Design of Single Speed FR-Reduction Bevel Gear Box

(For Low Speed Vehicles)

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***Abstract*—Gear boxes are designed for variable speeds and torque applications for different drives. Differential is an important component which splits the drive during turns and variable loads conditions. Differential is an expensive component which adds to the cost of the vehicle. In low-speed vehicles used for sprinkler vehicles, grass cutters etc.., introducing a differential will increase the cost and complexity of the vehicle. Finding an alternate for replacement of differential which serves the same purpose at low speeds will be of great advantage in reducing the cost, complexity, construction and maintenance. Hence this paper is aimed at making an attempt to find a similar type of alternate mechanism replacing differential with gear box.**

***Keywords*—FR (Forward & Reverse) Reduction Gear Box, Bevel Gears, Low speed Vehicles, Single Speed.**

II. INTRODUCTION

Design of reduction gear train for low-speed applications is very essential to overcome the effects of sudden and variable torque. This concept of reduction gear train is considered to replace the differential with reduction gear box with a provision of reverse drive. In low-speed vehicles used for sprinkler vehicles, grass cutters etc.

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The gear train is designed for an output torque of 57.6 N-m at a gear reduction ratio of 1:3.6 Taking in to account the design considerations for gears and gear trains, the proposed train has been designed.

Applications of this proposed gear box are

- Agricultural applications for weed cutting machinery
- Lawn moving vehicles
- Grass cutters
- Flour mills
- Paper mills
- Lathe machines
- Milling machines
- Conveyer belts

III. LITERATURE REVIEW

Concept of gear development, classification of gears [3], [4], [5], gear nomenclature, gear materials applications of gears [1] [5], design and development of gear trains [2] [6] are the concepts derived from standard references [1] [2]

1. RECOGNITION OF NEED

Low speed vehicles generally don't need differential and hydrostatic gear box which adds to the complexity of vehicle and increase of cost factor. An alternative to replacement of these is of great advantage which reduces the complexity and cost factor has led this work.

2. INPUT PARAMETERS

S. No	Functional Design Parameters	Value
1	Vehicle gross weight	220 Kg
2	Max. Speed	45 kmph
3	Max. Power	10 HP
4	Max. Torque	16 N-m
5	RPM	3400
6	Acceleration	2.5 m/s^2

Table 2.1 Functional Design Parameters

3. SELECTION OF MATERIAL AND BOM

S. No	Name of the component	Material	Quantity
1	Bevel gears	316 alloy steel	03
2	Shafts	EN19	02
3	Gear box casing	Al alloy	01
4	Ball bearing	6305 2RS	03

Table 3.1 BOM

4. DESIGN OF DRIVE AND GEAR ELEMENTS

4.1 Design of drive

i) Required force to overcome inertia

F = ma + Fr + Fs + Fd

Fr = Crr*N, Fr = 15N

Fp = ma = 220*2.5 = 550N.

Total force F = 550 + 20 = 570N.

We know that

Power = Force * Velocity

F = Power/Velocity = 74475/12.5

F = 596.56 N engine force.

{Engine force > required force}

Gear ratio
Engine RPM = 3400rpm
Wheel RPM= 940 rpm
Gear ratio = engine rpm / wheel rpm = 3400/940 = 3.6:1 @ 45kmph

ii) Design of shaft

D = Diameter of shaft
Torque transmitted by driven puts
$T = P*60/2\pi N_2,\ 62.8*10^3$ N-mm
Also
$T_e = \pi/16*\zeta*D^3$
$767.28*10^3 = \pi/16*320\ N/mm^2*D^3$
D = 23mm shaft

iii) Selection of bearing

T = 70 N-m.
Tangential force
$W_T = T/R_M$
$R_M = [70-34/2]\ \sin 60$
$R_M = 45.89$

iv) Axil force and radial force

$R_A = W_R \sin\theta p_1 = W_T \tan\varphi.\ \sin\varphi$
$R_R = W_R \cos\theta p_1 = W_T \tan\varphi.\ \text{Cos}\ \varphi$
$W_T = T/R_M$
$W_T = 70/50$ N-m $= 70*10^3/50$ N-mm = 1400N
$R_A = 1400*\tan 60*\sin 60 = 1790$ N
$R_R = 1400*\tan 30*\cos 30 = 682.23$ N
$W_R = 682.23$ N, $W_A = 1790$ N
Life = 20,000 hours
Life in revolutions
$L = 60*N*L_H = 60*1300*15000$
$= 1170*10^6$ rev
Basic dynamic radial load
$W = X.V.W_R + X.W_A$
$X = W_A/W_R > e^r = W_A/C_0$
Then X = 0.56, Y =1.2
X = 0.56, Y = 1.2
W = 0.56*1*682.23 + 1.2*1790
= 0.56*1*682.23 + 21348
= 382.0488 + 2148
W=2530.488N

v) Basic dynamic load ratios

$C = W[L/10^6]^{1/K} = 2530.5[1170*10^6/10^6]^{1/3}$
C = 26.664 N
C = 26.6 KN
For C = 26KN $C_0 = 17.6$KN
d = 25mm, D = 62, b = 17mm.
C = 26; $C_0 = 13.4$
Bearing No = 6305 ETN9
Or) = 6305-2z less
Or) = 6305 – 2RSI

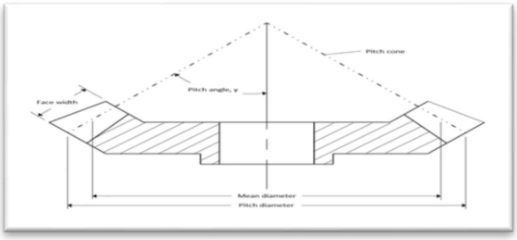

Figure 4.1 Dimensions

Vi) Design of gear.

