# Design And Fabrication Of Lift Using Helical Rack And Pinion Arrangement

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***Abstract-*** *This paper involves helical rack and pinion arrangement with simple gear train which is operated by means of the handle. The torque first which is given to the Primary rotating Shaft that having Primary gear wheel. The Secondary shaft having another gear wheel and the primary torque is transmitted to this shaft by the help of meshing with primary gear wheel. Here, Both the gear wheel shafts meshed with helical pinions at each side. Due to the rotation of pinions which are already contact with gear wheels of both shafts, the helical rack moves up and down (vertical movement) that is contact with respective pinions. The helical gears that are employed in this project having heavy load carrying capacity. And the rollers are fixed at the bottom.So that we can move to any place.*

***Keywords***- Helical rack and pinion, Lift, Simple gear train.

## I. INTRODUCTION

A Rack and pinion gear system is composed of two gears. The normal helical gear is the pinion gear and the straight helical gear is the rack. The rack has teeth cut into it and they mesh the teeth of the pinion gear. Rack and pinion arrangement establish greater feedback and steering sensation. Awelldesignedmechanism such as the rack and pinion gear save effort and time. The rack and pinion which is used to convert between rotary and linear motion. Rack and pinion can convert from rotary tolinearorfromlinearto rotary. The diameter of the gear determines the speed that the rack moves as the pinion turns. Rack and pinion are commonly used in the steering system of cars to convert the rotary motion to the steering wheel to the side to side motion in the wheel. A rack and pinion consists of a pinion engaging and transferring motion to or from a special kind of spur gear,called a rack, consisting of a series of teeth in a straight line on a flat surface.The rack and pinion changeslinear motion into rotary motion, or vice versa the rack and pinion is used to convert between rotary and linear motion. Rack and pinion can convert from rotary to linear or from linear to rotary.

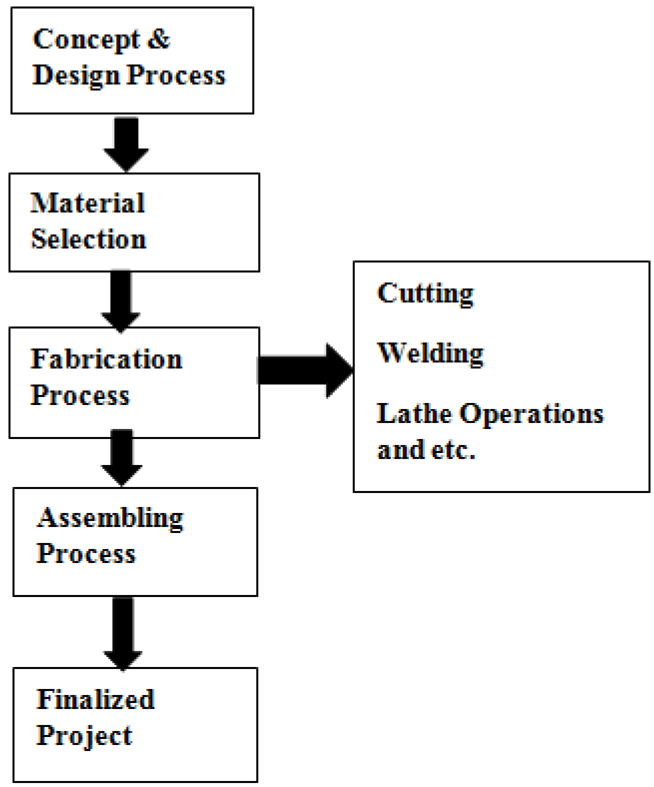


Fig 1. Methodology Flow Diagram

## II. EXPERIMENTAL SETUP

It consists of two helical racks and pinions with simple gear train. And also having radial ball bearings for supporting shafts. Main concept involved in this paper means rotary motion is converted into linear motion.In Starting, the power is given to the Primary rotating shaft by rotation of handle. The primary rotating shaft consisting of Primary gear wheel and Helical pinion.Secondary rotating shaft also consist of another gear wheel with 2nd pinion gear(helical). After supplying torque to the Primary shaft, that torque is transmitted to the Secondary rotating shaft by meshing of gear wheel tooth. Because of using two gear wheels in our project is to obtain the opposite direction of rotation. Here, Gear wheels are act as power transmitting medium between one shaft to another. Next, due to the rotation of the both shafts with rotating gear wheels, pinions are also rotates corresponding to the rotation of primary and secondary gears and pinions are already coupled with another each shaft for both sides of simple gear train. SoWhen the shaft rotates, the pinions will also rotate with same torque. The helical rack which is placed in vertical position and also meshed with the tooth of the pinions (both Primary and Secondary side). This pinion's rotation makes the helical rack mechanism to lift upward and downward as per the direction of given torque because meshing of rack tooth with pinions.

