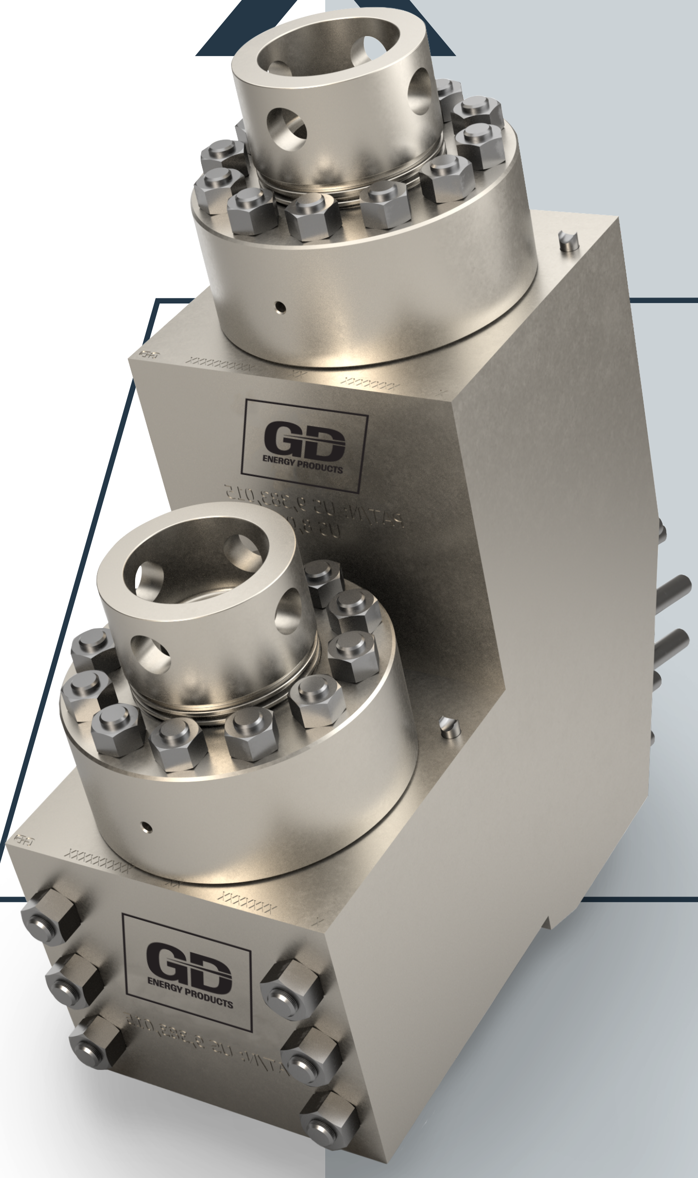
FLUID END TECHNOLOGY ON THE RISE



Performance life, downtime and operational efficiency are a few of the pump equipment metrics that drilling contractors have focused on improving. Increased well depth, higher drilling pressures and the ongoing need to improve operational efficiency have significantly increased the performance demand on drilling pumps and other rig equipment.

In light of this, GD Energy Products spoke with many of our drilling contractor customers and confirmed that operating pumps at >95% rated capacity with pressures in excess of 6000 psi is the new "norm". Although these high-horsepower, drilling pumps have been engineered for continuous duty service, this new standard mode of operation is placing incremental stress on the equipment and subsequently reduces the life expectancy of gearing and fluid end components such as modules, pistons and valve assemblies.

Today's high-pressure, high-speed drilling operations have made a significant impact on the mud pump's fluid end flow dynamics. Higher differential pressures within the fluid end, along with an increased flow velocity, has resulted in modules becoming more susceptible to failures caused by operational stress or more complex fluid dynamic issues, such as cavitation.

To address these increasingly common issues, GD Energy Products has invested in new fluid end design and manufacturing technology with the objective of improving performance. The days of running drilling pumps 'nice and easy' are over, and fluid end innovation has become increasingly important.

EVOLUTION OF PUMP FLUID END DESIGN

Since the invention of the triplex mud pump over 50 years ago, drilling pump fluid end module innovation has trailed in comparison to other drilling products. For example, the mono-block module, commonly known as the valve-over-valve module that accompanied the first generation of triplex mud pumps, is still being used today.

Although this original valve-over-valve design has been adjusted to withstand higher pressures and improve flow, the module design has essentially stayed the same over the decades. Its light-weight, compact footprint, along with economical maintenance cost, explain why it still remains the fluid end design of choice for many drilling contractors around the world.

After decades of being the only available design option, a new competitor was introduced to the market in the early 1980s in the form of the 2-piece, L-shaped fluid end design. [cont.]

Although significantly heavier than the valve-over-valve design, the L-shape system has the advantage of being easier to maintain and having separate, interchangeable suction and discharge modules.

