May/June 2014

UPSTREAM Pumping SOLUTIONS

Technology and Services for Oil & Gas Operations

Artificial Lift Alternatives

Choices for challenging reservoirs

*************************AUTO**3-DIGIT 980
#UPS0492963 7#
JAMES DOYLE
PRESIDENT
LASER TECHNIQUES COMPANY
11431 WILLOWS RD NE STE 100
REDMOND WA 98052-2501

PRSRT STD
US Postage PD
Permit 1216
Liberty MO

S85W
2/6
N980

GLOBAL PETROLEUM SHOW & EASA CONVENTION

Laser Technology Enhances PCP Manufacturing & Pump Flaw Detection

By James Doyle, Laser Techniques Company, LLC

Laser-based inspection can replace manual or visual techniques.

What do rocket thrusters, nuclear steam generators and progressing cavity pumps have in common? All are difficult to measure and inspect. All are associated with high-value operations, and if failure occurs in the field, all can have catastrophic and expensive consequences. During the past several years, laser-based inspection technology has been successfully used to improve the quality of safety-critical components used in the aerospace, nuclear power generation and many other high-value, safety-critical applications. Unfortunately, many manufacturers of progressing cavity pumps (PCPs) and positive displacement motors (PDMs) use outdated mechanical gauges and manually operated borescopes in an attempt to ensure the quality of stators.

A major application for PDMs is as mud motors, which are used to drive and steer high performance drill bits during oil well drilling operations. These motors are particularly beneficial because they can be used in directional drilling applications (see Figure 1). However, mud motors are subject to failure mechanisms such as chunking (loss of polymer on the minor diameter), abrasive erosion and swelling. This damage can reduce the efficiency and overall performance of the drilling assembly.

With increasing demands for performance, quality and efficiency, manufacturers and end users are beginning to abandon manually operated mechanical gauges and visual inspection. They are turning to technologies that do not rely on operator experience or judgment. Many manufacturers now use new, automated measurement and

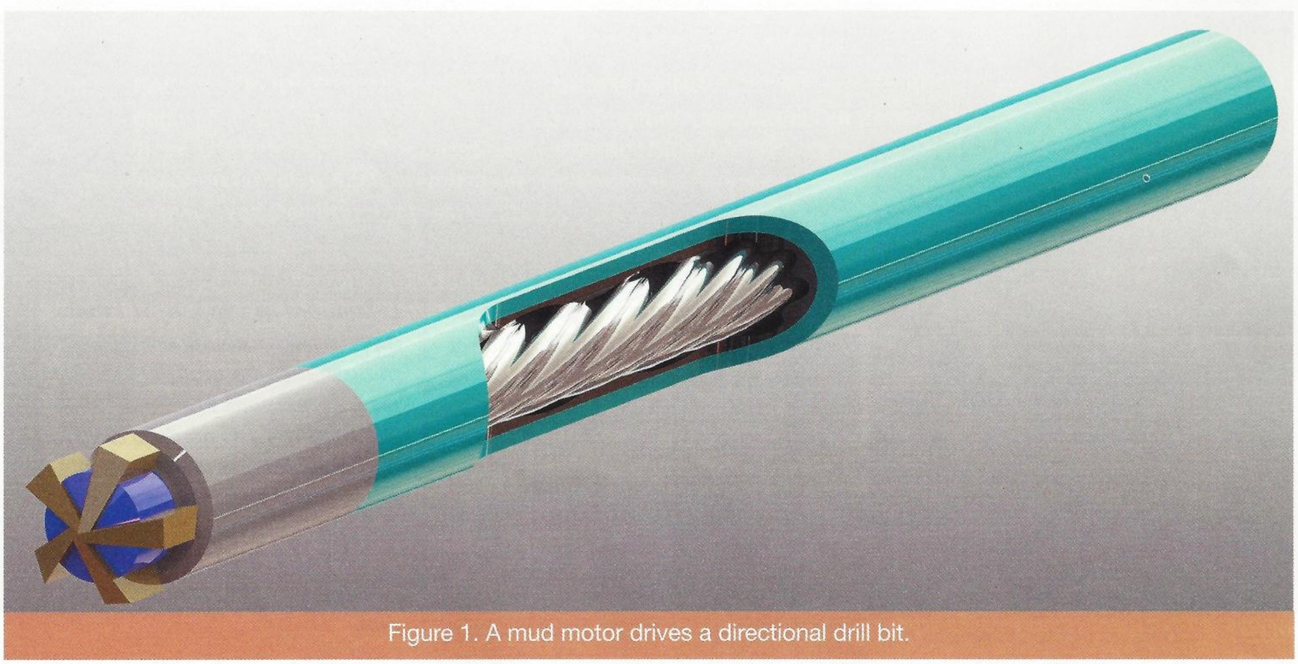
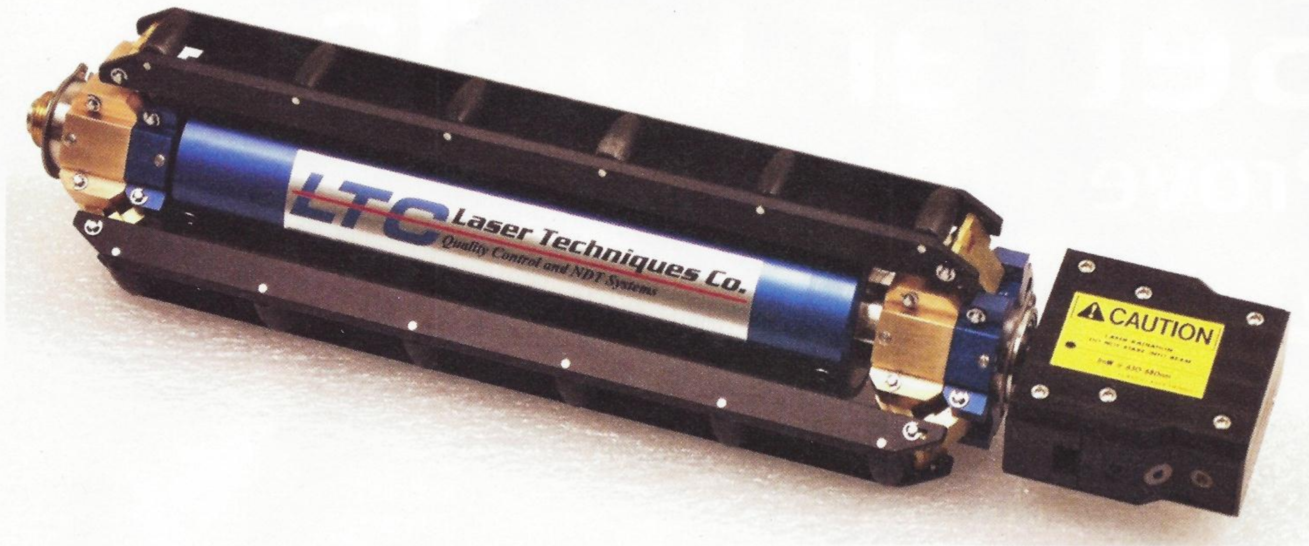


