plus functionality of HCl to attack carbonates and remove grouts by chemical and mechanical action.
- Use commercial fluid used by builders to clean bricks (of mortar stains)

MagnoxNorth

- Elegant method of cleaning the sediments out of Magnox Cooling ponds
 - Replace water with ice (can we get the promised volume reduction)
 - Reduce the stirring in the pond (can this be achieved...to dislodge sediment one needs shear, shear tends to stir up the looser materials)

BritishEnergy

- Difficulty with enhanced pressure loss in boiler tubes.
- Historically cleaned out with acid, to re-establish hydrodynamic performance. HSE beginning become uncomfortable.
- So...can the ice pig help?
 - As a delivery vehicle for a pill camera
 - (not looked at, but) as a means of getting enhanced residence time of acids where you need them.

Ice pigging Generic Summary

- Crushed, pumpable ice appears to make innovative and paradigm shifting pigs.
- We are further developed in the Water industry, but...your imagination is the limitation.
- Ice pigging provides the engineer with an elegant 'new' tool. It enables him to be more innovative, deliver greater benefits and do things that were not previously possible

Intermediate Summary

- The technique can move significant objects,
- Carrying capacity depends on ice fraction (obvious),
- Carrying capacity depends on local aging; if ice slurry is allowed to ‘mould’ itself around object, then local grip increases
- Typically 100 and as much as 1000 times ‘better’ than water

Intermediate Summary

- Wide choice of FPD available.
- Able to use FDP with additional functional benefits...grout removal by acids, grease dissolved in caustic
- Open pipes (drains) appear to be doable, but procedures still need to be optimised.

Intermediate summary

- Proven;
 - Can get pigs to form in open pipes,
 - Can get effluents out of open ducts,
 - Doable with ‘simple’ plumbing
- Still to do;
 - Mechanical requirement of robustness of duct,
 - Optimisation and development of ‘standards’

Intermediate Summary

- Complexity of topology appears NOT to be the pinch point, (the boiler tube stuff)
- Dynamics (thermalhydraulics) are complex; the 'Hoover' work is very promising, but presents challenges.

Realism

- The water industry appears happy because it works...and there are NO downsides.
- The downside for the nuclear industry is also low, but you need to try/adopt:
 - Magic bullet,
 - Delivery of chemicals,
 - Pig trains,.....
- **IDEAS/SUGGESTIONS WELCOMED**