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Design And Fabrication of Six Speed Constant Mesh Gear Box

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***Abstract* - All the automobile vehicles available are always set to changing speed and torque between engine and driving wheels. Torque is not directly changed but it can be done in the form of power using a suitable device. It is a very useful method that we adopt, and it is also easily affordable. Many other alternative, even though more elegant, and appear to be more effective are not feasible when it comes to transmission. This project mainly focuses on the design and fabrication of a gear box that can transmit torque to the maximum and also helps to do some useful work in automobile where power transmission is a major factor. The transmission of power is done in six speeds in this project. The setup uses two shafts and thirteen gears arranged in suitable distances to achieve the desired torque and speed.**

Key words: Gear, Shaft, Dog clutch, Ball bearing, lever.

1.INTRODUCTION

The present day world is moving towards globalization. Now to keep at par with the global market, the countries follow a different set of standards.

The main purpose of these standards is to make a product available, in every nook and corner of the world with exactly the same specifications without any single change.

The standards are being adopted in each and every field of technology and science. These changes, especially in automobile next to the clutch are the transmission in the transmission system of a motor vehicle. The word 'transmission' is used for a device that is located between clutch and propeller shaft. The device used for the transmission is Gear Box.

2. PURPOSE OF THE GEAR BOX

- The purpose is to provide high torque at the time of starting, accelerating and pulling load. When vehicle is starting a high torque is required at the driving wheels.
- Hence a device must provide to permit the engine crank shaft to revolve a relatively high speed, while the wheels turn at high speeds. This is obtained by a set of gears called a transmission or gear set. The gear set is enclosed in a metal box called a Gear Box.
- It helps to reduce the engine speed in the ratio of 4:1 in case of passenger cars and in a greater ratio in case of Lorries.
- It helps the turning of drive around 90 and to drive driving wheels at different speed.

3. THE WORKING OF 6 SPEED CONSTANT MESH GEAR BOX

The six speed constant mesh gear box has two shafts , one for the input and the other for output. Six gears are mounted on both the shafts and are in constant mesh. Ball bearings are connected to the gears on the output shaft which makes them to rotate freely on the output shaft.

The output gears have extensions on one side for the engagement purpose. The clutches are engaged and disengaged with the gears by the use of levers. The clutches are keyed to the output shaft. The engine flywheel is connected to the input shaft.

The gears on the output shaft rotate freely on the bearings. Inorder to engage the dog clutch with the gear the respective lever is moved. This moves the clutch towards the gear and the dog gets engaged with the extensions on the gear. The rotation is transferred to the output shaft. The wheels connected to the output shaft are also rotated.

4. DESIGN PROCEDURE

4.1. DESIGN CALCULATION

PINION

C45 steel

$\sigma_{u} =$ 630MPa HB=215

GEAR:

C45 steel

$\sigma_{b} =$ 210 MPa $E=2.15 \times 10^5$ N/ mm^2

[DATA BOOK Pg No. 8.4, 8.5, 8.14]

GEAR RATIO

i = 1.4

NUMBER OF TEETH

Teeth on Pinion: 38

Teeth on Gear: 54

TANGENTIAL LOAD

Power to be transmitted = 1.5 KW

Input speed =750 rpm

K_o =1 (steady load) $F_{t=}$(P/V) K_o

$F_{t=}$ [(1500)/[(∏m(38)(750)/60 x10^3]] x 1

V=[∏d1N1/(60 x 10^3)]

Ft = 1005.16/m V=[∏mZ1N1/(60 x 10^3)]

INITIAL DYNAMIC LOAD:

[C_v – From Data Book PgNo. 8.51]

$F_{d=}$ F_t xC_v Assume $V_{m\,=}$ 3 m/s

$V_{m<}$ 10m/s F_d=(1005.6/2) x 2

$C_{v\,=}$ (3+Vm)/3 F_d=(2011.3/m)

$C_{v=}$2

BEAM STRENGTH:

[F_s from DataBook PgNo. 8.50]

s=[σ_b] by∏m [σ_b = σo/3]

[σ_b]= [(σ_u)/3] = 210mPa

[y-From DataBook PgNo.8.50]

b=10m [Assumption]

y=0.154 – (0.912/z_1) = 0.13

[Take 20° INVOLUTE]

F_s=[210 x 10m x 0.13 x ∏ x m]

F_s=[857.22 m ^{2}]

EVALUTE

F_s = F_d

857.2 m^2= 2011.3/mm=1.32

Standard Value

m=1.5 mm

[From Data Book PgNo.8.2,Standard Value]