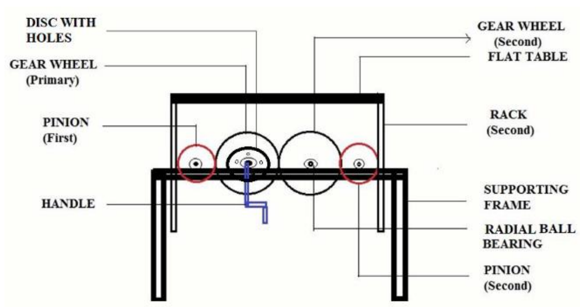


Fig.2 Line Diagram of Lift

## III. DESIGN CALCULATIONS

**A. Design of Helical Gear :**

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

= $\frac{2\times\pi\times50\times500}{60}$

= 2.6 kw

Speed,n = 50 rpm (Assumed)

$Z_1$ = 20

Gear Ratio,i = 1.5

Pressure Angle = $20^0$

Helix Angle = $20^0$(For Helical Gear)

E = 2.15$\times 10^5$ N/$mm^2$ (P.S.G: 8.14 Table)

**Step: 1 Gear Parameter**

Gear Ratio,i = 1.5

**Step: 2Selection of Material**

Both Pinion and gear- C45 Steel
(Mild Steel)

**Step: 3Gear Life (N)**

Assume, T= 20000 hours

N= 60nT (According to PSG.Pg:8.17)

N= $60 \times 10^7$ Cycles

**Step: 4Calculation of Initial Design Torque[$M_t$]**

[$M_t$]= $M_t \times K \times K_d \times K_o$ (PSG.Pg:8.15)

$M_t$= $\frac{60\times P}{2\pi n}$

= $\frac{60\times2.6\times10^3}{2\pi\times50}$

= 496.5 Nm

K.$K_d$=1.3 For a symmetric Scheme(PSG.Pg:8.15)

$[M_t] = 496.5 \times 1.3 \times 1.5$

= 960 Nm.

**Step: 5Calculation of E, [$\sigma_b$] &[$\sigma_c$]**

1. E = 2.15$\times 10^5$ N/$mm^2$ (PSG.Pg: 8.14)
   (Gear and Pinion are same material)
2. [$\sigma_b$] = Design Bending Stress

[$\sigma_b$]= $\frac{1.4K_{bl}}{nK\sigma} \times \sigma_{-1}$ (PSG.Pg: 8.18)

$K_{bl}$ = Life for Bending

(For HB> 350 & N = 6$\times 10^7$ Cycles)

$K_{bl} = \sqrt[9]{\frac{10^7}{N}}$ = 0.819 (Tab.22)

$K_\sigma$ = 1.5 (Tab.21) Pg.8.19

n = Facto of Safety (Steel- Cast-No H.T)

n = 2.5 (Tab.20)

Endurance

Limit($\sigma_{-1}$)= 0.35$\sigma_u$+120 (PSG.Pg.8.19)

$\sigma_u = 34$ N/$mm^2$(300 to 700) For CS 45

($\sigma_{-1}$) = 0.35 (340)+120

= 239 N/$mm^2$

. [$\sigma_b$]= $\frac{1.4(0.819)}{2.5(1.5)} \times$ 239

= 73.076 N/$mm^2$

3. [$\sigma_c$] = Design surface (Contact Compressive stress)

[$\sigma_c$] = CR.HRC.$K_{cl}$

CR= Co-Efficients (For CS 45) Tab.16 Pg; 8.16

CR = 230

HRC Surface Hardness- 40 to 55(Pg.8.16)

