

Designing and Drawing a Sprocket

Visualizing ideas through the creation of CAD solid models is a key engineering skill.

The process designing and drawing a sprocket is an excellent way to incorporate 8th and 9th grade algebra and geometry skills and knowledge.

The following text offers the information and procedural steps necessary to generate the profile of standard pitch sprockets. This process will yield an approximate tooth form that can be used to generate solid models of the sprockets used in the GEARS-IDS kit of parts. The process of producing and saving a solid model library of GEARS-IDS sprockets and parts, provides students and instructors with the opportunity to combine algebra, geometry and trigonometry knowledge with engineering drawing skills to produce the design elements necessary to fully visualize their mechanical creations.

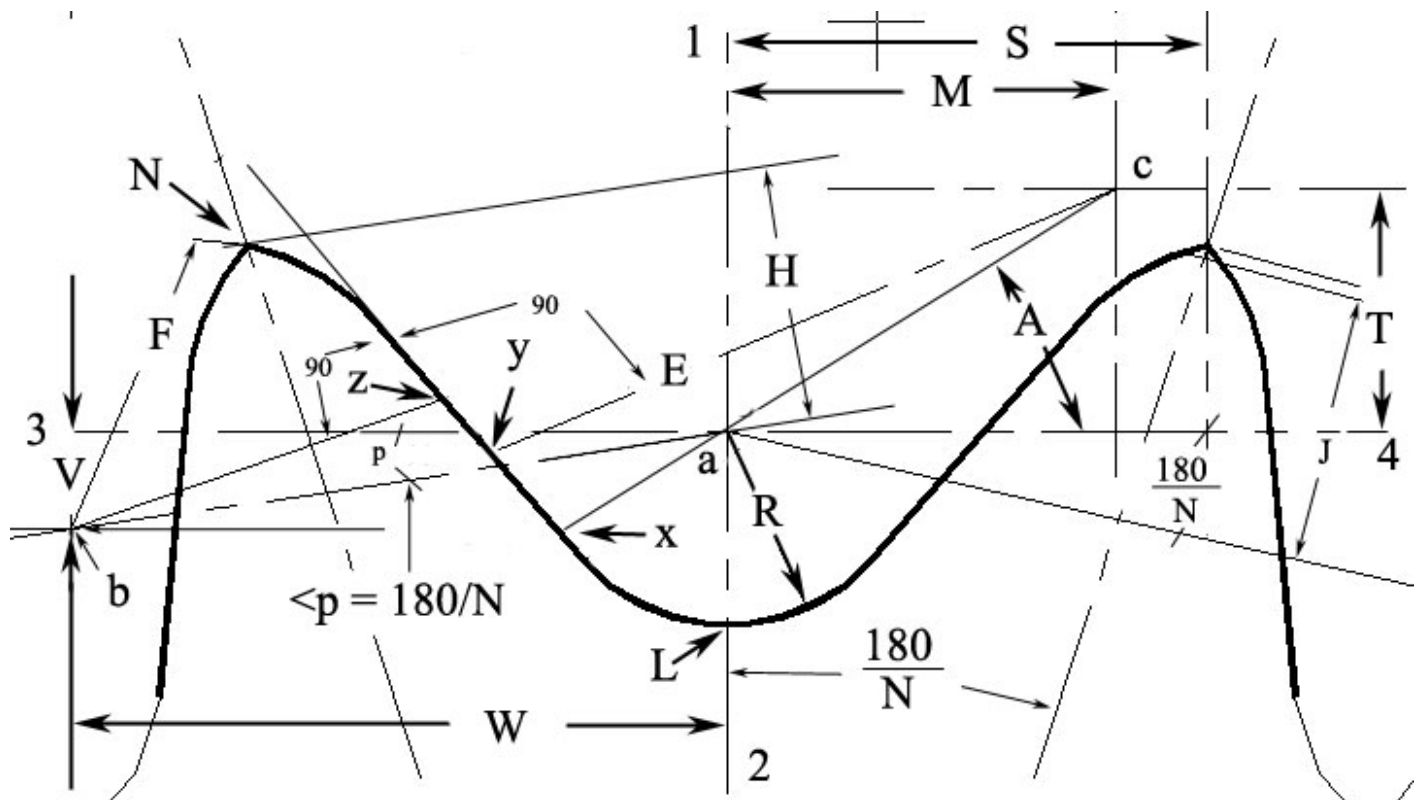


Fig. 6.2.2.1 Sprocket Tooth Geometry

(Adapted from the American Chain Association *Chains for Power Transmission and Material Handling* handbook.

Sprocket Tooth Design Formulas

Refer to Fig. 6.2.2.1 Sprocket Tooth Geometry

The tooth form of a sprocket is derived from the geometric path described by the chain roller as it moves through the pitch line, and pitch circle for a given sprocket and chain pitch. The shape of the tooth form is mathematically related to the Chain Pitch (P), the Number of Teeth on the Sprocket (N), and the Diameter of the Roller (Dr). The formulas for the seating curve, radius R and the topping curve radius F include the clearances necessary to allow smooth engagement between the chain rollers and sprocket teeth.

The following formulas are taken from the American Chain Association Chains for Power Transmission and Material Handling handbook, and they represent the industry standards for the development of sprocket tooth forms.

