CA4 : Selection of Spur Gears

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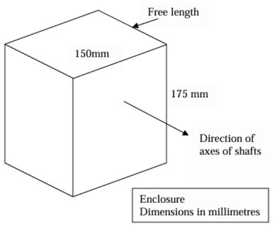
Task: You are to select a set of spur gears that operates under the following conditions.

Power transmitted = 1.2 kW
Input speed = 3100 rpm
Output speed = 130 ± 3% rpm
All round clearance = *to be assigned by Tutor*
Enclosure is as shown. Shaft axes are to be aligned as shown.

a) Study the guidelines on selection of spur gears given in the course catalogue for NOZAG spur gears. The sizes of spur gears are also available in this catalogue.
b) Select the gears for a quadruple (4 stage) gear reduction arrangement that will meet the speed, space and strength requirements. [*Note: you can attempt a triple or double gear reduction arrangement which is more challenging and hence gain a better grade!*]
c) Show full detailed calculations in the selection of the gears, and also show determination of the 2 outermost gears in the compound gear train and hence the outermost dimensions in the compound gear train.
d) Make a dimensioned sketch of the compound gear layout (not necessary to scale).



Requirements: Individual submission at the end of the session.

Suggested Steps:

1. Decide on gear ratio for each pair of meshing gears in the gear train.
2. Determine torque on each gear.
3. Decide on either number of teeth or module to select corresponding module or number of teeth
4. Check for no interference of meshing gears using the table below
5. Check for availability of gears from course catalogue
6. Check if final arrangement fits into the enclosed space (incl. addenda and all round clearance) by determining the 2 outermost gears in the compound gear train and hence the outermost dimensions in the compound gear train.

Table: combinations of number of teeth for spur gears in mesh to ensure no interference.

For a 20°, full-depth pinion meshing with a gear

Number of pinion teeth	Maximum number of gear teeth
18	Infinite
17	1 309
16	101
15	45
14	26
13	16

My Answer:

Power transmitted = 1.2 kW

Input speed = 3100 rpm

Output speed = 130 ± 3% rpm

= 126.1 to 133.9 mm

all round clearance = 2.5 mm

speed ratio, $SR = \frac{\text{Input spd}}{\text{Output spd}} = \frac{3100}{130} \approx 23.85$
$= SR_1 \times SR_2 \times SR_3 \times SR_4$

Assume uniform loading & less importance application,
service factor $f_B = 1.0$, safety factor, $S_B = 1.0$

$P_{tab} = P_{eff} \times S_B \times f_B$
$= 1.2 \times 1.0 \times 1.0$
$= 1.2\,kW$

$M_{tab} = M_{eff} \times S_B \times f_B$
$M_{eff} = \frac{P}{w} = T$
$M_{tab} = \frac{P}{w} \times 1.0 \times 1.0$

Assume all SR same for all gears,
$SR = \sqrt[4]{23.85} = 2.2098 \approx 2.20$ (approx for each stage)

Use Z-056 (SR_1)

$N_1 = 15T$

$T_1 = \frac{1.2 \times 10^3}{\frac{2\pi}{60}(3100)} = 3.6965 \approx 3.70\,Nm$ $\quad M_{tab} = T_1$

$m_1 = 1.25\,mm$

$\therefore N_2 = 2.2 \times 15 = 33T$

$\therefore N_1 = 15T,\ m_1 = 1.25$
$N_2 = 33T,\ m_2 = 1.25$ #

$T_2 = T_1 \times \frac{N_2}{N_1}$
$= 3.70 \times \frac{33}{15} = 7.89\,Nm$

@ $N_2, T_2 \to m_2 = 1.25$

Use Z-056 (SR_2)

$N_3 = 15T$

$T_3 = T_2 = 7.89\,Nm$

$m_3 = 1.5\,mm$

$N_4 = 2.2 \times 15 = 33T$

$T_4 = 7.89 \times \frac{33}{15} = 17.36\,Nm$

$m_4 = 1.5\,mm$

$\therefore N_3 = 15T,\ m_3 = 1.5\,mm$
$N_4 = 33T,\ m_4 = 1.5\,mm$ #

- Use same module for each gear to get meshing
- Calculate Torque to select the gears that offers the range

