"DESIGN AND DEVELOPMENT OF BORE WELL PUMP LIFTING MECHANISM''

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Abstract: This paper discusses about a mechanism designed for lifting and installation of Submersible Pump attached to a HDPE (High Density Poly Ethylene) pipe. Lifting of the bore well pump is very difficult and time consuming process. The machines available in the market for bore well pump lifting are very large in size and more costly. This mechanism is compact in size, cheaper and requires less labor. This paper also includes designing of various components and manufacturing processes.
Keywords – Submersible Pump, HDPE Pipe, Tyres, Induction Motor etc.

1. INTRODUCTION

Bore well is the very popular and major water source in India for domestic as well as agriculture fields. The bore well drilling is carried out with the available highly cost machine. The average size of bore well drilling in India varies from 2 to 5 inches. But after the bore well drilling, it requires number of components to lift the water.

The components required may be bore well casing pipe, submersible water pump, water lifting pipes, electric cables, starter and many more. One of these component i.e. Bore well motor pump has a great importance and its installation in the bore well after drilling is a major task.

For this installation procedure we required specially designed mechanisms and machines. It also requires labour in the major number to carry out this whole process.

Now a day's number of labour required are reduced by automation of some of the activities involved. But the operating cost of these big machines are high with great initial investment. After some successive working days of bore well Submersible pump, its maintenance should be done for its proper working. For that we have to lift that pump again, necessary actions are to be carried out and again we have to reinstall that pump successfully. These both procedures installation as well as lifting of bore well submersible pump are very time consuming and requires large number of labour to carry out. There are several machines and mechanisms available to carry out these processes, but the major problem is that there operating cost is high. Due to the large size of the machines, they are unable to work in the restricted space.

2. METHODOLOGY

Methodology of Design and Development of Bore Well Pump Lifting Mechanism is stated as below:

i. Survey

Survey of various HDPE pipe diameter, submersible pump, and their respective weight is done. Through this survey maximum diameter of pipe and maximum weight of pump is considered during design.

ii. Design:

Designing of various component such as shaft, bearing, total torque required for mechanism to pull the pipe up is calculated. Factors required for selection of motor are also calculated.

iii. Manufacturing:

Frame is manufactured with Mild Steel (C45) using the electric arc welding.

iv. Purchasing:

The standard components are purchased. The components are geared motor, bearing, shaft, tyres, chain drive and hydraulic jack.

v. Assembly:

The purchased components according to design specification are assembled on the frame.

3. DESIGN

The following assumptions are taken from the survey.

To find the total weight to be lifted by the mechanism:

Depth of bore well=400 Ft. (Assumed)
Diameter of the pipe =3 inches (Assumed)
Tyre Specification:
Considering smallest tyre available in the market,
Radius of tyre (r) =0.0762m
Width of tyre =0.0489 m
Weight of pipe for 3 inches diameter =0.7411 Kg /ft
∴Total weight of pipe for length of 400 ft = Weight of pipe*Length of Bore well
=0.7411*400
=296.44 Kg
≈297 Kg
Considering the submersible pump weight=41 Kg
∴Total weight =Total weight for pipe + Weight of Submersible pump

=297+41
∴Total weight =338 Kg
By considering weights of Cable and Rope connected to the submersible pump
∴Total weight to be lifted = 400 kg

To find the force required to lift the submersible pump:

F= 400*9.81
=3924 N
Torque required to lift the submersible pump (T):
T=F x r
=3924*0.0762
T =299 N-m
T ≈300 N-m

For finding the speed of the tyre:

Assuming linear velocity of pipe to be lifted (v):
v=0.04 m/s
Knowing that,
v=rω
Where,
ω=angular velocity of tyre (rad/s)
r=radius of tyre (m)
∴ $\omega = \frac{v}{r}$
$\omega = \frac{0.04}{0.0762}$
ω=0.52 rad/s
Also, $\omega = \frac{2\pi N}{60}$
Where,
N=speed of the wheel in rpm
∴$N = \frac{(60*\omega)}{2\pi}$
∴$N = \frac{(60*0.52)}{2\pi}$
N=5 rpm

DESIGN OF COMPONENTS

Design for Shaft:

Total Force = 3924 N
Force acting on each tyre (Shaft) = $\frac{3924}{3}$
=1308 N
Coefficient of Friction of tyre (μ) = 0.33
Now, for calculating the frictional force (F_1)
F_1=1308*0.33
=431.64 N
Finding torque for the frictional force F_1:
T=F_1 x r
=431.64*0.0762
=32.89 N-m
T=32.89*10^3 N/mm^2
Using Mild Steel material (C45), the properties of C45 material is as follows:
S_{yt}=330 N/mm^2
S_{ut}=600 N/mm^2
According to A.S.M.E code, Maximum shear stress (τ_{max}) is calculated as:
τ_{max} =0.18 S_{ut}
=0.18*600
=108 N/mm^2
τ_{max} =0.3 S_{yt}
=0.3*330
= 99 N/mm^2
Selecting the minimum value of τmax
τ_{max} = 99 N/mm^2
$\frac{\tau max}{R} = \frac{T}{J}$
Where, R= Radius of shaft
T= Torque of the shaft
J= Polar moment of inertia
$\frac{99}{\frac{d}{2}} = \frac{(32.89*10\text{^}3)}{(\frac{\pi d\text{^}4}{32})}$
d=11.91mm
For safety we are selecting the shaft diameter d =16mm
As per the available gearbox, the output shaft of the gear box has the diameter of 20mm

