PROBLEM 9-2

Statement: A 40-tooth gear has AGMA standard full-depth involute teeth with diametral pitch of 10. Calculate the pitch diameter, circular pitch, addendum, dedendum, tooth thickness, and clearance.

Given: Tooth number $N := 40$ Diametral pitch $p_d := 10 \cdot in^{-1}$

Solution: See Mathcad file P0902.

1. Calculate the pitch diameter using equation 9.4c and the circular pitch using equation 9.4d.

Pitch diameter $d := \dfrac{N}{p_d}$ $d = 4.0000\ in$

Circular pitch $p_c := \dfrac{\pi}{p_d}$ $p_c = 0.3142\ in$

2. Use the equations in Table 9-1 to calculate the addendum, dedendum, tooth thickness and clearance.

Addendum $a := \dfrac{1.0000}{p_d}$ $a = 0.1000\ in$

Dedendum $b := \dfrac{1.2500}{p_d}$ $b = 0.1250\ in$

Tooth thickness $t := 0.5 \cdot p_c$ $t = 0.1571\ in$

Clearance $c := \dfrac{0.2500}{p_d}$ $c = 0.0250\ in$

Note: The circular tooth thickness is exactly half of the circular pitch, so the equation used above is more accurate than the one in Table 9-1. Also, all gear dimensions should be displayed to four decimal places since manufacturing tolerances for gear teeth profiles are usually expressed in ten-thousandths of an inch..

PROBLEM 9-5

Statement: A spur gearset must have pitch diameters of 4.5 and 12 in. What is the largest standard tooth size, in terms of diametral pitch, that can be used without having any interference or undercutting and what are the number of teeth on each gear that result from using this diametral pitch? Assume that both gears are cut with a hob.

a. For a 20-deg pressure angle
b. For a 25-deg pressure angle

Given: Pitch diameters: $d_1 := 4.5 \cdot in$ $\qquad d_2 := 12 \cdot in$

Solution: See Table 9-4 and Mathcad file P0905.

1. To avoid undercutting, use the minimum tooth numbers given in Table 9-4b.

a. Pressure angle of 20 deg.

$$N_{min} := 21 \qquad p_{dmin} := \frac{N_{min}}{d_1} \qquad p_{dmin} = 4.667\ in^{-1}$$

From Table 9-2, the smallest standard diametral pitch (largest tooth size) that can be used is 5. But, since the pinion pitch diameter is not an integer, using 5 would result in a noninteger number of teeth. Therefore, we must go to the next larger (even) pitch (smaller tooth size) of $p_d := 6 \cdot in^{-1}$. The resulting tooth numbers are:

$$N_1 := p_d \cdot d_1 \qquad N_1 = 27 \qquad N_2 := p_d \cdot d_2 \qquad N_2 = 72$$

b. Pressure angle of 25 deg

$$N_{min} := 14 \qquad p_{dmin} := \frac{N_{min}}{d_1} \qquad p_{dmin} = 3.111\ in^{-1}$$

From Table 9-2, the smallest standard diametral pitch (largest tooth size) that can be used is 4. $p_d := 4 \cdot in^{-1}$.
The resulting tooth numbers are:

$$N_1 := p_d \cdot d_1 \qquad N_1 = 18 \qquad N_2 := p_d \cdot d_2 \qquad N_2 = 48$$

PROBLEM 9-8

Statement: Design a simple, spur gear train for a ratio of -7:1 and a diametral pitch of 8. Specify pitch diameters and numbers of teeth. Calculate the contact ratio.

Given: Gear ratio $m_G := 7$ Diametral pitch $p_d := 8 \cdot in^{-1}$

Assumptions: The pinion is not cut by a hob and can, therefore, have fewer than 21 teeth for a 20-deg pressure angle (see Table 9-4b).

Design Choice: Pressure angle $\phi := 20 \cdot deg$

Solution: See Mathcad file P0908.