HRC = 45

$K_{cl}$ = Life factor for surface strength

(Steel > 350-(25 $\times 10^7$) Table .19

$K_{bl} = \sqrt[6]{\frac{10^7}{N}}$ = 0.741

[$\sigma_c$] = 230$\times$ 45 $\times$ 0.741

= 7.66 N/$mm^2$

**Step: 6Calculation of Centre Distance(a)**

a $\geq$( i+1)$\sqrt[3]{(0.7/\sigma_c)}$ 2$\times$E [$M_t$]/i$\varphi$

$\varphi$ =0.3(Open type gear) Pg.8.14 .Tab.10

a $\geq$( 1.5+1) $\sqrt[3]{(0.7/937.3)}$ 2$\times$2.15$\times 10^5$

[948$\times 10^5$ ]/1.5 $\times$ 0.3

a $\geq$ 47.896

a $\geq$ 50 mm

**Step: 7Find$Z_2$**

$Z_1$ = 20

$Z_2$ = i $\times Z_1$ = 1.5$\times$ 20 = 30

**Step: 8Calculation of Normal Module [$M_n$]**

$M_n = \frac{2a}{(Z1+Z2)} \times \cos\beta = \frac{2(48)}{(20+30)} \times \cos 20^0$

$M_n$ = 2(Preferred Module) PSG.Pg.8.2

**Step: 9Revision of Centre Distance (a)**

a = $\frac{M_n}{\cos\beta} \times \frac{(Z_1+Z_2)}{2}$

a = $\frac{2}{\cos 20} \times \frac{(20+30)}{2}$ = 52.5mm

**Step: 10Calculation of b,$d_1$,$\varphi_p$**

Face width,b = $\varphi \times$ a =0.3$\times$ 52.1

=18.69 = 20 mm

Pitch diameter of pinion ($d_1$) = $\frac{M_n}{\cos\beta} \times Z_1$

= $\frac{2}{\cos 20} \times 20$

= 43mm

Pitch Line Velocity= $\frac{\pi d_1 n_1}{60}$ =$\frac{\pi}{60}$ $\times$43$\times 10^3$ $\times$50

= 0.11 m/s =$K_d$

$\varphi_p = \frac{20}{43}$ = 0.465=K

$d_2$ = m$\times Z_2 = 2 \times 30 = 60\ mm$

Revised,[$M_t$]= $M_t$ $\times$K.$K_d$

$K_o$= 496.5$\times$0.465$\times$0.11$\times$0.5

[$M_t$]= 51.6= 52 Nm

$\sigma_b = \frac{i+1}{amby}$ [$M_t$]

=$\frac{i+1}{52\times 2\times 20\times 0.389}$ $\times$52$\times 10^3$

$\sigma_b$= 58.16 N/$mm^2$

$\sigma_c = \frac{0.74(i+1)}{a}$) $\pm\sqrt{i+1/_{ib}}$ $\times$ E [$M_t$]

$\sigma_c = \frac{0.74(1.5+1)}{40}$) $\pm\sqrt{1.5+1/_{1.5(20)}}$ $\times$ 2.15$\times 10^5$

[52 $\times 10^3$ ]

$\sigma_c$=49.78 N/$mm^2$

$\sigma_b$< [$\sigma_b$]

$\sigma_c$< [$\sigma_c$]

Compressive Stress for Mild Steel= 250 N/$mm^2$
(Ref: R.S.Khurmi)
49.78N/$mm^2$ < 250 N/$mm^2$
Hence, Our Design Is Safe.

**B. Design of First Shaft:**

Length of shaft,L = 450mm
Diameter of shaft,d = 25mm
Diameter of gearwheel,D = 68mm = 0.68m
Pressure Angle,$\alpha = 20^\circ$

Torque to be transmitted ,T = m $\times$ g $\times$ 0.5

T = 40 $\times 9.81 \times$ 0.5

T = 196.2Nm

Max Shear stress,$\tau$ =16T/$\pi d^3$ = 180 .7 N/ $m^2$

Tangential force on the gear ,$F_t = \frac{2T}{D}$

= $\frac{2\times 196.2}{0.068}$

= 5770.5N

Normal load acting ontooth ofgear,W = $\frac{F_t}{\cos\beta}$

= $\frac{5770.5}{\cos 20^\circ}$

= 6140.8N

Bending moment at the centre of the gear, M = $\frac{WL}{4}$

= $\frac{6140.8(0.450)}{4}$

= 690.84 Nm

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

=$\sqrt{(690.84)^2+(196.2)^2}$

= 718.16Nm

= 718.16 $\times 10^3$ N

Allowable stress For Mild steel= 250 N/m$m^2$

180.7 N/m$m^2$< 250 N/$mm^2$

Hence, Our shaft design is safe.

