By successfully applying structural and fluid optimization techniques, the teams improved the efficiency of the fluid performance by 26 percent.

Subsea vehicles are used for trenching and burying rigid and flexible products and power cables below the seabed. These trenching vehicles must operate reliably and efficiently so that the products installed can be laid accurately into the trench. When designing the new XT1500 vehicle, Forum Energy Technologies — a global oilfield products company providing services to the subsea, drilling, completion, production and infrastructure sectors of the oil and gas industry — worked with Wilde Analysis to optimize the design and performance of the XT1500 Seabed Trenching System.
The ANSYS Fluent Adjoint Solver helped to optimize the manifolds of the subsea trenching vehicle. The new design would have an expected reduction in loss coefficient of approximately 26 percent.

The team ensured performance by using a combination of ANSYS fluid dynamics and structural mechanics simulation software. By successfully applying structural and fluid optimization techniques, the teams improved the efficiency of the fluid performance by 26 percent and, by changing the structural design and manufacturing process without significantly increasing weight, eliminated concerns over a potential loss in robustness.

**JET TRENCHING**

Jet trenching involves lowering the jetting swords of the trenching vehicle into the seabed to create a continuous fluidization zone. An eductor at the rear of the vehicle removes the fluidized material and ejects it to the sides of the trench. This creates a continuous trench behind the vehicle so that a stiff product, such as a rigid pipeline, can lay in the trench.

To maintain the fluidization generated by these main jets, a backwash of low-pressure water is injected into the trench from behind the main swords. This enables small, flexible products to be laid into the trench before the seabed compacts. A swivel manifold assembly on the jet arm allows the swords and nozzles to constantly point in the optimum direction when lowered to the maximum trenching depth.

**DESIGNING A NEW SUBSEA TRENCHING VEHICLE**

Forum was tasked with designing and constructing a new subsea vehicle based upon a smaller XT1200 vehicle currently in operation in the North Sea. A key objective for the new XT1500 vehicle was to improve performance of the forward tooling assembly to fluidize the seabed more efficiently. During this design project, Forum (a long-term user of ANSYS simulation software) engaged the consulting team from Wilde Analysis (its software, support and training supplier) to assist with the redesign of the forward tooling assembly, including optimization of:

- Internal flow characteristics
- Structural performance
- Strength-to-weight ratio
- Spatial design envelope and operational functionality

To achieve these objectives, structural mechanics and fluid dynamics technical specialists at Wilde worked together to perform an initial design assessment and then to evaluate potential design improvements. Computational fluid dynamics (CFD) methods were used to improve the internal flow characteristics, and finite element analysis (FEA) was then undertaken to assess the structural significance of any internal alterations. The team used ANSYS software throughout the project, as the ANSYS Workbench user environment provides an ideal platform for geometry editing, meshing and computational solving for both FEA and CFD.

**FLUID DYNAMICS ASSESSMENT AND OPTIMIZATION**

Forum specified the footprint of the manifold’s internal components and the locations of the inlet and three outlets. Wilde engineers analyzed each of the components downstream of the manifold using the ANSYS Fluent solver to determine a loss coefficient for each.

These were then applied to outlets of the manifold, ensuring correct flow distribution during the optimization phase, in which losses across the system were minimized. This was accomplished by exploiting the optimization capabilities of the ANSYS Fluent Adjoint Solver, using pressure loss as the target variable. By allowing the mesh to adapt, an optimized shape was produced for the internals of the manifold. Results obtained showed that the new design would have an expected reduction in loss coefficient of approximately 26 percent.

Changing the structural design and manufacturing process without significantly increasing weight eliminated concerns over a potential loss in robustness.

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“Wilde quickly understood the analysis that needed to be done on the forward tooling assembly and used their FEA and CFD expertise to develop a new design to optimize the efficiency of the new vehicle within the required time scales.”

—Paul Marshall, Project Engineer — Forum Energy Technologies
STRUCTURAL ASSESSMENT AND OPTIMIZATION

The original design of the XT1500 manifold was based on a fabricated construction method. Because the welded regions represented a structural weakness, Forum Energy Technologies Ltd. decided to alter the construction of the forward tooling assembly to a machined item. To gauge the performance of the machined design, a structural analysis of the original fabricated manifold was undertaken. The results of this preliminary analysis consolidated opinion on Forum’s design decision and provided a benchmark against which the machined manifold could be evaluated.

Working with Forum’s design team, the structural engineering team at Wilde incorporated the design modifications identified by the CFD team to ensure optimum operational performance of the trenching system. To optimize the design structurally, an iterative analysis procedure was adopted in which the structural performance of the manifold was evaluated in conjunction with the weight-reducing design adjustments being made. Another significant goal was reducing of any excess weight in the manifold that could impact buoyancy and stability of the trenching system.

Using ANSYS Workbench simulation tools, Wilde engineers reduced the weight of the machined design to within acceptable limits while optimizing the manifold’s structural performance and maintaining the desired internal flow characteristics.
Successful Collaboration

This was a truly collaborative project, not just between Wilde and Forum, but also between Wilde’s own fluid and structural mechanics engineers — and their tools. Wilde’s engineers were placed on-site at Forum and embedded into the design team there. This gave Forum guaranteed full-time access to the skilled analysts they required and facilitated direct and immediate communication across the combined team, to the benefit of all.

Beyond enabling the team to deliver a demonstrably improved design within time and budget, secondment arrangements like this offer educational advantages to both parties: Wilde’s talented analysts were directly exposed to real-world operational and manufacturing constraints on design, while Forum experienced first-hand the benefits of advanced interoperable simulation and optimization tools in driving design.