TRENCHING IN ROUGH SEAS

John Lincoln, OES, USA, discusses the challenges faced during a subsea pipeline trenching project offshore Ghana.

In early February 2018, the worst thing that could happen to a directional drilled shore crossing happened; it failed while only partially complete, and the soil collapsed in the hole over the 26 in. diameter gas pipeline casing during drilling, causing major completion delays to the owner, ENI Ghana. ENI was up for large cost penalties, as the company had signed delivery contracts with several gas utilisation industries in Ghana.

The pipeline had been laid by Subsea, a division of Halliburton, a company that now has one of only two very deepwater pipelay vessels capable of laying 26 in. diameter pipelines in 3000 ft of water. The system involves the use of vertical lay technology, first pioneered by Heerema Offshore for the Shell Maui B pipeline in New Zealand. This was also the project for which OES was called in to trench the pipeline, after methods using a plow failed. On this project OES not only invented and operated its first lead keel trenching machine, but also developed the first deepwater trenching using the lead clump weight system. On the Ghana project, Subsea had laid the pipeline from offshore to a depth of 300 ft, whereafter the shore pull would make an above-water tie-in at this point.

Formulating a plan

ENI called on Micoperi, an international pipelay construction company that had the moderately deep capability *Seminole* pipelay barge, and was located in the area. The *Seminole* barge, back in 1990, was one of the world's deepest water pipelay barges at the time, and was capable of picking up the 26 in. diameter pipeline in 300 ft of water. It was able to lay closer to shore in shallower water, lay the pipe, turn around, and make a shore pull of 1 km across the rough beach, from where it could then make an above-water tie-in to complete the pipeline.

This would complete the pipeline to the point that they could flow gas through, although not to the insurance company's requirements. This pipeline, like all shallow water pipelines, had to be trenched to protect it from ship grounding, large ship anchors, and from washing away in large storms. The owner of OES recalls that in 1989 when he worked for Woodside Petroleum, a 42 in. subsea pipeline in moderately deepwater (approximately 200 ft) was washed sideways approximately 80 m during a cyclone, but fortunately did not rupture.

Micoperi in turn called on OES, a company with experience in trenching subsea pipelines, with whom it had already completed several projects – including another pipeline in Ghana five years previously. For OES, the solution seemed simple; use a large barge that could take the heavy seas, had a shallow draft, and could get in within 150 m of the shoreline. The machine would be set over the pipeline, pulled towards the shore, then turned around and pulled back to the barge. In May 2018, OES was mobilised by Micoperi to Italy, in order to begin refurbishing all of the equipment.

The seas off the African coast in Ghana are rough and the water very shallow, creating a wave-breaking zone that extends 300 m out from the shore. It was difficult to find a suitable barge, and the process involved considerable creative thought from Micoperi, Subsea, ENI and OES. ENI, in the meantime, attempted to use a shallow water spread, but to no avail.

The search for a solution

Finally, Micoperi proposed to OES a shallow water floating jack-up barge that could walk up the beach. After extensive review, it was considered unsuitable, as there was fear it might sink or topple over in a large surf and liquefiable seabed. In addition, the deck was too high – approximately 6 m – and OES was unable to suck water that high with its large 1500 HP jet pumps. John Lincoln, OES, came up with the idea to dig a large 6 m deep hole at the beach and sheet pile it, then keep it open through a small window towards offshore to allow water to fill in from above, and also percolate from below through the permeable sands. The idea was discussed with the other parties involved in the project.

Micoperi provided critical design input, as the soils were dense compacted sands and percolation from underneath was not considered reliable. As a result, the company embarked on building a feed pipeline to the pit from approximately 50 m offshore, and found it also had to support this with a piled structure. A

Figure 1. Completed pre-trenching, and the start of post-trenching.

Figure 2. The layout on the beach for the onshore operation, including the failed shallow water spread to the left.

floating pull vessel provided by Micoperi could sit 300 m offshore, out of the surf, and pull the OES rolling lead keel machine. However, it had no crane and therefore no way of turning the machine around. OES had previously pulled its machines backwards on some projects; however, these soils were softer and less compact. If the machine could not be pulled backwards, it could get stuck on and potentially roll over under the pipeline, creating additional risk.

Another problem was insufficient hose length; OES had never undertaken remote trenching by more than 100 m, and this project required 200 m with no chance of recovering the machine should it become stuck. Additional hose was flown in. A completely new set of jet nozzles was added to the educator piping at the stern, to aid in a backwards pull operation. As there were no divers, both the forward and reverse nozzles had to be on simultaneously, reducing the available water. This was further reduced under the consideration that if two pumps are used – one for the forward jets and one for the stern jets – and one failed, there was no spare. Only one pump was used and a spare was there on-site, to be piped in if necessary. The number of passes could not be predicted because the waves were causing the sand to constantly backfill the trench over the machine, but hopefully not causing it to become stuck.

With a reduced amount of water available, it was also decided to cut a shallow trench. It became necessary anyway, as an additional problem was that the pipeline was live and under pressure. A stress analysis performed by OES using the company's proprietary software PIPETRANS, limiting bending stress to levels allowed by ANSI B31 codes, indicated a maximum trench depth per pass was approximately 600 mm. OES had previously undertaken live gas pipeline trenching several times, but there was still the risk that there may be a problem, such as an undiscovered weld defect.

The operation

Micoperi operational staff were concerned with the machine being located 200 m from shore, and that the hose being hit by the waves may pull the machine over. The machine was outfitted with a survey pole, so that its level (and consequently the pipeline) could be established easily on land. The pole also served as a tilt indicator, because it could be seen at all times and so knew if it wanted to list. In case of list, two 400 m floating polypropylene lines were attached which ran to two tracked vehicles on the beach that could pull the machine upright if necessary.

OES stipulated that personnel safety, the live pipeline integrity, and preventing the trenching machine from becoming stuck offshore were the priorities.

Another concern of OES and Micoperi was that this pipeline was very light and had little concrete, as it was supposed to go through the protective casing. If the soils liquefied and their specific gravity was greater than the pipeline overall density, the pipeline could float upwards; however, fortunately this did not happen. After input from Subsea and ENI, and with some assurances from Micoperi, a plan was agreed.

The trenching work began on-site in mid-December 2018. The operation went to plan; however, there was a large amount of debris that entered the pit and plugged up the pump suction strainers, so the suction pipes had to be removed daily and the suction strainers cleaned. In addition, it was difficult at times to deploy the machine with the crane, as the crane could not get out far near the water.

Conclusion

Thinking outside the box to find a solution to a challenging problem may seem risky, however in some situations – such as this offshore operation in Ghana – it is the only viable option, or at the very least the most cost-effective one. Fortunately, with the right team who have experience in overcoming similar risks, there is a strong chance of success.

Figure 3. Pumps at the edge of the suction pit.

Figure 4. A side view of the suction pit (foreground).