**C. Design of Second Shaft:**

Length of shaft,L=390mm =0.39 m
Diameter of shaft,d= 20mm
Diameter of gearwheel,D=45mm=0.045m
Pressure Angle ,$\alpha = 20^\circ$

Torque to be transmitted ,T = m $\times$ g $\times$ 0.5

T = 40 $\times$ 9.81 $\times$ 0.5

T= 196.2 Nm

Max Shear Stress,$\tau$ =16T/$\pi d^3$= 15.90 N/m$m^2$

= $\frac{2\times196.2}{0.045}$

=8720N

Normal load acting ontooth ofgear,W = $\frac{F_t}{\cos\beta}$

= $\frac{8270}{\cos 20^{\circ}}$

=9279.6N

Bending moment at the centre ofgear,M = $\frac{W\,L}{4}$

= $\frac{9279.6(0.39)}{4}$

= 904.76 Nm

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

= $\sqrt{(904761)^2 + (196.2)^2}$

=904.76$\times 10^3$ Nm

= 904.76 $\times 10^6$ Nmm

15.90 N/m$m^2$< 250 N/$mm^2$

Hence, Our shaft design is safe.

## IV. PARTS DIAGRAM USING SOFTWARE

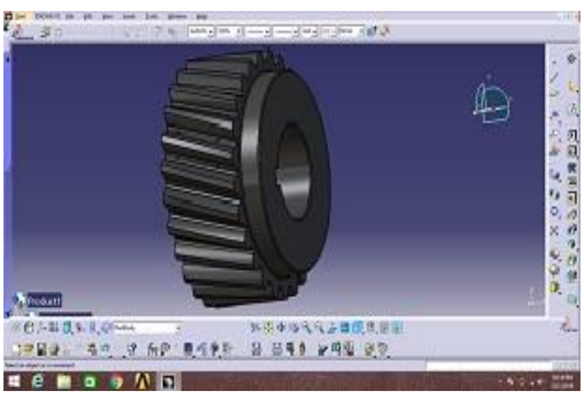

Fig 3. 3D Diagram ofHelical Gear by CATIA

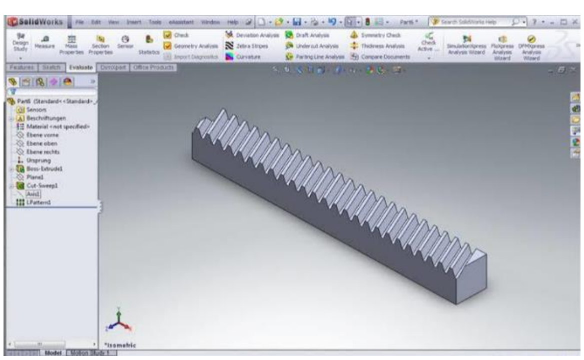

Fig 4. 3D Diagram of Rack by SolidWorks

Fig 5. Experiment Picture

**Fabricated Parts**

a. Helical Rack and Pinion
b. Frame
c. Handle
d. Shaft

## V. CONCLUSION

Therefore to conclude, we have designed and fabricated Rack And Pinion Lift using helical gears and design calculations are done perfectly. Helical Rack and pinion mechanism isintroduced in lifting mechanism. Since we came in to a contradiction that the installation of a lift is not an easy task and high installation cost. As compared with the other lifting mechanism, helical rack and pinion lift mechanism does not need any separate machine rooms. Well designed Helical Rack and pinion lift are more load carrying capacity when compared to spur rack and pinion mechanism because In Spur rack and pinion mechanism, only one teeth will be mesh. But In helical rack and pinion mechanism, more than one number of tooth ( two or three ) will be mesh. So it will raise the load carrying capacity than Spur gear mechanism.

## VII. ACKNOWLEDGEMENT

I express our sincere thanks to HOD and Assistant Professors in Department of Metallurgical Engineeringfor their excellent guidance that inspired to the very height of sincerity leading me all the way to reach the goal.

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