TECHNOLOGY DEVELOPMENTS ARE ENABLING THE NEW GENERATION OF CABLE BURIAL PLOUGHS TO OPERATE MORE EFFICIENTLY WITH A REDUCTION IN OPERATIONAL DOWNTIME

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Abstract: Plough development peaked during the early 2000's; since that period there have been limited advances. There is a renewed focus on the installation of telecom cables and new developments have followed.

Dynamic Simulation and, FEA are used to optimise mechanical structures, resulting in better construction and improved fatigue life. The latest control systems include distributed control architectures and intelligent condition monitoring feedback. Equipment can now be interrogated from the beach enabling fast fault correction. Subsea configurable jetting allows optimum ploughing right up to ultra-shallow waters.

All of these developments culminate in the production of stronger and more efficient systems which can stay operational in the water longer with less operational downtime.

1. INTRODUCTION

Subsea ploughing has been around for many decades.

In the 1970's AT&T's ploughs consisted of a moveable plough share mounted to a rigid sled structure with a fixed set of runners (Figure 1).

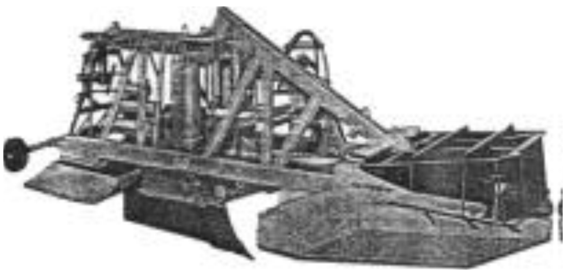

Figure 1: AT & T Plough (1970's)

Between circa 1990 and 2010 SMD had a significant share of the cable plough market lately with their MD3 and HD3 ploughs (see Figure 2).

Figure 2: SMD's MD3 Plough

During that period, others developed other ploughs such as the P1500 plough with its jet-assisted plough share function as a forward “rudder-type” steering system (see Figure 3.

Figure 3: Perry Slingsby Plough (2002)

In more recent times IHC have made a number of developments in ploughing technology to improve performance significant new developments

2. PULSED JETTING

The oscillating pressure fields within the water jet nozzles are generated passively, without the requirement for an additional power source or moving components which makes them ideal for subsea applications. Chambers within the nozzles are dimensioned such that their natural frequencies fall within this range of optimal frequencies under the intended operating conditions.

The two main concepts tested include organ pipe configurations and Helmholtz chambers.

The results from the first phase of testing and CFD analysis (see Figure 4) are encouraging and indicate that the concept of pulsed jetting to improve the efficiency of subsea cable burial applications is feasible. The increases observed in the RMS pressure are significant in themselves and with further testing and optimization work it is likely that the performance could be improved further.

The strongest modulation in the exit flow seemed to be produced by the Helmholtz configurations but the oscillations generated by the Organ Pipe configurations seem to retain their coherence for longer and experience a less rapid decay in the mean velocity.

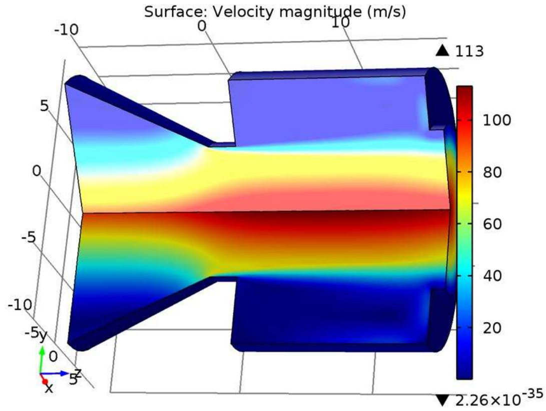

Figure 4: Pulsed Jetting CFD Analysis

The improvement in trenching performance is between 15% and 20%

3. PATENTED SHALLOW WATER ANTI-CAVITATION SYSTEM

The water pumps utilise a patented anti-cavitation system which increases the static inlet pressure at the pump intake reducing the depth of operation required before the onset of cavitation occurs (see Figure 5). This is particularly effective for shore operations where ploughing in sands can commence as soon as there is water around the plough without the need for an external water supply.