Use Z-056 (SR3)

$N_5 = 16$

$T_5 = T_4 = 17.36\,Nm$

$m_5 = 2mm$

$N_6 = 2.2 \times 15 = 33T$

$\therefore N_6 = 35$

$T_6 = 17.36 \times \frac{35}{16} = 37.98\,Nm$

$m_6 = 2mm$

$\therefore N_5 = 16T,\ m_5 = 2mm$

$N_6 = 35T,\ m_6 = 2mm$

Use Z-056 (SR4)

$N_7 = 16$

$T_7 = T_6 = 37.98\,Nm$

$m_7 = 2.5\,mm$

$N_8 = 2.2 \times 16 = 35.2T$

$N_8 = 36$

$T_8 = 37.98 \times \frac{36}{16} = 85.455$

$m_8 = 2.5mm$

$\therefore N_7 = 16T,\ m_7 = 2.5mm$

$N_8 = 36T,\ m_8 = 2.5mm$

$$\frac{\omega_{out}}{\omega_{in}} = \frac{N_1}{N_2} \cdot \frac{N_3}{N_4} \cdot \frac{N_5}{N_6} \cdot \frac{N_7}{N_8}$$

$$= \frac{15}{33} \cdot \frac{15}{33} \cdot \frac{16}{35} \cdot \frac{16}{36}$$

$$= 0.041978$$

$\omega_{out} = 3100 \times 0.041978$

$= \underline{130.13}$ rpm (2.dp)

$\therefore$ Outspeed is within range

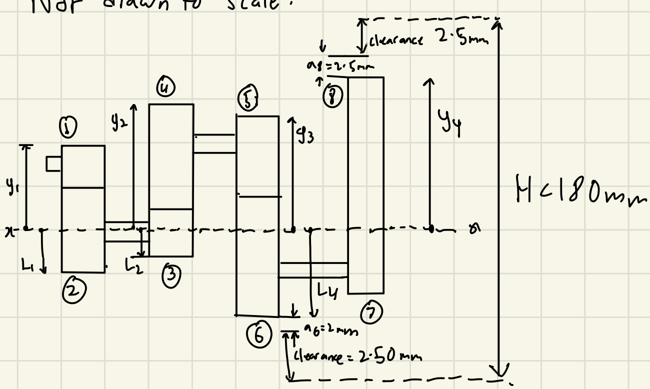
Gear	Teeth	Module	Pitch ϕ	Centre Dist
N_1	15	1.25	18.75	30.0
N_2	33	1.25	41.25	
N_3	15	1.5	22.5	36.0
N_4	33	1.5	49.5	
N_5	16	2	32	51.0
N_6	35	2	70	
N_7	16	2.5	40	65.0
N_8	36	2.5	90	

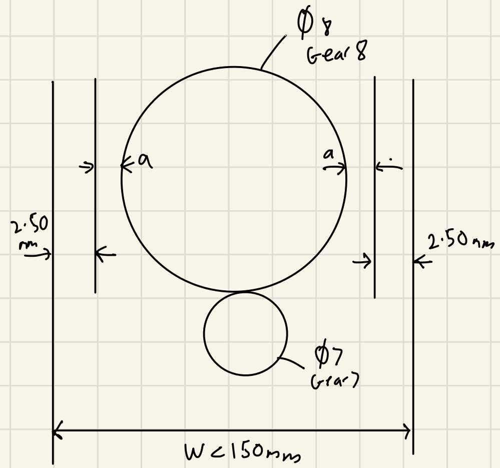
$$H = \text{clearance} + a_6 + \frac{D_6}{2} + \frac{D_7}{2} + D_8 + a_8 + \text{clearance}$$

$$= 11.2 + 2 + \frac{70}{2} + \frac{40}{2} + 90 + 2.5 + 11.2$$

$$= 171.9mm < 180mm$$

Not drawn to scale:





lowest pt → L_3

highest pt → y_4

width, w = largest gear + 2a + 2c

$= 90 + 2(2.5) + 2(11.20)$

$= 117.4mm < 150mm$