GEAR TEETH,DIMENSIONS AND ANGULAR VELOCITY CALCULATIONS

ME251

GROUP 3

1 Introduction

1.1 Concepts Used

1. The module of the mating gears was kept same.
2. The formula $M = \frac{d}{N}$ was used;where M is the module of the gear,d is the pitch diameter and N is the number of teeth in the gears.
3. Gear Ratio=$\frac{\text{No. of teeth in driven gear}}{\text{No. of teeth in driver gear}}$
4. If the gear ratio is **r**; it means that the driver gear must make **r** full revolutions to rotate the driven gear by one revolution.
5. $w = \frac{2\pi}{T}$, where T is the time period of the gear and w is the angular velocity of the gear.

2 Calculations

2.1 Hour and Minute Train

We know that for 1 revolution of hour wheel, the minute wheel must rotate 12 times. Since it is the minute wheel which drives the hour wheel, we require the gear ratio of this gear train to be equal to 12.

The net gear ratio of this gear train comes out to be:

$$\frac{N_{11u}}{N_7} \times \frac{N_8}{N_{11l}} = 12$$

where 7 drives 11upper, 11u drives 11lower, and 7 drives the hour wheel(8).
So we choose:

$$\frac{N_{11u}}{N_7} = 3$$

and

$$\frac{N_8}{N_{11l}} = 4$$

Hence, the following choices can be made for the number of gear teeth:
$N_{11u} = 36$, $N_7 = 12$, $N_8 = 40$, $N_{11l} = 10$

We also require the module of the mating gears to be the same, so we make the following choices:

$M_7 = M_{11u} = 0.23$ and $M_8 = M_{11l} = 0.229$

Thus getting the following pitch diameters:

$d_7 = 2.76$ mm
$d_8 = 9.16$ mm
$d_{11u} = 8.28$ mm
$d_{11l} = 2.29$ mm

2.2 Minute and Second Gear Train

We know that for 1 revolution of minute wheel, the seconds wheel must rotate 60 times. Since it is the minute wheel which drives the hour wheel, we require the gear ratio of this gear train to be equal to $\frac{1}{60}$.
t
The net gear ratio of this gear train comes out to be:

$$\frac{N_{26}}{N_{19}} \times \frac{N_{22}}{N_{28}} = \frac{1}{60}$$

where 19 drives 26, 26 drives 28, and 28 drives the minute wheel(22).
So we choose:

$$\frac{N_{26}}{N_{19}} = \frac{1}{12}$$

and

$$\frac{N_{22}}{N_{28}} = \frac{1}{5}$$

Hence, the following choices can be made for the number of gear teeth:
$N_{26} = 12$, $N_{19} = 144$, $N_{22} = 12$, $N_{28} = 60$

We also require the module of the mating gears to be the same, so we make the following choices:

$M_{28} = M_{22} = 0.083$ and $M_{26} = M_{19} = 0.083$

Thus getting the following pitch diameters:

$d_{19} = 11.952$ mm
$d_{26} = 0.996$ mm
$d_{22} = 1.553$ mm
$d_{28} = 4.980$ mm

2.3 Day Wheel

We wanted to drive the day and date gears using the Hour gear 8 directly and had made calculations for the same.But,we observed that the sizes of the subsequent gears were very huge.But,since we wanted the hour gear to drive the day wheel and hence we attached a gear $8a$ co-axially to the gear no. 8 so that they would have the same angular velocity.We made the gear $8a$ such that it had 15 teeth and module as 0.2. For 1 round of the day wheel the hour wheel makes 14 rounds. So we add intermediate gears namely Y_A and Y_B. The required gear ratio is 14. Hence:

$$\frac{N_Y}{N_{Y_A}} \times \frac{N_{Y_B}}{N_{8a}} = 14$$

where 8 is the hour wheel and Y is the day wheel.
Hence we can choose:

$$\frac{N_Y}{N_{Y_A}} = 7$$

and

$$\frac{N_{Y_B}}{N_{8a}} = 2$$

Since $N_{8a} = 15$, we have $N_{Y_B} = 30$.
Let $N_{Y_A} = 5$ then, $N_Y = 35$

We also have $M_8 = M_{Y_B}$ and $M_{Y_A} = M_Y$ since these are mating gears. So we now have:

$$\frac{d_{Y_A}}{d_Y} = \frac{N_{Y_A}}{N_Y} = \frac{1}{7}$$

Let $d_{Y_A} = 1$ mm and $d_Y = 7$ mm

We also have:

$$\frac{d_{8a}}{d_{Y_B}} = \frac{N_{8a}}{N_{Y_B}} = \frac{1}{2}$$

Since $d_{8a} = 3$ mm, $d_{Y_B} = 6$ mm

So we finally have:
$d_{8a} = 3$ mm $\qquad d_{Y_B} = 6$ mm
$d_{Y_A} = 1$ mm $\qquad d_Y = 7$ mm
$N_{8a} = 15$ mm $\qquad N_{Y_B} = 30$ mm
$N_{Y_A} = 5$ mm $\qquad N_Y = 35$ mm

2.4 Date Wheel

We have driven the date wheel with the hour wheel $8a$. For 1 round of the date wheel the hour wheel makes 62 rounds. Thus the required gear ratio is 62. So we need:

$$\frac{N_E}{N_{E_A}} \times \frac{N_{E_B}}{N_{8a}} = 62$$

where E is the date wheel and E_A and E_B are the intermediate gears.

So we choose:
$\frac{N_E}{N_{E_A}} = 31$ and $\frac{N_{E_B}}{N_{8a}} = 2$

The module of mating gears shall be the same. So:
$M_8 = M_{E_B}$ and $M_{E_A} = M_E$

Since $N_{8a} = 15$ hence, $N_{E_B} = 30$
Let $N_{E_A} = 4$ and $N_E = 124$

$$\frac{d_{E_A}}{d_E} = \frac{N_{E_A}}{N_E} = \frac{1}{31}$$

Let $d_{E_A} = 0.8mm$,therefore,$d_E = 24.8mm$

So we finally have:
$N_E = 124 \qquad N_{E_A} = 4$
$B_{E_B} = 30 \qquad N_{8a} = 15$
$d_E = 24.8$ mm $\qquad d_{E_A} = 0.8$ mm
$d_{E_B} = 6$ mm $\qquad d_{8a} = 3$ mm

NOTE: All the calculations that we made were checked using the following formulae:
Outside diameter = d + 2m ,
Root diameter = d - 2.5m
where 'd' is the pitch diameter and 'm' is the module of the gears. We observed a difference of approximately (0.03 - 0.1 mm)

3 Angular Velocity Calculations

1. Seconds Wheel: 6 degrees/sec
2. Minutes Wheel: 0.1 degrees/sec
3. Hour Wheel: 0.00833 degrees/sec
4. Day Wheel: 5.952×10^{-4} degrees/sec
5. Date Wheel: 1.344×10^{-4} degrees/sec

The above calculations were made keeping in mind the time period of the various gears.