Cokebusters

Case Study:
Descaling and Inspecting Solar Steam

Background

In 2021 Cokebusters were approached to investigate the feasibility of internally descaling and intelligently inspecting the extensive tubing network of a solar steam plant.

The plant converts water to steam via focussing solar energy. The steam can be used for a variety of utility and process needs, including enhanced oil recovery (EOR). Such a technology removed the requirement to burn natural gas, thus significantly reducing the adverse environmental load.

The solar steam system is constructed from nominal 2" (51mm) Schedule 80 tubing as shown in Figure 1. Certain portions of the tubing network have a heavier tube schedule which reduces the internal diameter further. The total length of tubing through the current 'glasshouse' is some 100km.

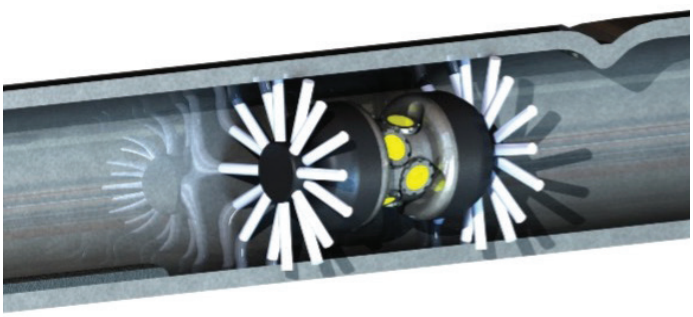
Figure 1 - Inside the glasshouse

Upon entry into the glasshouse, the solar tubing can be seen running along the focal point of the concave mirrors.

The tubing weaves a 'serpentine' path between the mirrors up to the point of exit. There are multiple independent loops, each some 1.75km long.

Cokebusters' smallest, 3rd generation, intelligent pig is capable of navigating an internal diameter of circa 2.5" (63mm), which was too large for the challenge.

Figure 2 - Design Prototyping



Development

Intelligent Pig
Following a short feasibility study and investment decision process, Cokebusters immediately set about the development of a prototype intelligent pig that would be capable of inspecting internal diameters as low as 1.5" (38mm). A fundamental decision was to adopt the basic principles of the Cokebusters 2nd and 3rd generation devices, specifically the device must retain the navigational advantages of the patented single bodied design.

The challenges were divided into categories:
• how to create a robust exoskeleton which would house the (ultrasonic) detection sensors and be light enough to be sufficiently buoyant

• how to design and build a miniaturised logic, with sufficient memory capability

• how to design and build a miniaturised power cell

• what sort of end cap and brush design would be most suitable, considering the need for water tightness also

Several design types were considered and trialed for each category. The system software was modified to suite the new design.

Cokebusters constructed a 30m, 2" diameter extension to the existing test loop which simulated the specific challenges to be encountered. It was also necessary to design and fabricate the miniature launchers.

Figure 3 – Test Loop Extension

The test loop contained restrictions and geometries more aggressive than the facility to ensure that navigation was not threatened. This included schedule changes and tight 180° bends.

A vertical section was included to assess momentum and buoyancy performance.

Descaling
In parallel to the development of the intelligent pig, a similar exercise was conducted regarding descaling technology.

It was determined that the starting point for the design would be to build upon the current procedures used across the Cokebusters mechanical pig range. The primary descaling challenge would be to overcome the inherent restrictions surrounding the entry and exit into the glasshouse.

To this end it was necessary to build a series of incrementally sized devices with variable characteristics, sufficient to overcome the restrictions but also able to remove subsequent scale.

Testing

Intelligent Pig
After six months of intensive development the first prototype was tested. Evaluation was initially restricted to bench testing of components.

Several iterations of circuit board and power design were needed, primarily driven by the challenge to compact for mechanical housing, whilst controlling heat sources.

Figure 4 - Developing Cokebusters Intelligent Pig

Practical testing on the loop revealed a need to modify the end cap design further, as a result of potential water ingress and navigational challenges.

Figure 5 - 4th Generation Intelligent Pig

Descaling
Multiple trials were conducted across a range of sizes and material properties to determine the optimum tooling characteristics.

