DESIGN OF AN AUTOMATED DRILLING RIG FOR DSATS DRILLING RIG COMPETITION

A simplistic design for construction of a laboratory scale automated drilling rig for the DSATS Drilling Rig Competition 2017

- Authored by
Kuldeep Chanchalani (B.Tech Final Year)
Palash Dhurvey (B.Tech Final Year)
Jai Mehndiratta (B.Tech Final Year)
Kartikey Mishra (B.Tech Pre-Final Year)
Deepali Gupta (B.Tech Pre-Final Year)

Under the mentorship of:

Prof. Anirbid Sircar,
Director School of Petroleum Technology,
Pandit Deendayal Petroleum University

Abstract

The Drilling Systems Automation Technical Section (DSATS) is a group of SPE volunteers from many nations, connected by their belief that drilling automation will have a long-term, positive influence on the drilling industry. DSATS implemented a student competition to encourage new entrants into the drilling industry who might consider creating and using automation tools and techniques in future drilling programs. The competition brings a hands on approach to the complex, multifaceted problem of drilling systems, expanding the breadth of knowledge and creative thought processes of the individuals who participate. This project challenges students who plan to become petroleum engineers and other students in related disciplines who may not currently think of the upstream drilling industry as a career opportunity. The competition requires university teams to design and build laboratory-scale drilling rigs to automatically drill through a sample of material unknown to the students. This paper presents the Pandit Deendayal Petroleum University Student Team's summary of the proposed rig design, proposed construction and the expected operation of the resultant drilling rig model and how it has created avenues to new learnings in the drilling process.

In the Phase I of the competition for year 2017, the student team has designed a rig that shall drill through the block filled with unknown formations provided by the organizers while dealing with a drill bit and drillpipe chosen to ensure some common drilling dysfunctions. Based on the rig design, the team is looking forward to escalate to Phase II where the team will construct and operate the Rig as per the proposed design. The proposal tends to address the following:

- The Rig Design and Critical Parameters
- The types of sensors to be used
- The cost estimate and the financial support body
- The timeline for the future work

Contents

CHAPTER 1:
Rig Design

Rig Design

- **Rig Substructure**

  The substructure shall consists of 2 parts:

  i) To hold the hydraulic top drive and hoisting system i.e. Rig Mast and provide a table top for drilling operations
  ii) To hold the circulating system assembly and other rig electrical away from the drilling assembly.

  It is a structure which supports the rig mast and elevated from the ground level and provides a space for keeping the drilling sample, it resembles as the Rig floor.

- **Rig Mast**

  Rig mast consists of 4 vertically mounted and connected strut channels to support the top mounted hydraulic piston, pulley system and the AC motor assembly. The top of the mast hold the hydraulic drive assembly in place firmly, the struts also serves as the railing system for the moving block and hence need of extra railing equipment is eliminated.

- **Travelling Block**

  The travelling block shall hold the circulation system, an AC Motor and gear & pulley assembly, it consists of 2 fiber plates with the gear and pulley assembly inside and connected together so as to move on the railing system. A VFD is required to control the speed of the electric motor. A VFD controls the frequency and voltage supply to the electric motors

- **Hoisting System**

  The hydraulic system is considered as a hoisting system for the rig design. It consists of a rotating motor and a pump. The hydraulic system provides accurate control of WOB and consists of less number of moving parts.

- **Circulation System**

  It consists of a simple pump which pumps the fluid (Water) to the bit to lubricate it, cool it and lift out the rock cuttings, the fluids travels from the pump to the rotary sealing system and then to bit, it returns back from annulus and back to the filtration unit and to the pit again.

- **Rotary Sealing System**

  It shall consists of a sealing mechanisms from below mentioned 3 types:

  - **Compression packing**

  These consist of a number of rings manufactured and engineered with specially treated yarns and fibers incorporating additive products, such as lubricants, densifiers, and protection and anti-corrosion agents. These rings are inserted into the annular space between the rotating shaft and housing of the device to be sealed. By tightening the packing gland against the outer ring, pressure is transmitted to the packing set. This expands the rings radially against the side of the stuffing box and the rotating shaft, effecting a seal.

  - **Mechanical seals**

  A mechanical seal consists basically of three components. A rotating component, known as rotary seal ring, a stationary seal ring and a spring. The material typically used for the faces of the rings are for example stainless steel or Silicon carbide. The ring faces are pressed together by the spring. This way the space inside the device is sealed against the environment. ·

  - **Magnetic couplings**

  These couplings work in a very different way. With this type of seal the end of the rotating shaft is surrounded by a containment shell. A cylinder encloses the containment shell, leaving only a small gap between containment shell and the surrounding cylinder. The torque is transmitted by the use of magnetic force.
  After the sealing systems a Lid is provided to act as a surface

