

## Technical problems of mud pumps on ultra deepwater drilling rigs

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### Abstract

The article presents selected technical issues relating to drilling performed by a drillship, one type of drilling rigs. Basic problems encountered in the main function of such rigs – drilling a well – are failures of mud pumps. The authors investigate these pumps in operational conditions, aiming at development of a system for monitoring the technical condition of these pumps. Work on a diagnostic system is in progress that will permit to predict the condition of mud pump valves well in advance.

### Introduction

A drillship is a vessel with own propulsion and dynamic positioning systems. Equipped with a characteristic derrick, it also has all auxiliary apparatus for drilling operations (Fig. 1). The equipment is capable of boring holes in rocky bottom of the sea or ocean.



Fig. 1. A ultra deepwater class drillship, under construction in Samsung Heavy Industries shipyard, Korea [1]

The drillship referred to in this article is of ultra deepwater class, which means it can make wells at a water depth of 3,600 metres and up to 12,000 metres down into the seafloor. These ships are fitted with up to date dynamic positioning systems,

which allow them to keep in position in varying weather conditions (in waves up to 11 metres high and wind speed to 26 m/sec). In extreme allowable conditions, six azimuth thrusters, each with 5500 kW power output, keep the vessel in place.

Figures 2 and 3 depict drilling rigs and their respective sea and subsea depth ranges.

### Drilling systems

Exploration of the seas in search of new mineral deposits brings technical problems associated with the construction and operation of drilling units. The main challenge is that the whole process and tools used have to satisfy the requirements at all times, no matter what type of bottom is encountered. Well drillers can reach increasingly deeper owing to continuous advancements in drilling technologies, including improvements in materials used. Drilling, however, requires that special fluids have to be used for cleaning the drill bits to carry away sediments and pieces of rock etc. The fluid presently used is a chemically treated mud, whose composition depends on, among other things, nature of the bottom where a well is being drilled. Mud is pumped in by high pressure pumps, primary components of the high pressure mud system (Fig. 4).

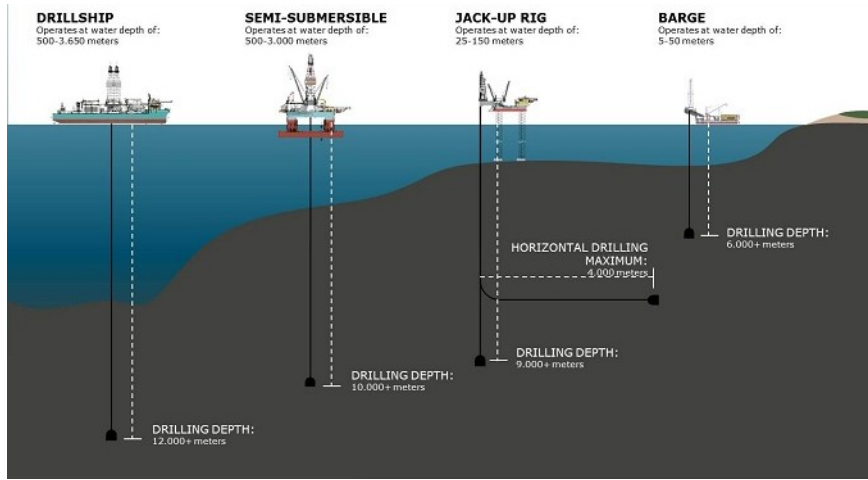


Fig. 2. Types of drilling rigs [1]

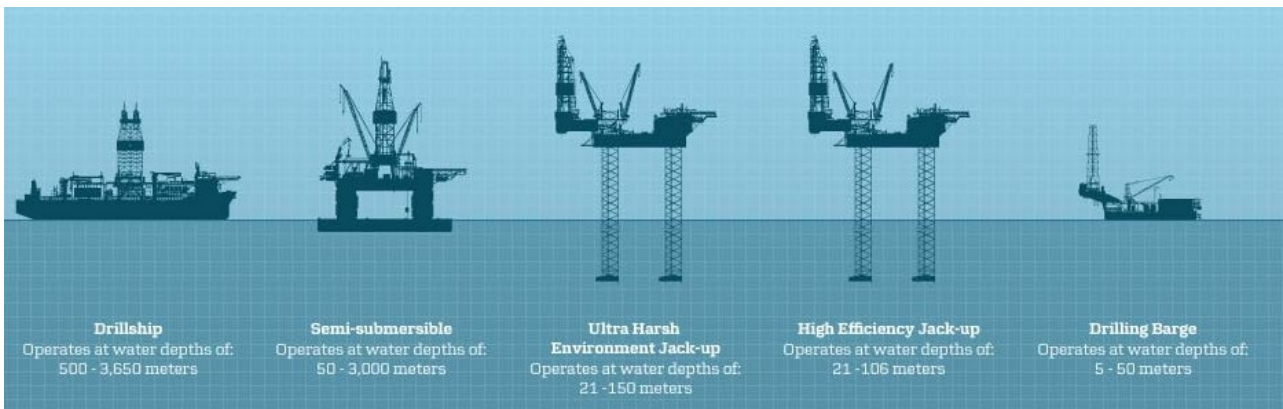


Fig. 3. Types of drilling rigs and their water depth ranges [1]