Figure 1. A mud motor drives a directional drill bit.



Laser-based sensors can be used to measure PCP and PDM stators.

inspection technologies such as laser-based bore mapping. The payoff is improved product quality, better performance and efficiency, and reduced product liability.

Dimensional Measurement of Stators

The performance of PCPs and PDMs depends on the precision of the mechanical fit between the rotor and the stator. Dimensional measurement of both PCP and PDM stators is inherently difficult because of the high aspect ratio of the major and minor internal diameters, the helical shape of the interior surface, and the rubber polymer that composes the inner surface.

The polymer material is, of course, slightly compliant when pressure is applied. When a mechanical gauge touches the surface, the material deflects. Therefore, manually acquired measurements tend to be inconsistent and subject to operator experience and "touch." Because of the complex helical geometry of stators, manufacturers are often only able to measure the average minor diameter. Information regarding the major diameter, lobe geometry and flank angle is typically not obtainable.

Recently, a few manufacturers investigated adapting laser-based sensors to measure PCP and PDM stators. Black and often shiny, the stator's internal surface presents a challenge for laser-based sensors. In addition, the large aspect ratio between the major and minor diameters may present significant design difficulties. However, recently developed laser systems overcome the majority of these complications.

The basic operation of a laser-based stator scanner is straight-forward. A tiny laser beam is projected onto the internal surface of the stator. The laser spot size is typically 0.05 millimeter (0.002 inch) in diameter. The sensor head rotates as it is drawn though the length of the stator. The sensor's receiving unit employs the principle of optical triangulation. By sampling at a high rate, the sensor can create a high resolution, three-dimensional data cloud that accurately depicts the internal geometry of the stator. Depending on the application, measurement precision of better than +/- 0.025 millimeter (0.001 inch) can be achieved. The advantages of fully and accurately mapping the internal surfaces of PCP and PDM stators are significant for research and product development, manufacturing process control, and field inspections or maintenance.