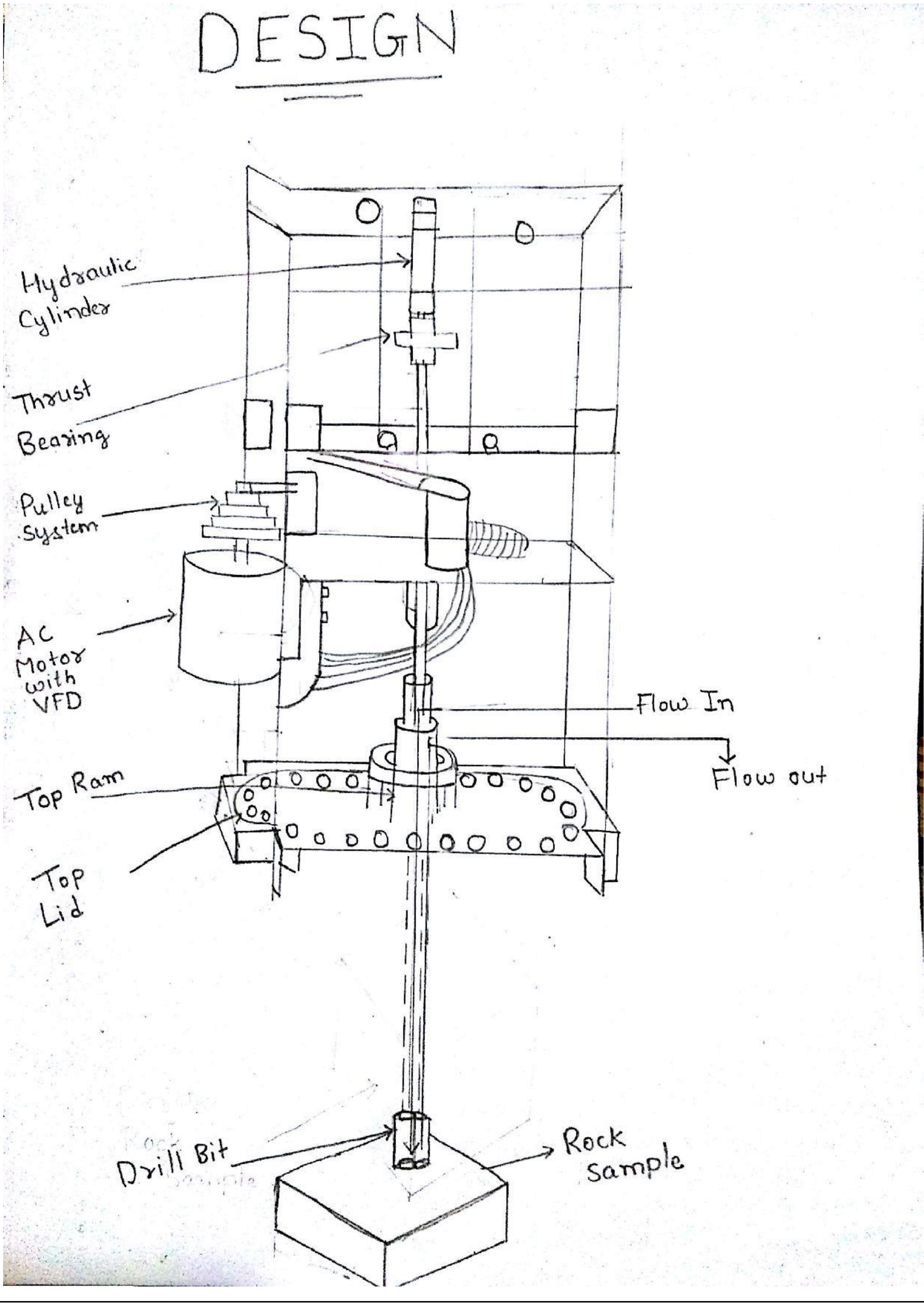

Figure 1: Scheme for the laboratory scale drilling rig

Summary of Rig Design

With the above concept in mind a top lid will be used as a drilling lid. The main shaft will pass through the top hydraulic ram and can handle various bits. The lid will be sealed using a set of extremely heavy-duty rotary seals. The sealing system will also enable circulation of drilling fluid by adjusting a special wide-opening back pressure valve. Employing an electric motor equipped with a Variable Frequency Drive (VFD) along with a system of pulleys and belts, different rotational speeds can be achieved. The Weight on Bit (WOB) will be applied by a hydraulic cylinder located at the very top end of the main shaft: this will exert axial loads. The resulting torque on bit will be measured using a torque and rotary speed sensor which is fitted in the main shaft. A thrust bearing will be fitted between the rotating shaft and the hydraulic cylinder to separate the rotating part from the static part.

CHAPTER 2:
Sensors used for study

Sensors used for study

- **Depth-tracking sensors**

Depth-tracking sensors digitally count the amount of rotational movement as the draw-works drum turns when the drilling line moves up or down. Each count represents a fixed amount of distance traveled, which can be related directly to depth movement (increasing or decreasing depth). Moreover, the amount of movement also can be tied into a time-based counter, which will give either an instantaneous or an average rate of penetration (ROP).