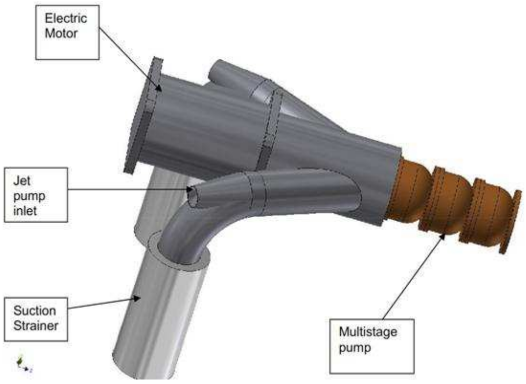

Figure 5: Typical arrangement of patented anti-cavitation system

4. SUBSEA CONTROLLABLE VARIABLE PRESSURE JETTING

Ploughing is historically best suited to trenching in cohesive soils (clays). In granular materials (sands), the pore pressure created by ploughing quickly especially in fine, dense sands requires massive pull forces.

IHC has developed and patented a system comprising two pumps which can be operated in either series or parallel. This is achieved by a simple pair of subsea valves and pipework.

The practical upshot is that the operator has the ability to direct water between 5 bar and 16 bar at any of the three sets of jets on the shares (see Figure 6).

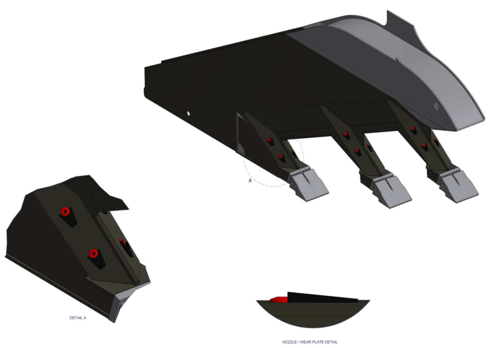

Figure 6: Share jetting with subsea variable pressure

In combination seabeds with a hard clay lower section and a sand overlay, flow can be concentrated in the upper share(s) by isolating the lower jets. In areas of environmental sensitivity, the jetting can be turned off completely producing a narrow, minimum disturbance trench.

Each jet can be fitted (on deck) with different nozzle diameters to allow the flow area to be optimised between the duty points

This jetting system, with it's highly subsea configurable flexibility, is also extremely useful to control how repeaters are buried.

In combination with the ultra shallow water anti-cavitation pumps, the operator has maximum flexibility of trenching right the way from the beach.

5. IMPROVED DESIGN ANALYSIS

There are now many design and analysis tools widely available to the designer. These include the familiar Finite Element Analysis. More sophisticated dynamic fatigue analysis within FEA (see Figure 7) and other dynamic simulation packages enable more of the plough structure to be operating nearer their design limit ie better use of the steel / plough weight. Plough mass is critical as an expensive LARS is required.

In the last 10 years, increased functionality including jetting and the tilting bellmouth has been achieved without undue increase in plough weight.

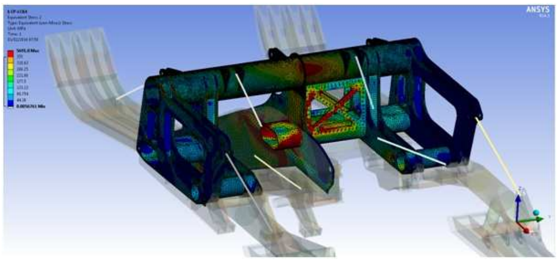

Figure 7: FEA analysis of cable plough

Analysis of the cable catenary in the water column using packages such as Orcina has increased the understanding of how it behaves and enabled development of new functions which further protect the cable during installation. The tilting bellmouth below was a direct result of these design studies.

6. TILTING BELLMOUTH – IMPROVED CABLE ROUTE

By pivoting the bellmouth down, towards the seabed the cable entry point in to the plough can be adjusted to minimise angle of bend of the cable minimizing the as-laid cable tension. The bellmouth can also be raised before deployment to the seabed to ease the passage of the cable. The position is controlled by a hydraulic cylinder mounted from the main structure of the Plough.

