Dounreay Shaft Intervention Platform – 17346

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Abstract:
In early 2013, Oxford Technologies Ltd, part of Kurion-Veolia, was awarded a contract by Dounreay Site Restoration Ltd (DSRL) to design, build, install and commission a remotely controlled Intervention Platform which will facilitate the retrieval of waste from the Dounreay Shaft and Stub tunnel complex.

Removing 1,500 tonnes of waste from Dounreay's 65-metre shaft is the world's deepest nuclear clean-up job and one of the site's most challenging tasks.

The shaft was originally sunk to allow a tunnel to be built for the discharge of low-activity radioactive effluent. In 1958, the shaft was licensed to take radioactive waste from Britain's post war nuclear power research programme and was routinely used over almost 20 years for the disposal of unconditioned Intermediate Level Waste (ILW). To enable decommissioning, the waste must now be retrieved so it can be safely packaged for long term disposal. With radiation levels too high for workers to operate in the shaft, remote handling is the only option for retrieving the material. A specialised platform has been developed, with telescopic mechanical arms attached to the underside which will reach down, grab the waste and bring it back to the platform.

The technology has been adapted from conventional hydraulic and electrical equipment, brought together and re-engineered to use in the shaft, with the additional requirement to operate remotely. The highly flexible system can tackle a range of activities including the grab becoming stuck and the cutting up in the shaft of items too large or heavy to be retrieved in one piece.

Recent trials involved the use of high pressure water cannon that is able to wash out the sludge left behind in the 18m long stub tunnel after larger items have been retrieved by the telescopic arms fitted with grab tools. Several different kinds of replica sludge were used to demonstrate the process would be successfully deployed.

INTRODUCTION

The Dounreay shaft (Fig. 1) was originally sunk to allow a tunnel to be built for the discharge of low-active radioactive effluent. In 1958, the shaft was licensed to take radioactive waste from Britain's post war nuclear power research programme and was routinely used over almost 20 years for the disposal of unconditioned Intermediate Level Waste (ILW). The waste must be retrieved so it can be safely packaged for long term disposal. With radiation levels too high for workers to operate in the shaft, remote handling is the only option for retrieving the material.

Fig. 1. The Dounreay Shaft.

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DESCRIPTION

In July 2013, the Dounreay Site Restoration Ltd (DSRL) awarded to Oxford Technologies Ltd (OTL), a specialist remote handling company, the contract for Concept, Design, Manufacture, Testing and Installation of the Dounreay Shaft Intervention Platform (SIP) equipment, which is required to assist with the retrieval of the waste from the shaft. Tasks that are required to be performed by the SIP include removal of wall mounted steel pipes, size reduction of waste inside the shaft and rescuing the shaft crane petal grab (SHARC) if entangled in waste.

Challenges

The main changes considered during this project were:

- Designing equipment that is capable of performing all of the required tasks in the shaft while retaining flexibility to deal with unexpected requirements.
- A design that is fit-for-purpose, cost-effective and efficient and capable of operating a suite of tooling in extremely hostile conditions.
- Sufficient CCTV cameras, lighting and tooling to enable the operator to remotely sort and size reduce items to facilitate their removal from the shaft.
- Designing maintenance, rescue and recovery strategies for all the equipment.
- Designing, manufacturing and using full-size complex mock-ups of key elements of the system design to provide practical knowledge that was not available previously. This included the Intervention Platform hydraulic retrieval arm and the stub tunnel clearance system.
- Manufacture and testing of the designed system. OTL had not previously manufactured such a large complex system so new facilities were commissioned and new company procedures were created. The provision of a pit in the testing facility enables testing representative of the final operating conditions.
- Managing key sub-contractors with limited previous experience of designing and manufacturing equipment for use in a radiation environment.

Solution

A multi-disciplinary team was gathered to work on a solution and identify modules to be attributed to a lead engineer to manage the design of the sub-systems.
The solution (Fig. 2) consists of a winch system called the Platform Winch Trolley (PWT) carrying a structure supporting two articulated hydraulic arms called the Intervention Platform (IP).

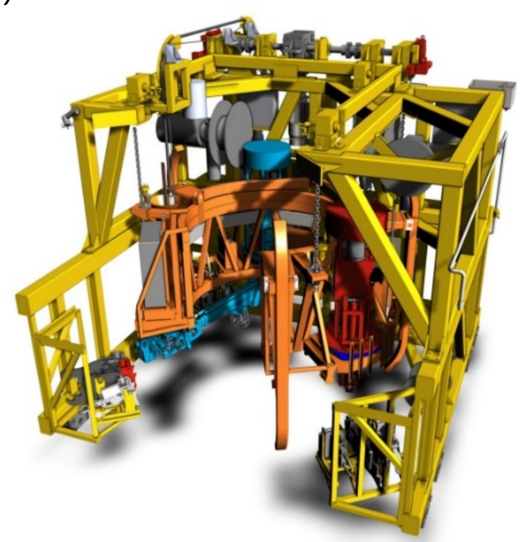

Fig. 2. Shaft Intervention Platform.

