ISSN: 2278 – 7798
International Journal of Science, Engineering and Technology Research (IJSETR)
Volume 2, Issue 1, January 2013

DESIGN DEVELOPMENT OF A.C DRAW WORKS WITH VARIABLE FREQUENCY DRIVE

P. SRINIVAS[@] & Dr. B.S.R MURTHY[$]

[@]PG Student, Department of Mechanical, QIS COLLEGE OF ENGG. & TECH., Vengamukkapalem.
[#]H.O.D, Department of Mechanical, QIS COLLEGE OF ENGG. & TECH., Vengamukkapalem

ABSTRACT

An oil rig is structure housing equipment used to drill into underground reservoirs for oil or natural gas. It mainly consists of Mast and Sub-structure, Hoisting and rotating equipments. The hoisting system of an Oil Rig consist of draw works, often called the hoist, the derrick or mast, the crown block, traveling block and the drilling line (wire rope). The system is used to lift drill stem and casing during the process of making hole and lining it the hoist itself is a lifting agent. The draw works is a special purpose winch of an Oil Rig, which is used for drawing in and out, the casing piping, drill bits and other equipment used in the exploration of oil.

"The latest state of art technology & equipment" available at B.H.E.L would enable, realize enormous savings in terms of energy consumption, reduced fatigue levels to operating staff, automated evaluation of potential risk to the drilling equipment From the preliminary data collected, the power factor of the drive can be maintained above 0.7 even at lower speeds- implying that the reactive power is reduced to a large extent when compared to the DC motor drive where in the power factor falls as low as 0.35. Another aspect of the VFD is that the speed of the motor can be maintained at 0 RPM to infinite time without hazard of potential damage to the internals. Another important aspect of AC Motors is that the power consumption would be proportional to the requirements as seen from the power factor value of 0.7 min. The same is not the case for DC motors – The motors would burn out in a short span of time. Variable frequency drive has advantage of increased speed range at constant voltage. The present work envisages new hybrid fuzzy controller for a direct torque control. Hence, to overcome the above problems, an attempt has been made in this project for the design and development of AC Draw works with variable frequency drive system. The main objective of the design modification of AC Draw Works is to increase the efficiency by replacing the chain and sprockets with gear box, with a view to make the system compact and also to reduce its cost and weight. The design of the draw works would follow from the basis of existing design prilimarily, with marked changes resulting by the application of AC power load with varying torque speed parameters. The footprint of the draw works is conceptualized to be comparatively smaller, which would call for improved materials.

1. INTRODUCTION:

Man's custom of digging holes into the earth is believed to be as old as civilization itself. One can reasonably suppose that his need for drinking water would have caused pre-historic man to scoop out depressions in streambeds, in search of water during a dry spell. With the development of better hand tools, such depressions or holes would be deeper and deeper.

An oil rig is structure housing equipment used to drill into underground reservoirs for oil or natural gas. The term can refer to a land-based structure, or a marine-based structure (oil platform) commonly called an ' Offshore Oil Rig' . While marine-based rigs can drill through the ocean bottom for oil or natural gas, the technology and economics of under-sea is not yet commercially viable.

Basic principles in digging a hole in the earth are:-

1. Break up the earth in digging by using a bit with downward thrust.
2. Removal of the cuttings from the hole by using continuous stream of fluid.

The oil rigs are mainly of two types viz.,

1. On-shore rig: It is meant for drilling on land

2. Off shore rig: It is meant for drilling on seas and oceans.

In the year 1975-76 B.H.E.L was started to manufacture of oil rigs with the co-ordination of United States Of America Manufacture range of B.H.E.L oil rigs includes

E-760- capable of drilling up to 3,650 Meters.
E-1400-capable of drilling up to 4,900 Meters.
E-2000-capable of drilling up to 6,100 Meters.

Modern rotary drilling rigs many hundreds of tons of drills stem or casing by using a principle of physics utilized thousands of years ago. The earlier hoist, windlass, was a simple horizontal drum around which rope was wound. Men turned the drum with a crank and were able to lift loads much heavier than they ordinarily could have. As demands for lifting heavier loads increased with the passage of time, men began looking about for power much greater than human strength to turn the drum for early rotary drilling; they used steam engines for this power. At present they use diesel engines and electric motors but the basic principle of gaining mechanical advantage in doing the work of lifting continues to lie at the basis of hoisting.