Dp = 63mm
Dg = 220mm
Np = 8
$N_g = 30$
m = 7.75
Pitch angles of gears
$\alpha_{p1} = \tan^{-1}(N_g / N_p) = 15^0$
$\alpha_{p2} = 30^{0.}$

5. RESULTS

FOLLOWING ARE THE RESULTS OBTAINED GEAR TERMINOLOGY VALUES

S.No	Nomenclatures	Values
1	Pitch	24.3 mm
2	Addendum	7.75 mm
3	Dedendum	9.3 mm
4	Module	7.75
5	Clearance	1.15 mm
6	Working depth	15.5 mm
7	Thickness	12.17 mm
8	α_{p1}	15^0
9	α_{p2}	30^0

Table 5.1 Gear nomenclatures values

6. WORKING

This gear box is compatible in working with IC-engine and electric drive with automatic clutch.

Power from the source is transmitted to pinion as input. From pinion the power takes a right-angled turn to the gears-1 and gear-2 which will be in mesh with the pinion. These gears transmit the proportionate amount of power to the road wheels.

The gear-1, and gear-2 are mounted on the shaft and can slide over the shaft manual.

Meshing of pinion with gear-1 facilitated forward drive and meshing of pinion with gear-2 facilitates reverse drive.

Figure 5.1 Cut section of assemblage of gear train in casing

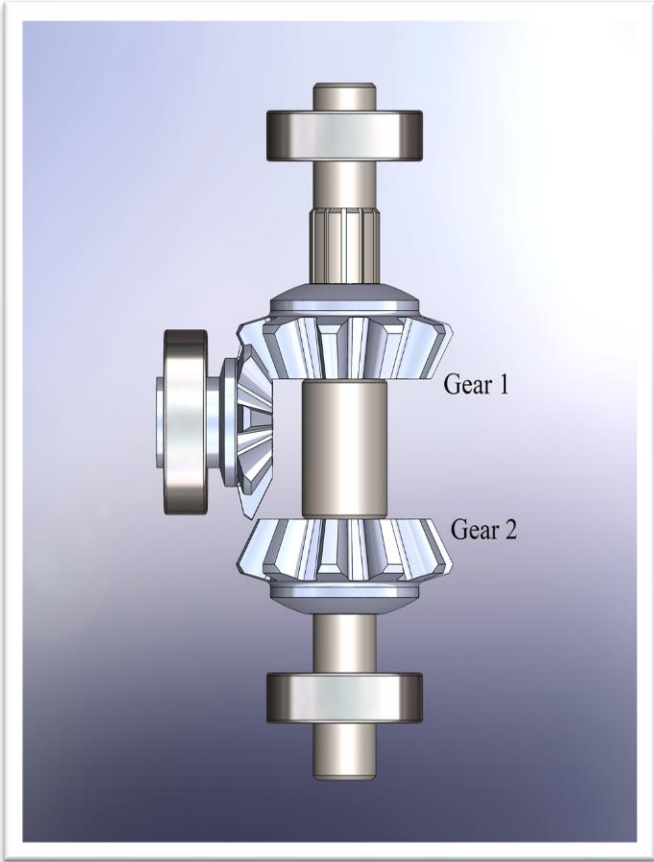

Figure 6.1 Forward drive mesh

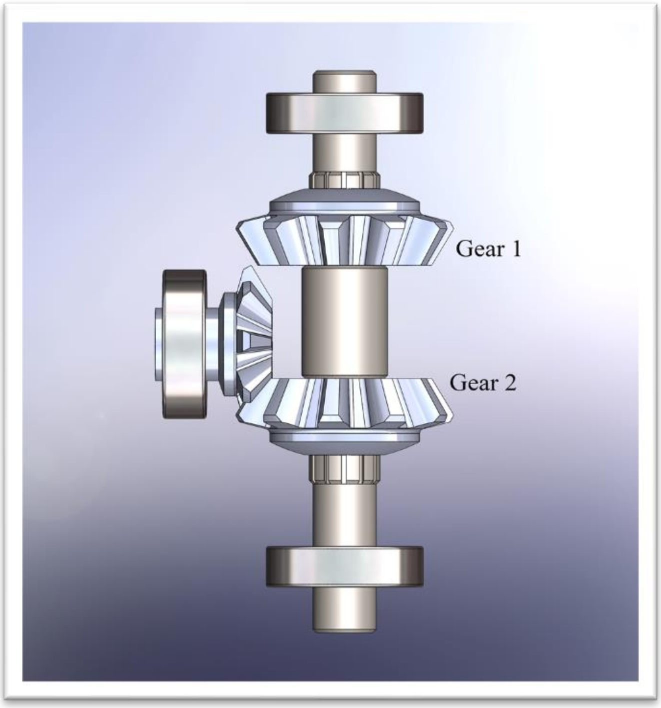

Figure 6.2 Reverse drive mesh

7. MODELING TOOL USED:

Solid works modeling tool of release 2021 is used. Basic features are,

- Extruded Boss Feature.
- Fillet Features.
- Revolved Boss Feature.

8. CONCLUSION

The proposed reduction gear box for low-speed vehicles has been designed satisfactorily as per the requirement to suite for the real time working environment.

Design parameters with calculated valued are identified using the standard relations which helped in manufacturing of the components of the gear box.

9. REFERENCES

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