Flaw Detection

The process of manufacturing PCPs and PDMs is challenging. Manufacturers often develop proprietary polymers and production methods, and many factors influence the outcome of the process. In addition to attaining proper mechanical tolerances, a wide variety of flaws can dramatically impact a stator's performance. Flaws such as blisters, bubbles and improper knitting of the elastomer are just a few of the many features that can negatively affect performance.

Currently, most stator producers employ borescopes for post-manufacture inspection. Although borescopes will always have a place in the inspection process, they have limitations. First and foremost, borescopes rely on the operator's skill, training and experience to thoroughly inspect the dark internal surface of a stator. Problems with focus, glints and shadows can hamper the inspection process. Finally, visual inspections of stator internal surfaces are subjective. Their outcome relies on an operator's experience, visual acuity and judgment to make decisions that may have major financial and legal repercussions.

By employing high-resolution laser scanning, manufacturers can obtain quantitative three-dimensional (3-D) maps of the entire stator surface (see Figures 1 and 2), which can be used to optimize manufacturing process control. In addition, any anomalies from theoretically perfect stator geometry can be detected, reported and measured. By applying post-processing analysis software, operators can quickly obtain reports ranging from a simple "go/no-go output" to full statistical process analysis. If flaws are detected, reports can be generated that provide the precise location of the flaw and information regarding the geometry, category and magnitude of an indication. An important aspect of the laser-based inspection of stators is the ability to archive every scan file for the life of the stator.

Once fielded, PCP and PDM stators are subjected to a variety of harsh environments. The productivity, efficiency and life expectancy of a stator depend on how well it maintains its original shape and ductility. Failure modes—such as abrasive wear, chemical swelling and explosive decompression—result in deformation of the stator's internal geometry. All these factors can reduce efficiency and, in the worst case, lead to catastrophic failure. Using laser-based technology for the periodic inspection of stators may help operators avoid these failures, which can halt drilling activities, incurring costs and downtime.

Figure 2. 3-D image of progressive cavity pump

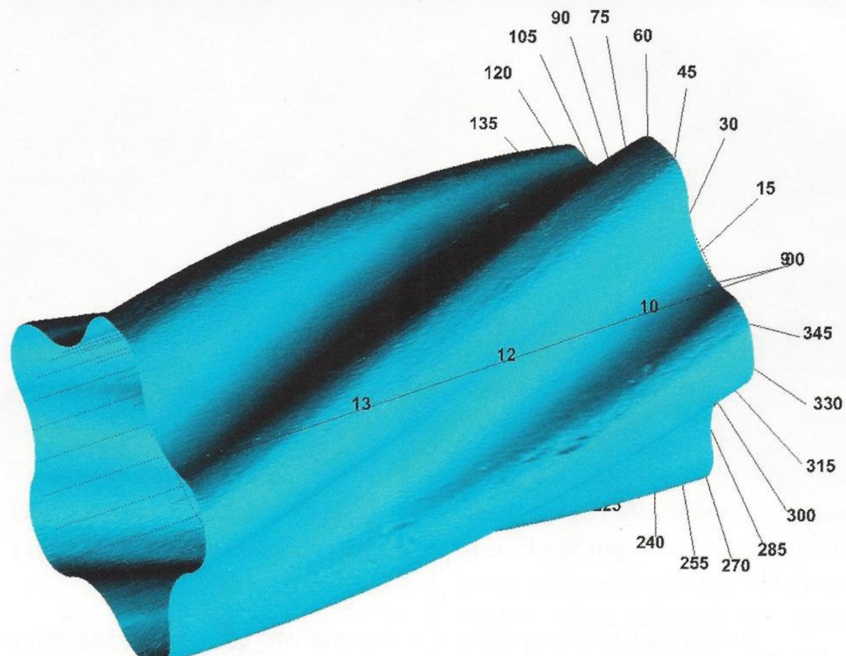


Figure 3. 3-D Image of positive displacement motor

Industry Adoption

Laser-based measurement and inspection technology is widely used throughout many industries. NASA employs it for the inspection of safety-critical oxygen and hydrogen tanks that are used on the International Space Station. The U.S. Navy employs this technology to inspect heat exchangers on nuclear submarines and aircraft carriers. Now, manufacturers of progressing cavity pumps are also adopting laser-based technology for the inspection of their products. The goals are simple: reduce dependence on operator judgment and subjectivity, improve performance and efficiency, and reduce failures in the field.

James Doyle is founder and president of Laser Techniques Company, LLC. He has worked in the field of laser-based measurement and inspection systems for more than 25 years. His systems are used in space, defense and energy applications worldwide. Doyle may be reached at jimd@laser-ndt.com or 425-885-0607.