P	= Chain Pitch	$yz = Dr \left[1.4 \sin\left(17^\circ - \frac{64}{N}\right) - 0.8 \sin\left(18^\circ - \frac{56^\circ}{N}\right) \right]$ $ab = 1.4 Dr$ $W = 1.4 Dr \cos \frac{180^\circ}{N}$ $V = 1.4 Dr \sin \frac{180^\circ}{N}$ $F = Dr \left[0.8 \cos\left(18^\circ - \frac{56^\circ}{N}\right) + 1.4 \cos\left(17^\circ - \frac{64^\circ}{N}\right) \right]$ $H = \sqrt{F^2 - \left(1.4Dr - \frac{P}{2}\right)^2}$ $S = \frac{P}{2} \cos \frac{180^\circ}{N} + H \sin \frac{180^\circ}{N}$ $PD = \frac{P}{\sin \left[\frac{180^\circ}{N} \right]}$
N	= Number of Teeth	
Dr	= Roller Diameter (See Table)	
Ds	= (Seating curve diameter) = 1.0005 Dr + 0.003	
R	= Ds/2 = 0.5025 Dr + 0.0015	
A	= $35^\circ + \frac{60^\circ}{N}$	
B	= $18^\circ - \frac{56^\circ}{N}$	
ac	= 0.8 x Dr	
M	= $0.8 \times Dr \cos\left(35^\circ + \frac{60^\circ}{N}\right)$	
T	= $0.8 \times Dr \sin\left(35^\circ + \frac{60^\circ}{N}\right)$	
E	= 1.3025 Dr + 0.0015	
Chordal Length of Arc xy = (2.605 Dr + 0.003) sin $\left(9^\circ - \frac{28^\circ}{N}\right)$		

Additional Sprocket Formulas

Table 6.2.2.2

Outside Diameter of a sprocket when $j = 0.3P$

$$OD = P\left(0.6 + \cot \frac{180^\circ}{N}\right)$$

Outside diameter of a sprocket when tooth is pointed

$$OD = P \cot \frac{180^\circ}{N} + \cos \frac{180^\circ}{N} (Ds - Dr) + 2H$$

Procedure for Drawing a Sprocket

In this example we will draw the tooth form for the GEARS-IDS 30 tooth Sprocket. Refer to Fig. 6.2.2.1, the Sprocket Formulas and the Maximum Roller Diameter Table.

NOTE: This is primarily an algebra and geometry exercise. The sprocket tooth profile does not need to be drawn perfectly. We will be generating, a mathematical model of the sprocket profile in order to help us draw an approximate model. When drawing the model, do not be overly concerned with arcs that are not exactly tangent to lines, or line lengths that are not exact to 3 or 4 decimal places. Use your drawing tools and common sense in order to create the profile as best you can.

Chain Number	Pitch	Max Roller Diameter
25	1/4	0.130*
35	3/8	0.200*
41	1/2	0.306
40	1/2	5/16

* This refers to the bushing diameter since the chain pitch is small and rollerless.

- 1.) Determine the values for **P**, **N** and **Dr**
- 2.) Calculate the remaining values and enter the data in the table below.

P = 1/4" (For the example Sprocket)	A =	W =
N = 30 (For the example Sprocket)	B =	V =
Dr = 0.130" (See table above)	ac =	F =
Ds =	M =	H =
R =	T =	S =
	E =	PD =
	Yz =	
	ab =	OD (J=.3P) =

- 3.) Draw the Pitch Circle using a radius equal to 1/2 PD.
- 4.) Locate point a on the top quadrant of the circle.
- 5.) Draw a pair of Intersecting (*Center*) Lines 1,2 and 3,4 through point a. (per Fig. 6.2.2.1.)
- 6.) Draw a circle with radius = R at the intersection of lines 1,2 and 3,4.
- 7.) Offset lines 1,2 and 3,4 distances M and T respectively. These lines will intersect at point c
- 8.) Draw line cx at angle A. Line cx must extend beyond the circle.
- 9.) Draw line cy. Line cy = length E and is drawn at an angle B from cx.
- 10.) Draw arc xy with radius E.
- 11.) Draw line segment yz perpendicular to line cy.
- 12.) Locate point b by offsetting lines 1,2 and 3,4 distances W and V respectively.
- 13.) From point b draw an arc with radius F.
- 14.) Smooth the transitions for arc line segment NL
- 15.) Locate the tooth tip by drawing a line from the Pitch Circle center at an angle of $\frac{180^\circ}{N}$

- 16.) Edit the tooth form NL. This represents $\frac{1}{2}$ of the tooth form. Mirror this form to create a complete tooth form and array this form N number of times around the Pitch Circle center.
- 17.) Complete the sprocket drawing by extruding the sprocket to a measured thickness equal to that of the GEARS-IDS 30 tooth sprocket. *Note: Industry standard thickness = $0.93W - 0.006$. The 0.006 " represents a "clearance" number.*
- 18.) Add the hub and webbing as measured from the GEARS-IDS sprocket. *Note: Use a dial caliper to measure the GEARS-IDS sprocket dimensions.*

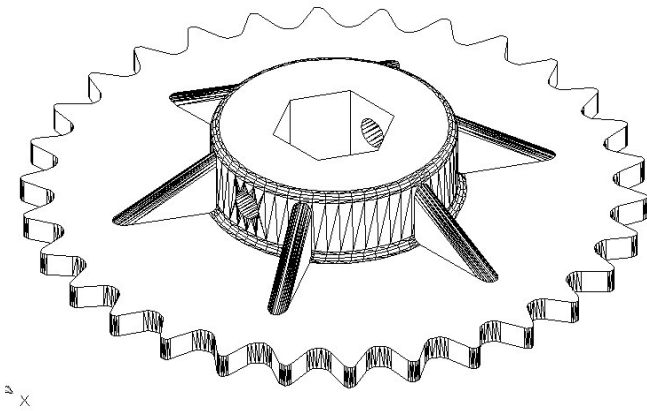


Fig. 6.2.2.2 CAD Solid Model



Fig. 6.2.2.3 Rendered Solid Model

Note: Use the GEARS-IDS spread sheet entitled **Equations for the Design of Standard Sprocket Teeth** to check answers to the equations listed in Table 6.2.2.2.