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# PUMPS & SYSTEMS

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## New Depths of **INNOVATION**



**Surface  
Pumping  
System for  
Oil & Gas  
Applications**

# Scratching the Surface

Neil Ferrier, Wood Group ESP, Inc.

**Technology that was originally developed for down hole applications now finds favor further downstream in surface production, pipeline and processing applications.**

Most product-oriented industries can be divided into four distinct divisions: resource procurement or extraction, transportation or shipping, manufacturing and marketing/distribution (Figure 1).

The American Petroleum Institute (API) classifies the worldwide petroleum (oil and gas) industry into four distinct and separate divisions: exploration and production (or upstream sector), pipeline/transportation (midstream sector), refining/processing (downstream sector) and marketing/distribution (Figure 2).

In the integrated petroleum industry, technology has frequently been developed for a specific application in the pipeline and/or processing sectors, only later to be proven adaptable upstream in the exploration and production (E&P) sector.

This has often been the case with pumping applications associated with positive displacement (PD) and centrifugal split-case (S-C) pumps. Seldom has this worked in reverse, where down hole technology developed for the E&P (or upstream) sector found wide-spread applications in the midstream or downstream sectors of the diverse petroleum industry.

However, over the last several years pump engineers and design consultants have discovered one pump technology, originally developed specifically for down hole applications, that can also provide specific solutions to a wide range of surface fluid-movement applications.

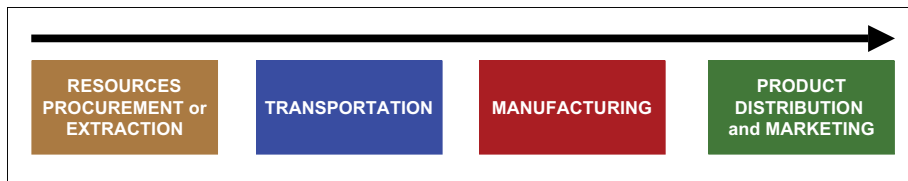


Figure 1. Product-oriented industry horizontal integration.

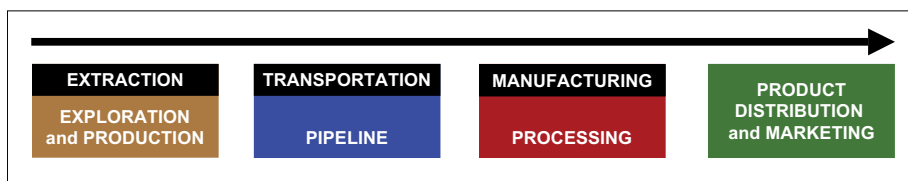


Figure 2. Petroleum industry horizontal integration.

## Down Hole Pump Technologies

In the upstream (E&P) sector of the oil and gas industry, several artificial lift (or pumping) technologies are used to bring down hole fluids to the surface. These include:

- Beam/sucker rod pumps
- Gas lift
- Plunger lift
- Electric submersible pumps (ESP)
- Progressive cavity pumps (PCP)

Of these, ESP systems are the fastest-growing form of artificial-lift pumping technology. ESPs are often considered the high-volume and depth champions among artificial lift systems. By design, they work in some of the most hostile pumping environments imaginable – thousands of feet down hole in vertical, horizontal or highly deviated wellbores; under high temperatures and pressures; producing abrasive fluids; without any opportunity for hands-on maintenance. Operating on a 24/7 basis, they are rugged and reliable.

On a cost-per-barrel basis, ESPs are considered to be both economical and efficient. They require very little surface space and are ideally suited for on and offshore applications.

ESP systems incorporate an electric motor and multistage centrifugal pump unit run on a production string and connected back to a surface control mechanism and transformer via an electric power cable. When other lift systems appear to be over their limit due to well depths creating heavy columns of oil or by large volumes of water that must be pumped-off a well to free gas production, the ESP is usually the system of choice.

Wells deeper than 12,000-ft can be produced efficiently with these pumps, which can be used in casing as small as 4.5-in outside diameter. Production rates range from 2 to 2000-gpm (70 to 64,000-BFPD), and variable-speed drives add pump rate



**Figure 3. Multistage centrifugal pump units consist of stages with rotating impellers and stationary diffusers stacked together to meet the lift requirements for various applications.**

flexibility. Modified equipment and special features allow sand and abrasive particles to be pumped with acceptable MTTF (Mean Time to Failure).

The multistage centrifugal pump units consist of stages with rotating impellers and stationary diffusers (Figure 3) cast from a Ni-resist high-nickel iron containing both abrasion- and corrosion-resistant properties. For severe environments optional tungsten-carbide, radially stabilized, and corrosion-resistant pump materials, including various stage coatings

and diffusion hardening processes, are available.

Depending on down hole conditions, the impeller is mounted on a shaft made of either Nitronic 50, Monel, Inconel or other high-strength alloy or stainless steel.

Due to limited well casing diameters, the lift or head developed by an individual stage is relatively low. This requires stages to be stacked together to meet the lift requirements for various applications. At each stage, the rotating impeller adds velocity to the fluid stream by centrifugal force and tangential redirection at the impeller outside diameter. The stationary diffuser converts this high-velocity energy to pressure as it redirects the flow to the next impeller. Diffusers also act as a bearing surface, providing additional stability to the pump shaft.