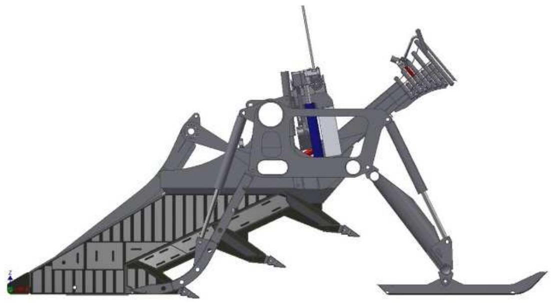

Figure 8: Pivoting bellmouth (shown raised) – more cable friendly in water column

Tilting the bellmouth separately from the tow point sub-assembly ensures that the tow point remains close to the seabed maximising plough stability and penetration.

7. DEVELOPMENT TESTING

One of the major areas of plough operational downtime is electrical harnesses. Traditional electrical circuits have multi-branched harnesses connected to the main electronics pod. Multiple breakouts split down to each motor, surveillance, instrumentation, etc. These are complicated and expensive. Additionally, they are almost impossible to replace in field, requiring challenging fault finding and in line field splice repairs.

IHC have developed distributed I/O using industry standard components. These have been tested to the equivalent of 2000m water depth over 5,000 cycles

These I/O components are located in multiple places already required around the plough, typically the Junction Boxes (JB's) as shown in Figure 9.

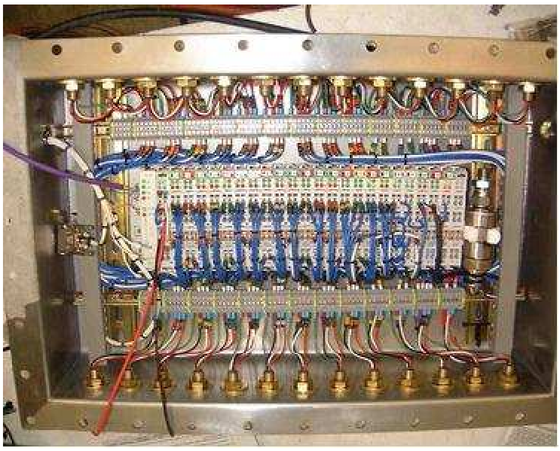

Figure 9: Typical distributed I/O in pressure compensated JB.

A simple straight line harness runs from the pod to each JB. Much simpler harnesses run from the JB to one or two surveillance, instrumentation etc.

Harnessing is much simpler in design, robust and easy to fault find & repair / replace in the much reduced likelihood of failure.

8. REMOTE DIAGNOSTICS

Plough systems operate in remote areas often inaccessible from even the closest port. They are frequently locked to their location by the product they are installing.

In the event of a breakdown, fast fault finding and repair is critical to minimise any exposure of the spread to possible bad weather (which may have caused the failure).

A key element of this capability is remote diagnostics of equipment from the design office. This can also be used when an operator identifies an unusual set of circumstances. These can be investigated and action taken to prevent a fault occurring.

Using this facility, IHC's experts in the office have been able to work closely with the vessel equipment team to diagnose a problem whilst the vessel is still on station and the product through the plough. The fault has been identified (often a simple sensor connection failure that can be worked around once the fault is understood). The dive can be completed without any requirement for an unplanned recovery.

9. CONCLUSIONS

Cable ploughs have been used to protect submarine telephone cables for nearly half a century.

Development has been somewhat discontinuous with innovation following periods of increased market activity eg the introduction of practical fibre optic cables in the 1980's.

Recent advances in internet and electronic technologies have enabled more detailed design and analysis optimising the hardware for reduced weight and increased reliability. Remote diagnostics have allowed the experts to be virtually on the vessel immediately and diagnose faults faster.

Most importantly, innovations in mechanical and hydraulic systems – the bits that do the work – enable the best protection of the cable and cost reduction. The tilting bellmouth and anti-cavitation subsea configurable jetting systems are excellent examples.

10. REFERENCES

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