The hoisting of an Oil Rig consist of draw works, often called the hoist the derrick or mast, the crown block, traveling block and the drilling line(wire rope) the system is used to lift drill stem and casing during the process of making hole and lining it the hoist itself is a lifting agent. It consists of

1. A large revolving drum around which the drilling line is spooled.

2. A series of gears, clutches, brakes, chains and pulley to transmit and control power.
3. A car shaft on which cat heads and often a sand reel are mounted.
4. The driller's control.

Because the draw works is a very expensive part of drilling rig equipment, each component is to be constructed with greater accuracy and what it does so that they can operate and maintain it well. The basic part of draw work is a strong rigid frame work that can be readily moved from one rig side to another. Frame works are designed by manufacturers to with stand large twisting and bending load put upon them during drilling they must have been made to confirm tow laws regarding size for movement on high ways, large draw works are split in halves main drum on the front half transmission and the cat shaft at the back besides the frame work the draw work include transmission drum brakes cat shafts and control its auxiliaries include cat heads sand reel and auxiliary brakes sometimes it has a connected counter shaft to drive the rotary table power for running the draw works comes for the rigs prime mover meaning its basic power size more rigs used internal combustion engine as prime movers. Their power is transmitted by means of a component of a mechanical drive rig. On a electrical drive rig their power drive generator which in turn power electric motor to run the various electric parts of the rig.

Hence, an attempt has been made to design and development of A.C. Draw works with variable frequency drive, focusing at optimum efficiency, wide range of speeds, low cost, compact, and maintenance free with optimum life of AC draw works. All the parts of the winch viz, drum, drum shaft, bearings and supporting plate are designed using analytical formulae and results are presented.

Jan Artymiuk [1] A new concept drilling hoisting systems 2006 proposed two new designs from the conventional hoisting system. The first one is the Maritime Hydraulics A.S RamRig© drilling concept, based on hydraulic cylinders as actuators powered by up to 3.4 MW of hydraulic power in a closed loop hydraulic system The second is a new land rig concept based on a patented rack & pinion drive system with a new generation of rigs which can instantly switch between the work over, drilling and the snubbing operations. Finally it is concluded that RAM RIG Drilling Concept, developed and designed by the Maritime Hydraulics, is found to have many technical advantages compared to a conventional drilling concept, which will lead to a field development of cost savings when applied. This concept gave raise to a reduced number of moving parts, and operations on the drill floor and none in the ram structure will result in: a lesser maintenance, safer working environment, and a reduced crew. Ahmed A.Walid[2] etal, Modeling and Simulation of an Active Heave Compensated Draw-works. Proposed that, a hydro-mechanical concept comprising the main components of the draw-works and hoisting rig were modeled. Ankit Verma[3] Alternate Power And Energy Storage/Reuse for Drilling Rigs: Reduced Cost And Lower Emissions Provide Lower

Foot Print for Drilling Operations Researched on alternate drilling energy sources which can make drilling process economic and environmentally friendly **Stephen** Kangogo Cherutich[4] Rig Selection and Comparison Of Top Drive And Rotary Table Drive Systems For Cost Effective Drilling Projects In Kenya. 2009 Proposed that the depth capacity of the rig is determined by the rating of draw works, mast and mud pumps. In this paper A.C. Top drive rigs with a high degree of automation used. Akpedeye[5] Advancement On Drilling Technology In Petroleum Industry explained a new drilling technique that can be applied by petroleum and gas industries to optimize drilling practices and hence, production. This research work briefly outlines the first petroleum and gas drilling techniques and follows the trend to today's methods in a chronological order

2. THEORY

Draw works (winch) is a mechanical device that is used to wind up a rope or wire rope (also called cable). In its simplest form it consists of a spool and attached crank. The spool can also be called the winch drum.

Fig.2.1 Winch

More elaborate designs have gear assemblies and can be powered by electric, hydraulic, pneumatic or internal combustion drives. Some may include a solenoid brake and/or a mechanical brake or ratchet that prevents it from unwinding.

Besides industrial applications (e.g.in cranes), winches are used for towing cars, boats, or gliders. There are several winches on almost every boat or ship where they are used to pull anchor or mooring lines, halyards, and sheets.