## Surface Applications

Pressure to reduce initial capital expenditures, along with the desire to lower ever-increasing maintenance costs and reduce



**Figure 4. Six surface pumps in West Texas, each rated for 800-gpm at 1600-psi with 800-hp motors used for produced water re-injection.**

environmental impact, has encouraged many in the oil and gas industry to evaluate alternative fluid handling technologies for surface applications.

Building on down hole ESP technology, recent surface pumping systems have developed a reputation as a low-maintenance, cost-effective alternative to vertical turbine, split-case and positive displacement pumps in a variety of petroleum and industrial surface fluid-movement applications. These systems feature a direct-drive, multistage centrifugal design ideally suited for most high-pressure, low- to medium-volume and environmentally sensitive applications.

Offering a low surface profile coupled with quiet vibration-free operation, these surface pumps can be electric, gas- or diesel-powered. They can typically handle up to 2000-gpm (64,000-BFPD) and discharge pressures ranging up to 6000-psi. They feature design flexibility that facilitates onsite installation and maintenance with minimal site preparation.

Over the last few years, these surface pumps have proven effective for numerous fluid-handling applications in the petroleum, mining and other industries. In the petroleum industry, for example, these units have been employed for the following surface applications:

- Produced water injection
- Produced water disposal
- Waterflood injection
- Pipeline booster
- CO<sub>2</sub> flood injection/booster
- Crude oil transfer
- Cavern storage pumps
- NGL/propane, ethane, amine and other gas services
- Condensate transfer
- FPSO fluid handling
- Power fluid pumps for downhole jet/hydraulic pumps



**Figure 5. Installation of two surface pumps used to pump methanol to a remote chemical plant via a 4-in pipeline. One pump is rated for 230-gpm at 1100-psi with a 300-hp motor; the other is rated for 330-gpm at 1870-psi with a 450-hp motor.**

The three recent examples that follow show how this down hole technology solved specific surface pumping problems further downstream in the oil and gas industry.

### Water Injection Application

The surface pumps in Figure 4 replaced twelve end-suction and split-case centrifugal pumps. The older pumps were operating in parallel and series, and required a good deal of maintenance and higher combined horsepower.

The six surface pumps operate in parallel and each is able to achieve the total discharge pressure. Five of the six pumps are required to meet the duty conditions and one is on standby. PD plunger pumps were also considered when replacing the old pumps, but the initial cost of the surface pumps was significantly lower.

Additionally, it was determined that the surface pumps would have significantly lower whole-life-cost due to less ongoing maintenance and replacement part costs.

### Pipeline Booster Application

The pumps in Figure 5 were installed to feed methanol into a 4-in pipeline and transport it 35 miles to a remote chemical plant near Corpus Christi, TX. This pipeline operator specified surface pumps because of their low maintenance requirements, the reliability of their single low-pressure mechanical seal, their lower whole-life-cost, and the ability to easily repair or replace the units as needed.

The design of this new installation provided the necessary flexibility related to flow requirements, redundancy and optimum operating pressure.

### Refining/Petrochemical Application

In this Louisiana refinery, wash water that contains H<sub>2</sub>S and NH<sub>3</sub> is re-circulated continuously. One surface pump (Figure 6) replaced two PD plunger pumps, which had routinely required extensive daily maintenance.

Compared to the PD pumps, the surface pump has had virtually zero leakage emissions from the single rotary low-pressure mechanical seal. It has also operated at dramatically reduced levels of noise and vibration as well as with zero pulsation.

Since replacing the PD pumps, there has been infrequent maintenance required. Additionally, the surface pump was supplied within two months of order, compared to the six-to-twelve months offered by alternative pump designs, resulting in greatly improved operation with little down time.

### Conclusion

Recent surface pump technology incorporates the same high-efficiency pumps that have been used for decades in down hole oil wells around the world. Additionally, for almost 20 years,



**Figure 6. A single surface pump, rated for 160-gpm at 3000-psi with a 400-hp motor, installed in a Louisiana refinery on wash-water pump service.**

these pumps have proven to be extremely cost effective and reliable for produced water injection applications.

The latest surface pumps can now handle higher and lower flow rates and pressures, with different material and design configurations to match an increasingly diverse installation base. As a result of successful application in new markets, these pumps are now considered a serious alternative for many services where plunger (triplex, quintiplex), split-case centrifugal, high-speed centrifugal or canned vertical turbine pumps (VTP) were previously employed.

As system design engineers and operators evaluate costs, maintenance requirements, environmental impact, efficiency and flexibility, they are finding more applications throughout many industries where these multistage centrifugal surface pumping systems provide significant advantages.

In many cases, surface pumps now offer inherent advantages of low NPSH, lack of pulsation, product containment, volume and pressure flexibility, and the lack of high-pressure packing glands that help the operator eliminate costly maintenance repairs, nuisance shutdowns, product leakage, piping stresses and man-hour consumption.

Surface pumps are very flexible and can be easily modified to handle a variety of service requirements. Design adjustments to such items as the seal assembly, elastomers and metallurgy are made routinely to accommodate special applications.

**P&S**

*Neil Ferrier is the worldwide engineering and marketing manager of surface pumping systems for Wood Group ESP, Inc., 19416 Park Row, Suite 100, Houston, TX 77084, Phone: 281-492-5163, Fax: 281-492-8107, [www.woodgroup.com](http://www.woodgroup.com), [neil.ferrier@woodgroup.com](mailto:neil.ferrier@woodgroup.com).*