The PWT travels on rails from a shielded maintenance cell into the processing cell above the shaft opening (Fig. 3). Once positioned, the IP is lowered into the shaft to the depth required for the task. The hydraulic arms have the functionality of remotely connecting with tooling from the PWT to achieve all the required tasks inside the shafts.

Fig. 3. Platform Winch Trolley (PWT).

The SIP platform uses a reliable, simple and robust winching system comprising of three steel chains driven from one common shaft. Whilst chain winching is common in other industries, wire rope lifting is the normal practice in the nuclear industry. To provide a cost effective solution, the winch system was designed in-house with design input and expertise provided by SCX, a UK-based specialist in bespoke handling solutions.
A safety device called a "MotoSuiveur® [a]", supplied by project partner SCX Special Projects Ltd, was specified to reduce failure scenarios, and provide a simple and reliable safety system.

Rather than buying an expensive manipulator arm or robot, the IP hydraulic arms (Fig. 4) are based on a Commercial Off The Shelf (COTS) telescopic crane with an articulated tool changer from the construction industry fitted at the end of it. This design offers optimal kinematics while relying mainly on COTS components for a cost effective solution. A full-size Proof of Principal test arm was designed and assembled by OTL at its Assembly, Integration and Testing (AIT) facility to substantiate the design, confirm its functionality with the proposed tooling and provide demonstrations to the Client.

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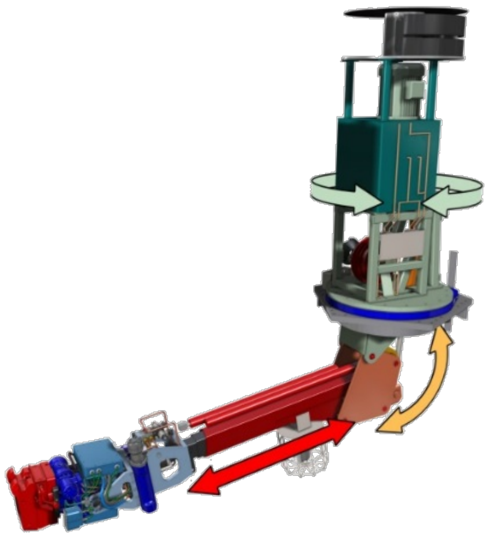

Fig. 4. IP Hydraulic Arm.

Full Scale Mock-Up & Bench Trials:

The project requirements identified a list of typical remote tasks to be completed by the SIP during its operational period. These included:

- Size reduction of large items, including large sections of concrete.
- Removal of 10" steel pipe fixed to the shaft wall.
- Removal of steel mesh lining the upper sections of the shaft.
- Opening steel drums.
- Removal of debris and sludge from the 18m long stub tunnel.
- Deployment of water washing & sludge retrieval systems down the shaft.
- Assisting retrieval of the shaft crane petal grab (SHARC).

Extensive trials were conducted at the AIT facility using a prototype hydraulic arm bolted onto a 10m x 5m x 5m deep pit to evaluate the effectiveness of tooling and remote handling methods. Critical in this was developing remote methods to clean out the 18m long stub tunnel at the base of the 65m deep shaft. The Client's baseline concept described the use of remote excavators for this task. Analysis of potential failure modes and the resulting recovery precluded the use of such remote equipment in this environment. In agreement with the Client it was concluded that large debris items were unlikely to have travelled beyond the reach of the hydraulic arms when deployed at the mouth of the stub tunnel. A method was then required to remotely remove the anticipated 0.5m or so of sludge from the base of the tunnel. A full-scale mock-up of the stub tunnel was constructed (Fig. 5), including the use of 75 tonnes of simulated sludge, which enabled trials to be conducted using a 4" hose deployed by the hydraulic arms to develop operational methods for sludge removal. This saved the Client over £600,000 of project costs by removing the need for remote excavators.

Fig. 5. Full scale mock-up of stub tunnel.

CONCLUSIONS

The Shaft Intervention Platform is currently undergoing final assembly at OTL's AIT facility. Following assembly, a detailed integration and test programme will begin that will make use of the specially design pit, used for the prototype trials, to demonstrate functionality of the complete system and enable successful Factory Acceptance Testing to be completed in 2017 prior to delivery to Dounreay for final installation, Site Acceptance Testing and Operations.