The rope is usually stored on the winch, but a similar machine that does not store the rope is called a capstan. When trimming a line on a sailboat, the crew member turns the winch handle with one hand, while tailing (pulling on the loose tail end) with the other to maintain tension on the turns. Some winches have a "Stripper" or cleat to maintain tension. These are known as "Self-tailing" winches.

Winches are frequently used as elements of backstage mechanics to move scenery in large theatrical productions. Winches are often embedded in the stage floor and used to move large set pieces on and off.

2.1 WORKING DETAILS OF DRAW WORKS

A fully redundant draw works is provided with two complete and totally independent systems for controlling and powering the drum and drum shaft of the draw works. Each system broadly comprises least one source of power(e.g., a motor or engine), a power transmission means, preferably of the gear or chain type, and some means of

mechanically coupling the power source, transmission and drum shaft together. Each system may also be provided with a brake means, such as one or more disc band, electric or water-cooled brakes. In the event that any component of either system fails, the fully redundant draw works still have the ability to raise drill pipe from a borehole and thus avoid the risk of a "Stuck" drill pipe. This unit is known as "DRAW WORKS". The name has come from the basic function of the equipment –it draws, i.e. it is a Hoist. Draw works is the king pin of rotary rig. The draw works is a hoist of special design, which performance a no. of essential functioning rotary drilling operations. Its brand name, model or nominal capacity is often used to designate or identify the particular rig size of which is a part. A draw works for use with a drilling rig, comprising: a mounting base; a left gear transmission assembly secured to the mounting base and having a collector gear drive and a first and a second multiple-speed gear transmission, the collector gear drive being coupled to the first and second multiple-speed gear transmissions; a right gear transmission assembly secured to the mounting base and having a collector gear drive and a first and a second multiple-speed gear transmission, the collector gear drive being coupled to the first and second multiple-speed gear transmissions. Electrical draw works are available in 4 models. Covering a drilling depth range from 2100 meters to 9000 meters. The models E-3000,E-2000,E-760 are based on field prove OIL WELL design where as the E-1400 has been developed for the intermediate range depth.

The motors have an ABS-approved design and are engineered from the same concepts used for GE'S freight locomotive traction motors. The motors' heavy-duty frames absorb the high torque and pounding of drilling conditions. Form-wound winding with Class H insulation and double-VPI application provide superior protection from voltage spikes. A high- strength, rotor assembly, including copper-chromium-alloy rotor bars and brazed end-turns, increases the rotor assembly's reliability and life. The low-inertia rotor enhances draw-works performance with responsive acceleration, reduced breaking time and less wasted energy.

Fig. 2.1.1 Complete Layout of AC Draw Works

The major design objectives for all the models of Draw Works are

1. EFFICIENT POWER TRANSMISSION: Ensured by use of simple power flow system utilizing alloy steel shafts, roller bearings, hardened sprockets and oil bathed chains.

2. REDUCED SERVICE TIME: Achieved through easy accessibility of lubrication points. Brake adjustment and inspection covers.

3. HIGH RELIABILITY: Ensured by maintaining optimum compatibility of all components plus ample reserve capacity of clutches and brakes

3. OIL RIGS

The oil rigs mainly classified as 4 types

1. Deep drilling rigs
2. Mobile rigs
3. Work over rigs
4. Desert rig

3.1 DEEP DRILLING RIG

The drilling range for the Deep drilling rigs will be 3500-9000m. They are classified into 4 types.

E-760(3600m)

E-1400(4900m)

E-2000(6100m)

E-3000(9000m)

Fig.3.1 Deep Drilling Rig

3.2 MOBILE DRILLING RIGS

The range of drilling depth is 2000-3000m. The mobile rigs are classifieds into 3 types.

- SM-450(1500m)
- M-750(2000m)
- M-900(3000m)

Fig.3.2 Mobile Rig

3.4 WORK OVER RIG

The range of drilling depth will be 3500m to 6000m. They are of two capacities.

1. 450-S (5500m)
2. M-500 (6100m)

Fig.3.4 Work over Rig

3. 4.DESERT RIG

The range drilling depth for this type of rig will be 3500 m to 4000m.