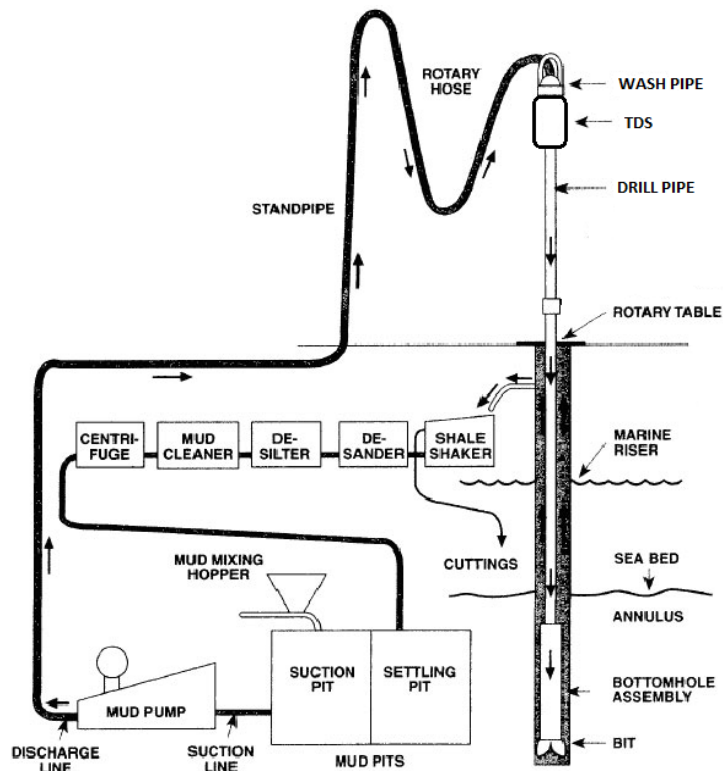


Fig. 4. High pressure mud system used on drilling rigs [2]

## Mud pumps in drilling units

The function of a mud pump used in drilling rigs (Figs 5 and 6) is to exert a specific pressure on mud while drilling is taking place. Mud, in turn, is used for washing away bits of rock and sand produced in the process of crushing caused by the rotation and pressure of the drill bit on the well bottom. Thus formed rock pieces, or cuttings, have to be continuously removed from the drill bit and transferred up to the surface. The mud pump discharges mud under a high pressure through the drill pipe and through a number of nozzles in the drill bit washes away tiny rock pieces under the drill bit. Therefore, the mud pump functions like the “heart” maintaining constant flow of mud under high pressure. Other essential functions of the mud are cooling and lubricating, reducing the weight of the drill pipe, and protecting the unit elements against corrosion.



Fig. 5. A view of the mud pumps section of a drilling rig's power plant



Fig. 6. A view of a mud pump used on drilling rigs; triplex 14-P-220 mud pump made by NOV [3]

Smooth and failure-free operation of mud pumps is crucial. Any stoppage caused by a failure of a key component results in a stoppage of drilling

works. Modern drilling rigs usually have four pumps to assure a stable drilling process. In case of complex wells, three pumps work in parallel discharging mud into the drill pipe, while one is on standby.

A mud pump is a high pressure piston pump of high capacity. The pump referred to in this article is a triplex pump with three single action pistons.

High pressure mud pumps are the main components of the high pressure mud supply system (Fig. 7). Each High Pressure Mud Pump is charge with mud from mud pits at around 0.8–1.0 MPa by Super Charge Centrifugal Pump. On the suction side, suction pressure transmitter is fitted. If suction pressure is not detected HP Pump will be interlocked. Suction, discharge and pump stroke transmitters send signal to Driller cabin for constant monitoring of all parameters. The suction manifold on the pump has dampener and pressure safety valve. Safety valve on suction manifold is set to 0.5 MPa (~70psi). Discharge manifold has pulsation dampener designed to reduce damaging effects of fluid flow pulsations. To avoid over pressurizing the pump on the discharge side the special “Titan BX” pressure relief valve is fitted. Titan valve will open at 50 MPa (7500 psi) to release pressure and give alarm. All High Pressure Mud Pumps has following interfaces:

- MCS – Mud Control System;
- Potable water filling for mud pump auxiliary cooling system;
- Electrical power system;
- Electrical instrumentation;
- Instrument air system;
- Seawater system.