1. From inspection of Table 9-5a, we see that 17 teeth is the least number that the pinion can have for a gear ratio of 7. therefore, let the number of teeth on the pinion be

   $N_p := 17$ and $N_g := m_G \cdot N_p$ $N_g = 119$

2. Using equation 9.4c, calculate the pitch diameters of the pinion and gear.

   $d_p := \dfrac{N_p}{p_d}$ $d_p = 2.1250\ in$ $d_g := \dfrac{N_g}{p_d}$ $d_g = 14.8750\ in$

3. Calculate the contact ratio using equations 9.2 and 9.6b and those from Table 9-1.

   $r_p := 0.5 \cdot d_p$ $r_p = 1.0625\ in$ $r_g := 0.5 \cdot d_g$ $r_g = 7.4375\ in$

   $a_p := \dfrac{1}{p_d}$ $a_p = 0.1250\ in$ $a_g := \dfrac{1}{p_d}$ $a_g = 0.1250\ in$

   Center distance $C := r_p + r_g$ $C = 8.5000\ in$

   $$Z := \sqrt{(r_p + a_p)^2 - (r_p \cdot \cos(\phi))^2} + \sqrt{(r_g + a_g)^2 - (r_g \cdot \cos(\phi))^2} - C \cdot \sin(\phi)$$

   Contact ratio $m_p := \dfrac{p_d \cdot Z}{\pi \cdot \cos(\phi)}$ $m_p = 1.693$

PROBLEM 9-11

Statement: Design a compound, spur gear train for a ratio of 50:1 and diametral pitch of 8. Specify pitch diameters and numbers of teeth. Sketch the train to scale.

Given: Gear ratio $m_G := 50$ Diametral pitch $p_d := 8 \cdot in^{-1}$

Solution: See Mathcad file P0911.

1. Since the ratio is positive, we want to have an even number of stages or an odd number with an idler. Let the number of stages be

Possible number of stages $j := 2, 3 .. 4$ Ideal, theoretical stage ratios $r(j) := m_G^{\frac{1}{j}}$

then $j = \begin{pmatrix} 2 \\ 3 \\ 4 \end{pmatrix}$ $r(j) = \begin{pmatrix} 7.071 \\ 3.684 \\ 2.659 \end{pmatrix}$

2. Two stages would result in a stage ratio less than 10 and about 7, so we will use two stages. The average ratio for two stages is about 50:7. Using a pressure angle of 20 deg, let the stage ratios be

Stage 1 ratio $r_1 := \frac{50}{7}$ Stage 2 ratio $r_2 := 7$

and let the driver gears have tooth numbers of (note that N_2 must be a multiple of 7)

Tooth number index $i := 2, 3 .. 5$

$N_2 := 21$ $N_4 := 18$

then the driven gears will have tooth numbers of

$N_3 := r_1 \cdot N_2$ $N_5 := r_2 \cdot N_4$

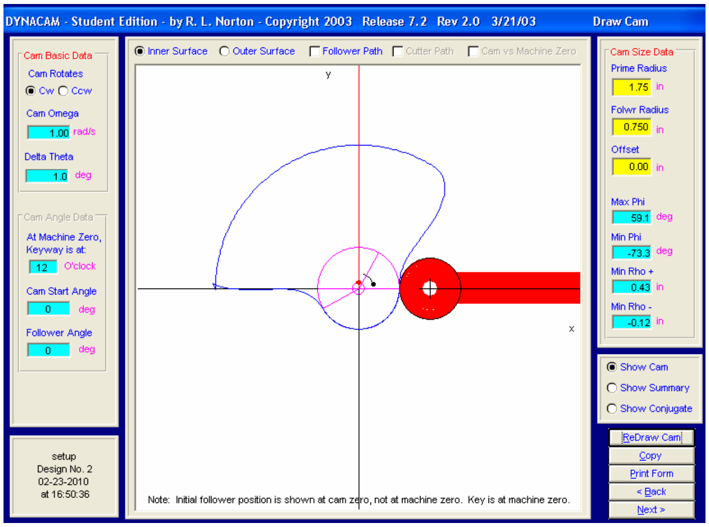
$N_3 = 150$ $N_5 = 126$

The pitch diameters are: $d_i := \frac{N_i}{pd}$

Tooth numbers:

$i = \begin{pmatrix} 2 \\ 3 \\ 4 \\ 5 \end{pmatrix}$ $\frac{d_i}{in} = \begin{pmatrix} 2.6250 \\ 18.7500 \\ 2.2500 \\ 15.7500 \end{pmatrix}$ $i = \begin{pmatrix} 2 \\ 3 \\ 4 \\ 5 \end{pmatrix}$ $N_i = \begin{pmatrix} 21 \\ 150 \\ 18 \\ 126 \end{pmatrix}$

Checking the overall gear ratio: $\frac{N_3 \cdot N_5}{N_2 \cdot N_4} = 50.000$



Prime Radius = $R_{\text{base circle}} + R_{\text{follower}}$