Figures 6A & 6B - Cokebusters Mechanical Pigs

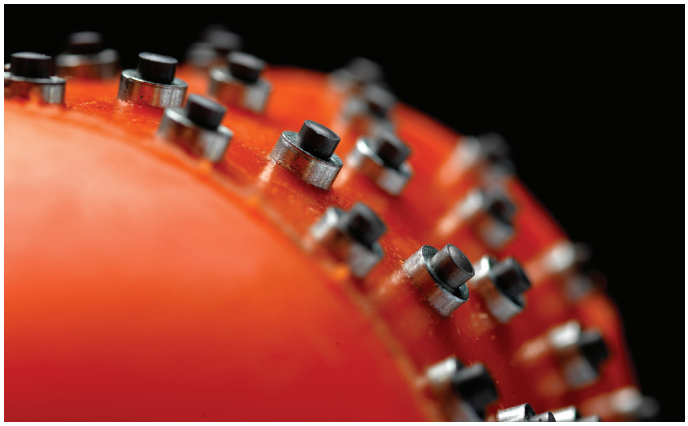


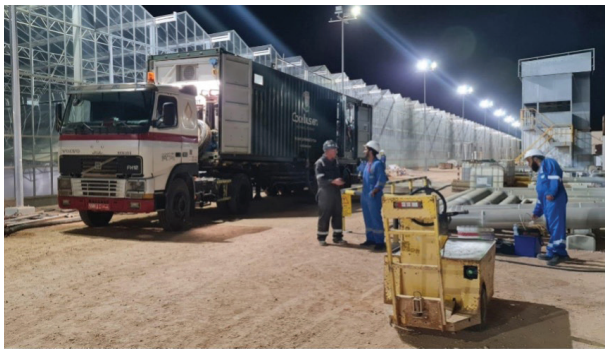
Figure 7 - Testing Cokebusters scraper pigs at UK Technology Centre

Deployment

After months of research, development and preparation, a full scale trial was conducted at the facility in 2022.

Figure 8A - Deployment of Pumping Unit and Equipment to Site

Figure 8B - Cokebusters Double Pumping Unit connected to facility



The trial successfully demonstrated that:

- the descaling pigs navigated the circuit
- scale was removed and recovered
- flow rate before and after cleaning was enhanced
- the intelligent pigs navigated the circuit
- internal diameter and through wall thickness data was collected as shown in Figure 9

Figure 9A – 3D Image of Solar Steam Tubing

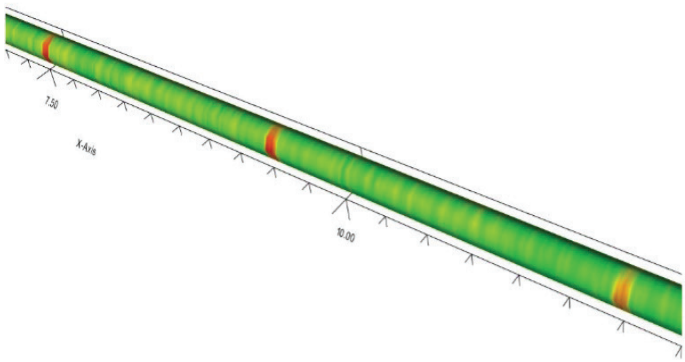
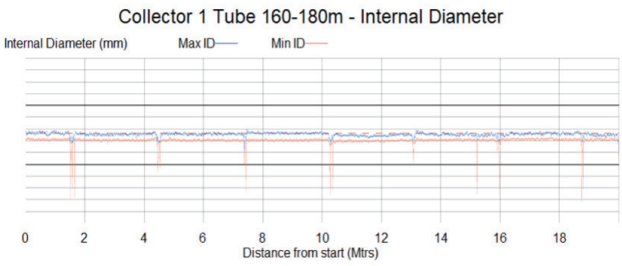


Figure 9B – Section Graph



Conclusions

In response to an initial challenge, Cokebusters has developed what is believed to be the smallest, untethered, single bodied intelligent pig available in the market.

This rapid development is a testament to how quickly Cokebusters can turn a challenge in to a design, to a prototype and then to a deployment.

The ability to clean and inspect at such small diameters is considered something of a world first and equipment previously 'off limit' can now receive the same treatment to ensure and assure containment integrity for our customers.

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