Mud used in offshore drilling is a mixture of liquid substances and chemicals. Mud returning from the well to the pits undergoes a complex operation of cleaning, then it is pumped again down to the bottomhole assembly. Pump elements suffer damage when mud is insufficiently cleaned of cuttings. The frequency of failures strictly depends on the chemical aggressiveness of fluids added to mud. Chemicals improve mud parameters (viscosity, density, ability to rinse out and dissolve contaminants etc.). Chemicals are essential for the well to have the right standard and quality, but in most cases they act aggressively, particularly on elastomer parts of the pumps, e.g. on valve faces (Fig. 8).

Typical faults in mud pumps include wear resulting in increased clearance between the cylinder and piston and damage to suction and discharge valves. The latter, while the drilling is intensive, may become defective every hour or so.



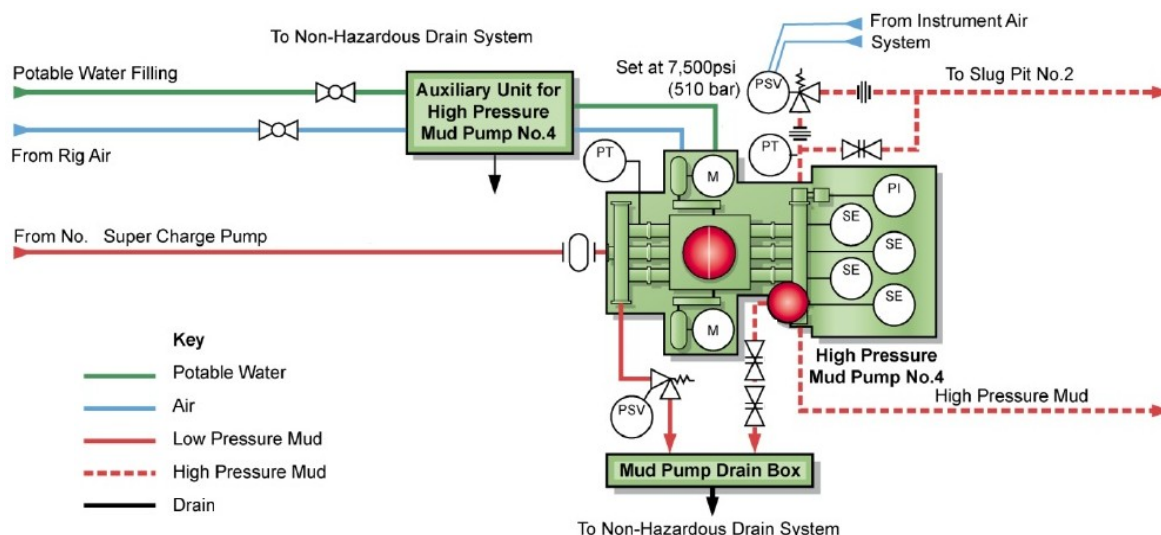


Fig. 7. A diagram of a mud pump installed on a drillship

Leakages due to worn out piston-cylinder units have a symptom, namely contamination of water cooling the cylinder liners (the symptom is visible even if the damage is slight), because water flowing in a closed circulation system returns to a cooling water tank. Defective suction and discharge valves are more difficult to identify, as leaks caused by wash-out are not visible anywhere. They may be detected only in an advanced stage of damage, when maintaining constant discharge pressure becomes difficult. In such cases a pump must be stopped immediately and valve exchanged. The difficulty, however, lies in identifying which valve is damaged or works incorrectly. One of the methods of valve condition assessment include “method by listening”. Unfortunately, these methods are far from accurate, unreliable and require a comparison of acoustic effects from different working units approximately every quarter of an hour.

A mud pump works under a pressure of up to 52 MPa (7500 psi), so this diagnostic method involves risk of operator’s injury [4]. Besides, the room with mud pumps also houses up to eight centrifugal pumps used for other purposes, mixing of mud fluids, therefore, the noise inside the room often makes leak detection impossible.

A failure of a mud pump due to a leaking valve may cause a complete stoppage of the drilling operation, which is particularly dangerous when drilling takes place in the so called hard segments. For a drilling company an hour of suspended work means loss of thousands of dollars.



Fig. 8. Damaged seat and head of a mud pump valve [5]

The authors are doing field research into issues of mud pump valve failures aimed at developing and implementing a system for diagnosing mud pump valves by using high frequency elastic waves of acoustic emission.

Preliminary results indicate with high probability that such system will be capable of detecting an initial stage of valve damage, which will allow pump operators to plan a prompt repair of the diagnosed pump without stopping the entire drilling operation.

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