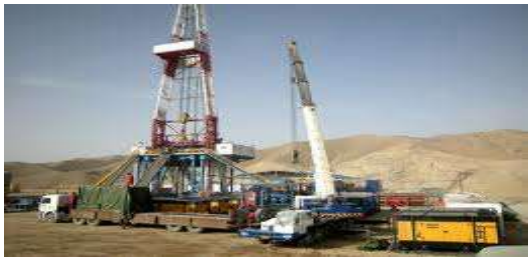

Fig.3.4 Desert Rig

4. FORMULATION FOR DESIGN OF A.C. DRAW WORKS

The design is carried out for the various parts of the Draw work viz., Drum, drum shaft, bearing and housing plate. Each DRAW WORKS comprising of VFD Controlled AC motor powered. The complete draw works mounted on heavy duty oil field type skid with accessories suitable for drilling oil/gas wells to depth range 6000 Mts with 5" drill pipe.

4.1 SPECIFICATIONS:

Rated Horse Power: 2000 HP Minimum

Drive Motors: Two AC motors, each of 1400 HP intermittent rating explosion proof motors.

No. of Drums: Single

Drum size: 32"x56"

Grooving: Grooved for 1-3/8" casing line.

Hoisting speed: Direct gear drive

Brake: Two 60" or above diameter Air cooled Disk Brake with Locking device

Inertia Brake: Locking device.

Auxiliary brake: Regenerative type braking system.

Crown & Floor Saver system:Electronic system for preventing accidental hitting of crown blocks or rig floor by the travelling block and pneumatic crowno-matic type crown saver system

4.2 DRUM

The drum is the heart of the hoisting system. It spools up and lets out drilling line, raising or lowering the traveling block and thereby getting the job of hoisting done.

Fig. 4.2 Wire Wounded Drum

Modern drums vary in size, depending on the depth rating of the drilling rig. The diameter must of course be larger for greater lengths of drilling line. The cylindrical surface is grooved for efficient spooling; a wedge shaped device at the flanges eases the line over for its return wrap. The flanges are wide to accommodate the mechanical brake bands that cover them. Elements of the drum that receive the greatest wear are flame hardened for durability.

Output= efficiency * input

The torque available at the motor is

$$P = \frac{2\pi NT}{60}$$

Torque acting on the drum $T = \frac{60P}{2\pi N}$ N-m

The maximum shear stress due to the torsional load is given by

$$\tau_{max} = \frac{\tau yt}{factor\ of\ safety} = \frac{\sigma yt}{2 * factor\ of\ safety}$$

The bending stress due the weight of Rotary, Swivel, and drill bit is given by

$$\sigma b = \frac{32M}{\pi[D^3 - d^3]}$$

Then, the maximum shear stress due to BM and TM according to Maximum Shear stress theory is given by

$$\tau max = \frac{1}{2}\sqrt{\sigma b^2 + 4\tau^2}$$

But

$$\tau max = \frac{16}{\pi[D^3 - d^3]}\sqrt{M^2 + T^2}$$

$$\tau max * \frac{\pi}{16} [D^3 - d^3] = \sqrt{M^2 + T^2}$$

As a thin cylinder

$$f = \frac{pd}{2t}$$

$$p = \frac{maximum\ \ load}{lateral\ \ surface\ \ area}$$

$$\text{Circumferential stress} = \frac{yield\ \ stress}{factor\ \ of\ \ safety}$$

For thick cylinder

Circumferential or hoop stress for internal pressure zero and external pressure pr

$$fr = -p_R[\frac{2R^2}{\sqrt{R^2 - r^2}}$$

4.3 BEARING

Spherical bearings are designed to manage high radial loads and perform consistently, even when misalignment, marginal lubrication, contamination, extreme speeds and critical application stresses are present. The selection of the bearing is given by

Vertical component is w_{cv}=wcos16=w_{dv}

Horizontal component is w_{ch}=wsin16=w_{dh}

Equivalent Dynamic Load rating,

$$P = V[XF_r + YF_a]$$

Then the life of bearing can be calculated as

$$L = [\frac{c}{p}]^k \text{ mr}$$

$$L_{mr} = 60\ N L_h$$

$$\text{Static Load Rating, } C = P\left(\frac{L}{10^6}\right)^{1/K} \text{ mr}$$

