MM2DMP

MARINE GEARBOX

Preliminary Design Review

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Concept Definition

The designed marine gear box uses the power transmitted from the twin cylinder diesel engine to useful output on the propeller shaft. The engine is connected to the input shaft which is attached to the input gear of 21 teeth and spins at 2600rpm. This input gear is linked directly to the output gear which must have 1300rpm. This is done by using reduction gears. Reduction gears are used to increase the torque and decrease the angular speed between of the output shafts. Hence, the gear ratio of 0.5 to increase the torque at the output. Which computes to 42 teeth on the output gear.

An oil pump is included in the gearbox to ensure smooth function by lubricating the system. A gear connected to the oil pump driving gear is also linked at the bottom of the output gear. The oil pump gear is required to drive an oil pump at an angular speed of 3900rpm. So, a gear ratio of 3 is used giving 14 teeth for the oil pump gear.

The output shaft is integrated with a cone clutch which is operated hydraulically, this is so that the propeller only runs when the engine is on and clutch is engaged. It is also to ensure that there is constant oil flow when the engine is on, regardless if the clutch is engaged or disengaged. The outer core of the clutch is connected to a hydraulic actuator, the helmsman will be able to control the engagement and the disengagement of the clutch by means of a leaver or a pedal. When the clutch is engaged the actuating spring pushes the outer core towards the inner core so that the friction lining is in contact with the outer core. The strong friction between this causes the propeller shaft to rotate at the same speed as the inner core.

Bearings are used on either side of the output shaft and on one side of the input shaft. Bearings are used to enable rotation while reducing friction between surface of bearing and the shaft. A ball bearing is used on one side output shaft and roller bearing is used on the other this is to handle stress on the shaft and for stability of the gearbox.

The casing of the gearbox has been designed in a way that it is easy to assemble. The cover of the casing can be removed for the ease of maintenance. It also provides spacing for attachment of bearings and seals. It incorporates enough space around the gears hence, there won’t be any overheating of mechanical parts.

Engineering Calculations

Given quantities:

- Maximum input power = **20.8 kW**
- Output power = **15 kW**
- Input shaft speed = **3600 rpm**
- Output shaft speed = **1300 rpm**
- Maximum oil pump Speed = **3900 rpm**

Driving and driven torques calculations:
Using,

$$\tau = \frac{P}{\omega}$$

τ =Torque
P= Power
ω= Angular speed

$$\tau_{input} = \frac{20.8 \times 10^3}{3600 \times \frac{2\pi}{60}}$$

$$= \mathbf{55.17Nm}$$

$$\tau_{output} = \frac{15 \times 10^3}{1300 \times \frac{2\pi}{60}}$$

$$= \mathbf{110.18Nm}$$

Since we assume all conditions are ideal,

$$P_{input} = P_{output}$$

$$\tau_{input}\omega_{input} = \tau_{output}\omega_{output}$$

$$55.17 \times \omega_{input} = 110.18(1300)$$

$$\omega_{driving} = 2596.23\, rpm$$

$$\cong \mathbf{2600\, rpm}$$

Hence, input speed of **2600 rpm** will be used in further calculations.

Gear ratios can be calculated by using,

$$Gear\ ratio\ N = \frac{\omega_{driven}}{\omega_{driving}}$$

The angular velocity of input shaft is 2600 rpm whereas the output shaft has an angular speed of 1300rpm.

$$Gear\ ratio\ N_{12} = \frac{\omega_{2\ (output)}}{\omega_{1\ (input)}} = \frac{1300}{2600}$$

$$Gear\ ratio\ N_{12} = \mathbf{\frac{1}{2}}$$

The angular velocity of oil pump is 3900 rpm whereas the output shaft has an angular speed of 1300rpm.

$$Gear\ ratio\ N_{23} = \frac{\omega_{3\ (oil\ pump)}}{\omega_{2\ (output)}} = \frac{3900}{1300}$$

$$Gear\ ratio\ N_{23} = \mathbf{3}$$

Gear teeth for gear 2 and gear 1 can be found by using the gear ratios and gear teeth of oil pump. (Gear teeth for oil pump = 14)

$$\begin{aligned} Gear\ teeth\ for\ gear\ 2(output) &= N_{23} \times Gear\ teeth\ for\ oil\ pump \\ &= 3 \times 14 \\ &= \mathbf{42}\ \text{teeth} \end{aligned}$$

$$\begin{aligned} Gear\ teeth\ for\ gear\ 1(input) &= N_{12} \times Gear\ teeth\ for\ Gear\ 2(output) \\ &= \frac{1}{2} \times 42 \\ &= \mathbf{21}\ \text{teeth} \end{aligned}$$

The gear tooth module is,

$$\text{Module} = \frac{\text{Reference diameter}}{\text{Number of teeth}}$$

$$= \frac{42mm}{14}$$

$$= \boldsymbol{3mm}$$

In order to calculate the length of the gear box, we must estimate the center to center distance between gears. To do this the following are calculated:

- Pitch circle diameter(d)
- Diametral pitch(P)
- Addendum(a)
- Dedendum(b)

The below calculations are done for the input gear (Gear 1) only.

Pitch circle diameter:

$$Pitch\ circle\ diameter(d) = Number\ of\ teeth\ \times Module$$

$$d_{gear1} = 21 \times 3 = \boldsymbol{63mm}$$

Diametral pitch:

$$P = \frac{Number\ of\ teeth}{(Pitch\ circle\ diameter \div 25.4)}$$

$$P_{gear1} = \frac{21}{63 \div 25.5}$$

$$P_{gear1} = \boldsymbol{8.5\ teeth/Inch}$$

Addendum:

$$Addendum = Module$$

$$a_{gear1} = \mathbf{3mm}$$

Dedendum:

$$Dedendum = 1.25 \times Module$$

$$b_{gear1} = 1.25 \times 3 = \mathbf{3.75mm}$$

Similarly, the calculations are repeated for output gear (gear 2) and oil pump gear (gear 3). The values are shown in the table below.

	Gear 1	**Gear 2**	**Gear 3**
Pitch Diameter (d/mm)	63	126	42
Diametral Pitch(P/teeth/inch)	8.5	8.5	8.5
Addendum(a/mm)	3	3	3
Dedendum(b/mm)	3.75	3.75	3.75

Hence the center to center distance can be calculated by summing the pitch radii.

$$l = \frac{d_1}{2} + \frac{d_2}{2}$$

Center to center distance between gear 1 and gear 2:

$$l_{12} = \frac{d_{gear1}}{2} + \frac{d_{gear2}}{2} = \frac{63}{2} + \frac{126}{2}$$

$$= \mathbf{94.5mm}$$

Center to center distance between gear 2 and gear 3:

$$l_{23} = \frac{d_{gear2}}{2} + \frac{d_{gear3}}{2} = \frac{126}{2} + \frac{42}{2}$$

$$= \mathbf{84mm}$$

Since we know the pitch radius, center to center distance and the addendum we are now able to calculate the total gear train length (l_{max})

$$l_{max} = l_{12} + l_{23} + \frac{d_{gear1}}{2} + a_{gear1} + \frac{d_{gear3}}{2} + a_{gear3}$$

$$= 94.5 + 84 + 31.5 + 3 + 21 + 3$$

$$= \boldsymbol{237mm}$$

Hence, the estimated Hight of gear box is above 237mm.

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Concept Drawing