Bevel Gear Blank Drawing Procedure

Dr. Hermann J. Stadtfeld

*With this first installment — "***Bevel Gear Blank Drawing Procedure***" — we begin a series of randomly excerpted chapters from Dr. Hermann J. Stadtfeld's new book —* **Practical Gear Engineering.** *The foreword, found on p. 60, will tell you everything you need to know about it, i.e. — what it's about, why it was written, and where you can buy it.*

How to Create a Correct Blank Drawing

In the following sections, a five step procedure is presented, which can be helpful for Design Engineers in the generation of a customary blank drawings for bevel pinions and ring gears. In many cases, the missing background information results in drawings which show the members of a bevel gearset from the view point of the transmission designer, however they often fail to include several information which are required for cutting, grinding and coordinate measurement of pinions and gears.

The Bevel Gear Dimension Sheet

The Dimension Sheet of a Gleason bevel gear design includes all required design parameters. Gleason defines as the origin of pinion and gear blank the crossing point of the axes of both mating members. The crossing point generally doesn't match any of the cone apex points. However, the crossing point is the most important reference point for all calculations, for the manufacturing and the CMM inspection.

In order to define the axial location of the turned blank relative to the crossing point it is important to define an axial location datum. The distance in axial direction from this datum to the crossing point is called the "Mounting Distance". The mounting distance is required for the manufacturing machine because the CNC has to relate the tool position to the crossing point. The step by step guidance in the following section begins with a coordinate origin, located at the crossing point on the axis of each member.

There are five major design steps which each require two numbers from the Dimension Sheet. The two connected numbers for one step have the same color in Figures 1 & 2. The Dimension Sheet numbers marked 1 through 6 in Figure 1 locate the cone apexes relative to the crossing point. The numbers marked 7 and 8 in Figure 2 locate the inner and the outer boundary of the tooth.

Dimension Sheet - Second Page

		PINION		GEAR	
PITCH APEX BEYOND CROSS PT .		54.25		-6.19	← 5
FACE APEX BEYOND CROSS PT. .		41.92		-6.19	← 1
ROOT APEX BEYOND CROSS PT. .		50.89		-6.21	← 3
CROWN TO CROSSING POINT. . .		77.32		29.77	
FACE ANG JUNCT TO CROSS PT .					
FRONT CROWN TO CROSS. POINT.		41.00		22.66	
MEAN NORMAL TOPLAND.		1.91		3.45	
PITCH ANGLE.		13.70		73.55	← 6
FACE ANGLE OF BLANK.		18.64		74.53	← 2
INNER FACE ANGLE OF BLANK. .					
ROOT ANGLE		12.85		67.88	← 4
OUTER SPIRAL ANGLE		50.94		20.74	
MEAN SPIRAL ANGLE.		49.99		15.94	
INNER SPIRAL ANGLE		55.68		9.60	
HAND OF SPIRAL		LH		RH	
DRIVING MEMBER		PIN			
DIRECTION OF ROTATION-DRIVER		REV			
BACKLASH	MIN	.13	MAX	.18	
GEAR TYPE.				NON-GENERATED	
DEPTHWISE TOOTH TAPER. . . .		DPLX			
FACE WIDTH IN PCT CONE DIST.				30.172	
DEPTH FACTOR - K					
PROFILE SHIFT - X2				-.497	
OFFSET ANGLE		9.309		33.724	

Figure 1 Second page of Dimension Sheet with cone angles and apexes.

Dimension Sheet - First Page

		PINION	GEAR	
NUMBER OF TEETH.		9	35	
PART NUMBER.		# 1HFT	GLEASON	
FACE MODULE.			4.843	
NORMAL MODULE AT CENTER. . .			3.954	
FACE WIDTH		38.19	26.66	← 8
PINION OFFSET.	BC	44.45		
PRESSURE ANGLE - PIN CONCAVE		29.35		
PRESSURE ANGLE - PIN CONVEX.		8.65		
LIMIT PRESSURE ANGLE		10.35		
SHAFT ANGLE.		90.00		
TRANSVERSE CONTACT RATIO . .		.970		
FACE CONTACT RATIO		2.768		
MODIFIED CONTACT RATIO . . .		2.933		
OUTER CONE DISTANCE.		137.35	88.36	← 7
MEAN CONE DISTANCE		118.26	75.03	
PITCH DIAMETER		65.04	169.49	
ADDENDUM		7.93	1.51	
DEDENDUM - THEORETICAL . . .		2.77	8.78	
WORKING DEPTH.		9.44	9.44	
WHOLE DEPTH.		10.70	10.29	
OUTSIDE DIAMETER		80.45	170.35	

Figure 2 First of Dimension Sheet with outer cone distances and face widths.