4.4 SHAFT DESIGN

The shaft design used in draw works is through shaft. For design the shaft is assumed as simply supported beam with uniformly distributed load. Torque is being transmitted to shaft by gear which will be further transferred to hollow drum fitted on this shaft and hence this shaft happens to be the crucial member of total assembly in transferring the torque.

$$T_e = \sqrt{M^2 + T^2}$$

$$\tau max * \frac{\pi}{16} * d^3 = \frac{1}{2}\sqrt{\sigma b^2 + \tau^2}$$

4.5 PLATE DESIGN

This part of the design happens to be the supporting plate to the whole housed parts in draw works. The number of plates is two placed on the either side of shaft assembly which will take up the loads equally. As the total unit of draw works is mounted on the supporting plates the thickness of this part is considered and design of this part is carried out assuming it to be a simply supported beam.

Inertia at point A $i_A = \frac{-Wl^2}{16EI}$

Deflection of the beam y= $\frac{wl^3}{48EI}$

5. RESULTS AND DISCUSSIONS

5.1 RESULTS

From the above design calculations the dimensions of the various parts presented.

Dimensions of the drum D = 812.9 mm

d = 802.6 mm

t_d = 5.15 mm

Diameter of the Drum Shaft D_s=275 mm

Bearing No. Selected 23236E1A.M (SKF)

Plate thickness t = 40 mm

5.2 DISCUSSIONS

Considering the hollow drum by taking both the torsion and bending load the inner diameter of the drum is 802.6 mm and the thickness is 5.15 mm. the drum being hollow, to calculate its thickness considering the drum as thin cylinder we got a thickness of 0.42 mm and when we considered it as a thick cylinder the calculated thickness is 0.42 mm as this thickness is very less for the drum to sustain the on coming loads so we are neglecting this thickness. From the above results the thickness is taken as

5.15 mm

The diameter of the shaft is obtained as 275 mm

The radial load and axial load acting on bearing is 0.24 MN and 0.06 MN so we are considering spherical roller bearings as it can take heavy radial loads and small axial loads.

The spherical roller bearing of higher dynamic capacity than the calculated value i.e., 23236E1A.M(SKF) bearing is selected.

For plates the deflection is 0.06mm for 40 mm thickness

As the thickness assumed is between the safe limits we are considering the plate to be safe.

6. CONCLUSION

As discussed earlier the main objective of change and development of some of the features in existing E-2000 draw works, which is been now operated by chain driven system (had 6 different speeds only) is replaced by a gear driven system(16 speeds)

Here changes are made to minimize the cost factor and maintenance cost, thereby making the system compact, reduces its weight when compared.

The design has been modified and the final analysis of AC draw works shows that the AC draw works is within the designed limits. The dimensions of the drum shaft and the spool drum and the deflection of the housing plate is acceptable. The modified design carried out for E-2000 Oil Rig with the required features has been evaluated.

7. BIBLOGRAPH

1. *Jan Artymiuk* A new concept drilling hoisting systems 2006
2. Ahmed A.Walid etal, Modeling and Simulation of an Active Heave Compensated Draw-works.
3. Ankit Verma Alternate Power and Energy Storage/Reuse for Drilling Rigs: Reduced Cost and Lower Emissions Provide Lower Foot Print for Drilling Operations
4. Stephen Kangogo Cherutich Rig Selection and Comparison Of Top Drive And Rotary Table Drive Systems For Cost Effective Drilling Projects In Kenya. 2009
5. Akpedeye Advancement on Drilling Technology In Petroleum Industry.
6. Joseph E Shigley "Mechanical Engineering Design", 6/e, Tata Mc Graw Hill
7. R.S.Khurmi & Gupta, " A text book of machine design", fourteenth edition S. Chand's & company ltd, New Delhi.
8. Data book by PSG College of Engineering, Coimbatore.
9. SKF bearings catalogue, (TIMEKEN).
10. Oil Rigs catalogue, B.H.E.L.
11. S.Md Jalaluddin, "Design of Machine Members"- vol-1 second edition-2002, Anuradha agencies, Kumbakonam.
12. Pandya & Shah, "Machine design Fifteenth edition, Chariton Publisher's ltd.,".