Over the past decades, the market preference for these competing designs has been split. Based on historical performance data, life expectancy and overall performance of these competing designs has been relatively equal, and selection is primarily based on user-preference.

When GD Energy Products set out to develop a next generation drilling pump fluid end, the design team considered a multitude of factors. The company analysed the benefits of the valve-over-valve and 2-piece, L-shape design and potential improvements that could be made to these field-proven products. Considering the majority of drilling rigs have been equipped with 7500 psi mud systems and are drilling at higher pressures than ever before, GD Energy Products leveraged its background in frac fluid end manufacturing to aid understanding of what factors become more critical to module performance and life expectancy.

COMBATING CAVITATION

Faster stroking, higher-pressure pump operation has drastically increased the velocity at which drilling fluids flow through the mud pump's module. Although there are several factors that can negatively impact pump performance, today's faster pace operations have significantly increased fluid velocity and the amount of fluid turbulence that occur within the module. This turbulence can have a detrimental impact on pump performance and increases the chances of issues, such as cavitation, occurring within the fluid end module.

Cavitation is an undesirable condition that reduces pump efficiency and leads to excessive wear and damage to components. It occurs when rapid changes of pressure in a liquid lead to the formation of small vapor-filled cavities (air bubbles). When subjected to higher pressure, these cavities collapse and can generate an intense shock wave.

Figure 1. *Cavitation occurs when rapid changes of pressure in a liquid lead to the formation of small vapour-filled cavities (air bubbles) and can ultimately lead to cracking or module washout.*

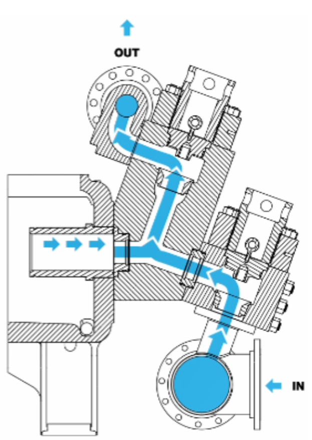


Figure 2. *This simple, uniform flow pattern reduces fluid turbulence, which decreases the internal stress placed on a module.*

Mild cavitation occurs when the mud pump is starved for fluid, which introduces air into the pump. While the pump itself may not be making noise, damage is still being done to the internal components of the fluid end. In the early stages, cavitation can damage a pump's module, piston and valve assembly. Cavitation causes numerous pits to form on the module's internal surface. Over time, these cavitation pits create a stress concentration, which can ultimately lead to cracking or a washout (Figure 1).

To reduce the possibility of cavitation, the module's internal geometry should be designed so that the drilling fluid flows smoothly from the suction to discharge section with the least amount of restriction and/or redirection. As illustrated in Figure 2, fluid-flow in a valve-over-valve system flows up from the suction to the discharge section via a single channel without changing direction. This simple, uniform flow pattern reduces fluid turbulence, which decreases the internal stress placed on the module. The inherent drawback of this design is that the entire module has to be replaced when a failure occurs.

In the competing, 2-piece, L-shape design, this issue is resolved by having a separate discharge and suction module assembly. In the event a failure occurs, the individual module (suction or discharge) can be replaced, which is more cost-effective than replacing the entire assembly. However, the internal channel pattern of the L-shape module design is not favorable in regard to flow efficiency.

The flow pattern of an L-shape module requires the drilling fluid to make several 90˚ turns before exiting. This change in flow direction creates areas of high-stress concentrations at these channel intersections. This flow inefficiency is a key factor in exacerbating module fatigue.

Lastly, when comparing the overall height of an L-shape to a traditional valve-over-valve or GD Energy Products's Y-shape,the L-shape is significantly taller. This additional height increases the percentage of un-swept volume present in the module on each stroke. Commonly referred to as 'dead' volume, this residual fluid further reduces flow efficiency of the L-shape design.

The Y-shape module addresses these concerns by opening up the 90˚ intersection radius to 120˚, resulting in improved flow and reduced back pressure. Basically, it is the difference between following a curve in the road versus making a right-hand turn at an intersection. By modifying the bore radius, the design removes the areas of stress concentration and optimizes the flow pattern of this 2-piece design. The forward leaning orientation of the module is not only ergonomic for maintenance, but it also eliminates any discharge manifold clearance concerns, which allows for a height reduction of the discharge module. By keeping the height to a minimum, the un-swept volume is decreased in comparison to L-shape designs, thus increasing flow efficiency. Through years of field testing, the Y-shape module has proven its reliability and performance in high-pressure drilling applications.

CONCLUSION

As the competitive drilling landscape becomes increasingly challenging advanced drilling technology is a key focal point within the industry. The introduction and adoption of new technologies, such as the Y-shape module, will continue to increase operational efficiencies and boost long-term cost savings.