Design of Bearings

Selecting bearing 6302 (single row deep groove ball bearing) as per the diameter of shaft 16mm:

1. Checking Static Load (C_o):

P=XFr + YFa

Where, P= equivalent static load

Fr= radial force

Fa= axial force

Due to no any axial loading on the bearing, the axial force is given as:

Fa=0

Force acting on the shaft:

Fr =1308 N

From manufacture's catalogue,

X=0.56, Y=0

P = 0.56*1308

P = 732.48 N

From manufacture's catalogue, static load for bearing number 6203 is given as:

Static Load (C_o) =5400 N

$\therefore P<C_o$

Therefore, it can be concluded that, the design is safe for Static Load

2. Checking for Dynamic Load

As, mechanism is used intermittently

L_{10h}=4000-8000 hours

$L_{10}=\frac{(60nL10h)}{10\text{^}6}$

$=\frac{(60*5*8000)}{10\text{^}6}$

L_{10}=0.24 million revolutions

$C=P*(L_{10})^{1/3}$

$=732.48*(0.24)^{1/3}$

=455.197 N

From manufacture's catalogue, the dynamic load for the bearing number 6203 is given as:

C=11400 N

Therefore, it can be concluded that, the design is safe.

Selection of Induction Motor

The power of a motor can be calculated by the formula:

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

$=\frac{2\pi 5*800}{60}$

=156.55 W

=0.20 HP

According to available gear box, we are selecting 1 HP motor

4. MANUFACTURING

Frame

Fig.4.1. Frame structure

Specifications of the frame are as below:

Material: Mild Steel

Size: 560*560 mm

Height: 510 mm

Ring diameter: 6.5 inches

Sliding bar diameter: 16mm

Base of the tyres: 6*2 inches

Weight of the frame: 35Kg

Welding: Electric Arc Welding

5. CONSTRUCTION AND WORKING

Construction:

The mechanism is an electro-mechanically operated mechanism, where the power supply is given to a 3-Phase Induction Motor. The induction motor shaft is internally connected to a two stage worm wheel gear box. The power is transmitted from gear box to a fixed shaft through a chain drive. The three tyres are mounted on a frame at 120° to each other. One tyre is mounted on the fixed power transmitted shaft and the other two tyres are kept movable on the sliding bars of the frame. In these two sliding tyres, one tyre is connected to a hydraulic jack with a cross sliding mechanism ; and the other tyre is free to slide on the sliding bars, which can be fixed at any position by the nut bolts mounted on the base of the tyre. The hydraulic jack is fixed on the frame. The actual model is shown in below figure.

Fig. Actual Model

Working

The figure shows the actual model of the mechanism. The three tyres are arranged in 120^0 to each other. In which one of the tyre is connected to the motor-gear box shaft with the help of the chain drive, one tyre is fixed to the frame and the remaining tyres are kept movable for adjusting the distance between the tyres according to pipe diameter. For maintaining pressure on the pipe hydraulic jack is attached to the movable tyre. The HDPE pipe is to be suspended between the three tyres. As 3-Phase electricity is supplied to the motor, motor with worm wheel gear box starts rotating, the tyre connected to the output shaft of gear box with the chain drive also starts rotating. This results in the vertical movement of the pipe. Another two tyres will support the pipe and maintain the pressure on the pipe and also rotates with vertical movement of the pipe. The worm wheel gear box also helps in one directional motion of the shaft. The figure below shows the actual working model.

Fig. Actual Working Model

6. CONCLUSION

The bore well pump can be lifted easily by using Bore Well Pump Lifting Mechanism. This mechanism helps in reducing human effort required for lifting the pipe manually. The cost of bore well pump lifting mechanism is low as compared with other machines available in market. This mechanism is compact in size, thus it can be easily used in restricted areas.

7. FUTURE SCOPE

The bore well pump lifting mechanism can be modified in various aspects for reducing its size, weight and cost. Following modifications can be done with the bore well pump lifting mechanism:

i. The Induction Motor can be replaced with higher Horse Power for increasing lifting capacity.

ii. The worm wheel gear box can be replaced with helical gear box, for increasing the efficiency of the bore well pump lifting mechanism.

iii. Mounting wheels at bottom of the frame can help in easy transportation of the mechanism.

iv. The breaking mechanism can be applied to the mechanism for reducing the risk of falling down pipe in the bore well.

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