Face value, b =15 mm

Pitch diameter, d= 57mm

Velocity, v= 2.237 m/s

4.2 RECALCULATED BEAM STRENGTH

[F_s = From Data Book PgNo.8.50]

F_s= [210 x 15 x0.13 x ∏ x 1.5]

F_s=1928.47 N

ACCURATE DYNAMIC LOAD

F_d= F_t+[21V (b_1F_t)]

F_t={p/V}=670.54

b=15mm

V=2.237 m/s

Assume Carefully Cut Gear:

e=0.025

[e- From Data Book Pg 8.53 Table 42, m upto 4]

c=296.5

F_d=670.54 + [(46.977(51118.04))/46.977+71.54)]

F_d=2699.19 N F_d> F_s

Design is not safe

Assume precision Gear:

e=0.0125

[e- From Data Book Pg 8.53 Table 42, m up to 4]

c=148.25

F_d=670.54 + [(46.977(2894.29))/46.977+53.79)]

F_d=2019.844 N F_d> F_s

Design is not safe

D_1=57mm

Q=2i/(1+i)=[(2 x 1.42)/2.42]=1.173

[From Data Book PgNo.8.51]

B=20 mm

K=[((σ_1)^2)sin 20)/1.4] x [(1/(2.15 x 10^5))+ (1/(2.15 x 10^5))]

[From Data Book PgNo.8.51]

[σ_c] = Contact compressive stress

[Data Book PgNo.8.16]

HCR -48[scale]

[Data Book PgNo.8.38]

HB –460[Case hardened]

[Data Book PgNo.8.16]

K_{c1}=1[life <10 ^{7}rpm]

[Data Book PgNo.8.17 Table 17]

$[\sigma_c]= C_r$ HRC K_{cl}

=256 x 48 x1

12720 kgf/cm^2

1272 N/mm^2

$K=[(1272)^2)\sin 20)/1.4]$ x $[(1/(2.15 \times 10^5))+ (1/(2.15 \times 10^5))]$

K=3.67

F_w=57 x 1.173 x 3.67 x 20

F_w=40907.59N

$F_d= F_w$

Design is Safe

Basic Dimensions:

MODULE m=1.55mm

FACE WORTH b=20mm

TEETH

$Z_{1=}$ 38 $Z_{1=}$54

PITCH DIAMETER

$d_{1=}$ 57mm $d_{2=}$ 81mm

CENTER DISTANCE O=69mm

TOOTH DISTANCE H= 3.375mm

4.3 DESIGN PROCEDURE FOR BEARING

SHAFT DIA: 10 mm

Bearing No: SKF 6200*[from DataBook PgNo.4.13]*

ISC NO: 10BCO2

Inner Dia: 10mm

Outer Dia: 26mm

Width: 9mm

Life required for Bearing: 1 x 10^7 rev

Dynamic capacity $C= (L/L_{10})^{(k/p)}P$

Equivalent Load $=P[XF_r+YF_s]S$

[L10 =1mr K=3vfor Ball Bearing from Datebook]

$F_r=[2M_t/D]$ $M_{t=}[(P \times 60)/2\prod dN]$

$F_r=[(2 \times 27.13 \times 10^3)/81]$ $M_t=227.13 \times 10^3$ N mm

P=Power =1.5 x W

d=57mm

N_1=Initial Speed

N_1=750 rpm

N_2=75001.42 = 528 rpm

F_t=670.8N=F_a

$F_r=F_t$ ton 20

F_r=243.81N

F_a/F_r=2.75

For bearing no:skf 6200

C_o=2240N

F_c/C_o=(670.8/2240)=0.299

F_c/C_o=e=0.299 Fc/Fr>e

[from databook Pg No:4.4]

X=0.56 Y=1.1608

S=service factor

[databook Pg No:4.2]

S=1.3[Rotary m/c with no impact]