The same digital sensors are attached to the compensators so that any change in movement can be taken into account, allowing accurate depth measurement (**Fig. 2**).

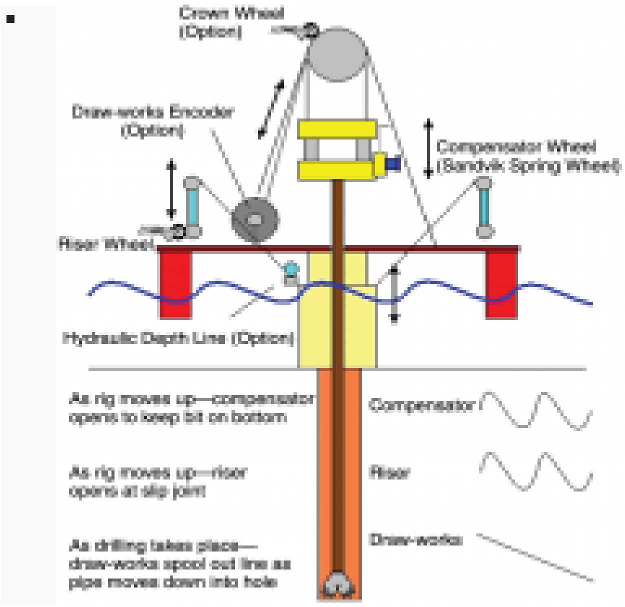

Figure 2: Depth Tracking Sensor

- **Flow-in tracking sensors**

Flow-tracking sensors are used to monitor fluid-flow rate being applied downhole as well as the pump strokes required to achieve this flow rate. Data gathered from these sensors are essential inputs to calculating drilling-fluid hydraulics and cuttings lag.

Two commonly used types are proximity and/or whisker switches. A proximity switch, activated either by an electromagnet (coil) or a permanent magnet, acts as a digital relay switch when it incorporates electrical continuity. An increase in counts will correspond to a specific increase in both flow rate and pump rate.

Figure 3: Flow-in Tracking Sensor

- **Pressure-tracking sensors**

Pressure-tracking sensors are used mainly to monitor surface pressure being applied downhole. Data gathered from these sensors are used either to validate calculated values.

Two types of sensors are available, and both monitor pressure from a high-pressure diaphragm unit (knock-on head) located on either the standpipe or the pump manifold. The first sensor type derives its physical input from mud pressure expanding a rubber (or viton when high temperature is involved) diaphragm within the knock-on head. This expansion proportionally increases the pressure in the hydraulic-oil-filled system and, in doing so, relays the mud pressure to the appropriate transducer

Figure 4: Pressure Tracking Sensor

- **Flow-out tracking sensor**

Commonly called a "flow paddle," this sensor measures flow rate coming out of the annulus using a strain-gauge analog transducer (**Fig. 4**). Changes in resistance values are directly related to either an increase or a decrease in mud-flow rate.

Figure 5: Flow-out Tracking Sensor

- **Load Cell**

The tension/compression load cell was used to provide an indirect measurement of WOB. This cell has a load capacity of 100 lbf. It was mounted between the hoisting cylinder and the travelling block.

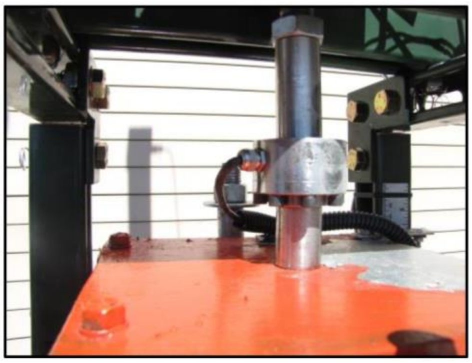

Figure 6: Load Cell

- **Tachometer**

The rotational speed directly affects ROP and drillstring vibrations, which makes it a very critical parameter to ensure a safe and optimum drilling process. An optical RPM sensor was mounted at the travelling block to measure the rotational speed of the crossover sub, which connects the swivel to the drill pipe.

Figure 7: Tachometer

- **Pressure transducers**

  These devices are used for monitoring the pressure response of high pressure hydraulic fluid to be circulated to run the downhole tubulars.

Financial Support Bodies

It is critical to track the total rig construction cost limitations, especially those placed by DSATS automated rig design competition which restrict the rig total costs to $10000 for those teams selected in second phase. Our total cost of the rig design and construction will be very well within the limit as mentioned in the guidelines (Within $10,000).

The major organizations which we are hopeful be funding our project will be

- Office of Research and Sponsored Program (ORSP), Pandit Deendayal Petroleum University
- Society of Petroleum Engineers (SPE) India Section
- School of Petroleum Technology, Pandit Deendayal Petroleum University

We have applied for grants in the above mentioned bodies and we are hopeful that the above bodies will support our project with the confirmation about the same still pending.