P=[0.56x243.8+1.1608x670.8]1.3

P=1189.75 N $C=(L/L_{10})^{1/k}p$

$C=(1 \times 10^7/1 \times 10^6)^{1/3} \times 1189.75$

C=2563.23 N C=256.32 Kgf

As dynamic load ratio for SKF6200 bearing is c=400 kgf

The selected bearing SKF6200 is safe

SKF6200

D=10mm D=26mm

B=9mm allowable speed=20000 rpm

4.4 DESIGN OF SHAFTS:

Shaft-engine shaft

N_{min}=750 rpm

$M_t=Px60/2\pi$ N

$=1.3x10^3x60/2x\pi x750$

$=19.10x10^3$ Nmm

$P_t=2M_t/D$

$=2x19.10x10^3/38$

=1065.7 N

$P_n=P_t/\cos 20$

=1069.7

M_b=PnL/4=1069.7x100/4

Mb=$26.742x10^3$ Nmm

$Mt_{eq}=\sqrt{Mb^2+Mt^2}$

$Mt_{eq}=32.86x10^3$ Nmm

$T=16Mt/\pi d^3=55$

$=16x32.86x10^3/\pi\ d^3$

D=14.49mm

D=16mm

N_{HW}=529 rpm

Mt=$27.09x10^3$ Nmm

p_t=[(2x 27.09x103)]

$p_n=(P_t)/\cos20$=1067.7 N

$M_b=(P_n$ x L)/4 =26.09 x 10 ^{3}Nmm

M_{tor}= 38.031 Nmm

T=[(16Mb)/ πd^3]

55=[(16x 38.03 x 10^3)] d=15.21 mm

D=16mm R_{20} Series DataBook

5. FABRICATION PROCESS

The material for shaft and gear are taken as C 45 steel. The gears and the shafts are fabricated in the following method.

Gears

Machining, drilling and boring

These operations where done in gears at centre to produce hole in the gears to hold on the shaft.

Shafts

Turning-These operations are done in lathe for the shaft in which the cylindrical objects may be produced. With the work piece rotating and single point cutting tool

Welding-This sort of operation is done to fix the gears onto the shaft.

Assembly

After machining the components, they were assembled.

- At first, the gears are mounted on the shafts as a preliminary process the two dog clutches are mounted on the shaft. One in the input shaft and another in the output shaft.
- For the rigid support of gears on the spline shaft a bearing is provided over a dog clutch.
- The bearings are fixed to the mountings on the shaft.
- The gear shift lever is fixed, in the assembly for engaging gears.

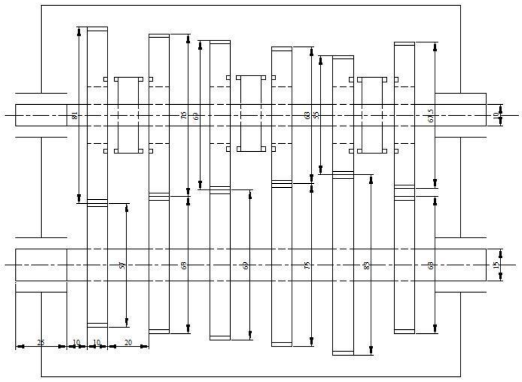

Fig. 1 CAD Model of Six speed constant mesh Gearbox

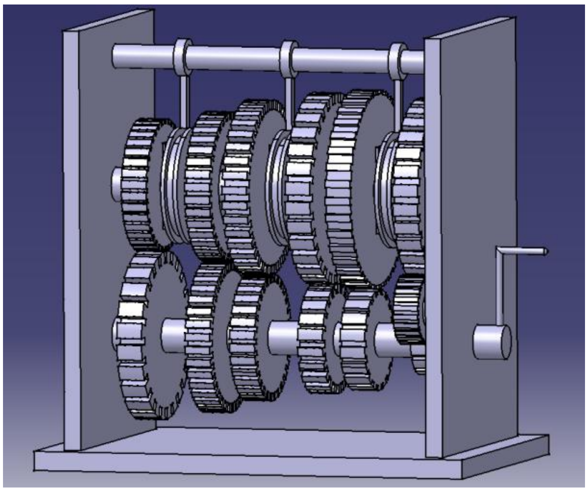

Fig. 2 CATIA Model of Six speed constant mesh Gearbox

CONCLUSION

Although there are much advancement in the field of designing and fabrication of gear boxes, the constant mesh gear box is one of the most efficient gear boxes. The Project was an exposure to the world of practical working knowledge. It gives us an opportunity to apply the theories studied in the curriculum in a practical situation. It also gave an opportunity to know the practical difficulties that arise in the process of designing and fabrication. A gear box can also be designed and fabricated for 4, 8, 12, 16, etc as per the requirement using the same principle and method.

FUTURE SCOPE OF THE PROJECT

The future scope of the project is by replacing the material of the components with a low weight and high strength materials. The dog clutch can be engaged or disengage by hydraulic or pneumatic systems with help of sensors. We can also reduce the number of gears and obtain the same number of speeds. The type of engagement between the dog clutch and the gear can also be improved by some other means.

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