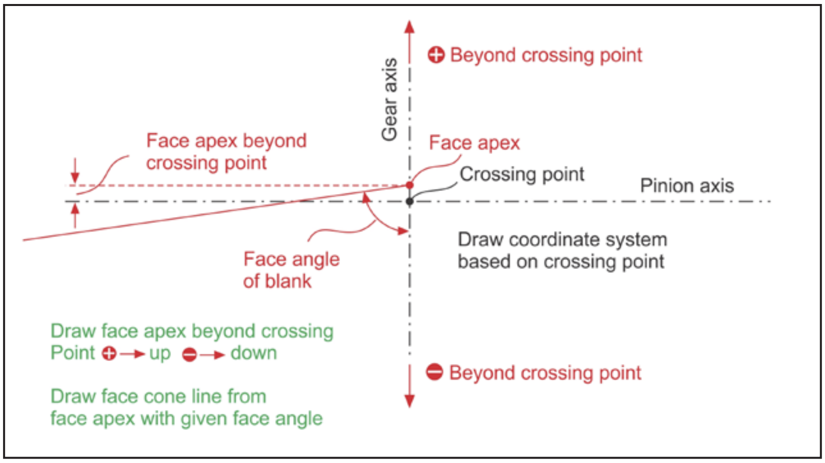

Figure 3 **Draw face cone line.**

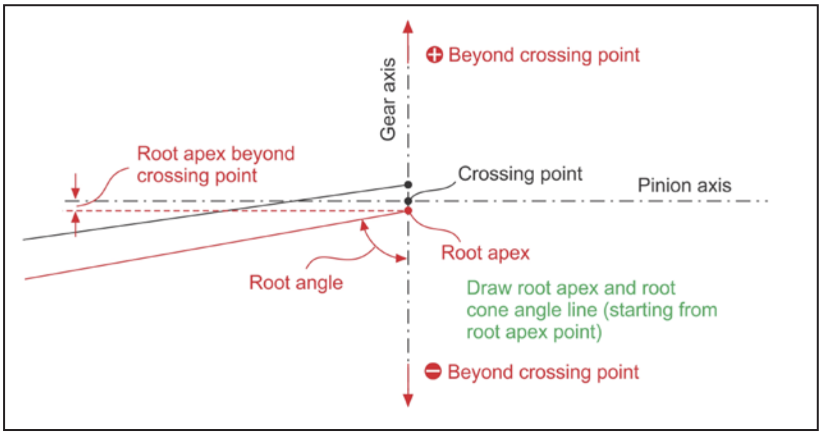

Figure 4 **Draw root cone line.**

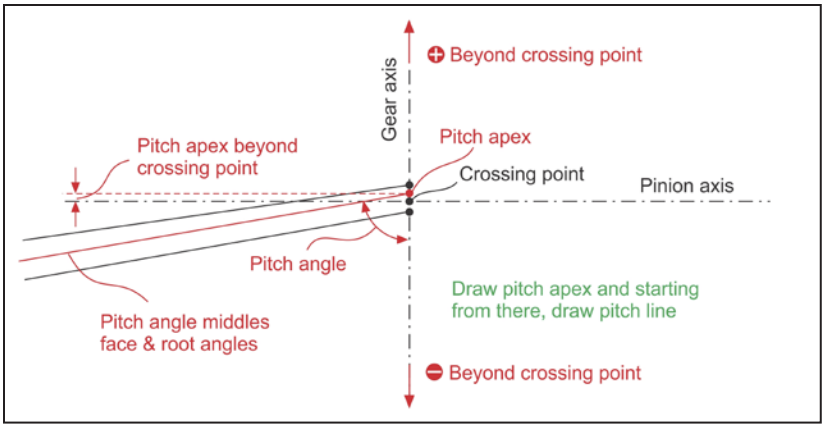

Figure 5 **Draw pitch cone line.**

Step-by-Step Explanations to Create a Blank Drawing

Begin the CAD drawing with a horizontal pinion axis and a vertical gear axis as shown in Figure 3. The crossing point is in the center of the screen. According to the value and the sign in the Dimension Sheet (Figure 1, item 1), mark the "Face Apex Beyond Crossing Point" of the gear at -6.19 mm (negative direction). Then draw the face cone line starting at the Face Apex point with an angle of 74.53° relative to the lower, negative part of the gear axis (Face Angle of Blank, item2).

Now mark the "Root Apex Beyond Crossing Point" at -6.21 mm (item 3) as shown in Figure 4. Then draw the root cone line starting at the Root Apex point with an angle of 67.88° versus the lower, negative part of the gear axis (Root Angle, item 4).

The next step is to draw the pitch line. The pitch line is not a required information in the blank drawing but it gives a more complete information about the bevel gear. Mark the "Pitch Apex Beyond Crossing Point" at -6.19 mm (item 5) as shown in Figure 5. Then draw the pitch cone line starting at the Pitch Apex point with an angle of 73.55° versus the lower, negative part of the gear axis (Pitch Angle, item 6).

In the following step, the Outer Cone Distance (Item 7 in Figure 2) is drawn along the pitch line as shown in Figure 6 which gives the location of the tooth heel border. The toe border is found by marking the Face Width (item 8 in Figure 2) from the outer cone distance towards the center of the gear (in direction of the pitch line), which marks the location of the tooth toe border.

The last step is devoted to fit the tooth boundaries together with face, pitch and root lines as well as the crossing point (labeled as such in the drawing) with the part of the blank dimensions which come from the gearbox design. The mounting shoulder of the ring gear (or the axial seating surface on a pinion shaft) is now used to define the mounting distance. The mounting distance as shown in Figure 7 is the distance from the crossing point to the mounting shoulder or seating surface of the bevel gear.

The example in Figures 3 through 7 demonstrated the creation of a ring gear blank drawing. The pinion blank drawing is done in analogy to the gear by following the exact same steps. The pinion blank values are found in the Dimension Sheet in the column left to the gear values (see Figures 1 & 2).

Summary

After the first draft of a gearbox the major boundary conditions for drawing the correct pinion and gear blanks are given. This chapter explains where the additional bevel gear design related numbers can be found and how those numbers are used in 5 easy steps in order to generate precise pinion and gear blank drawings, which include all required values for turning the blanks as well as for manufacturing and measurement.

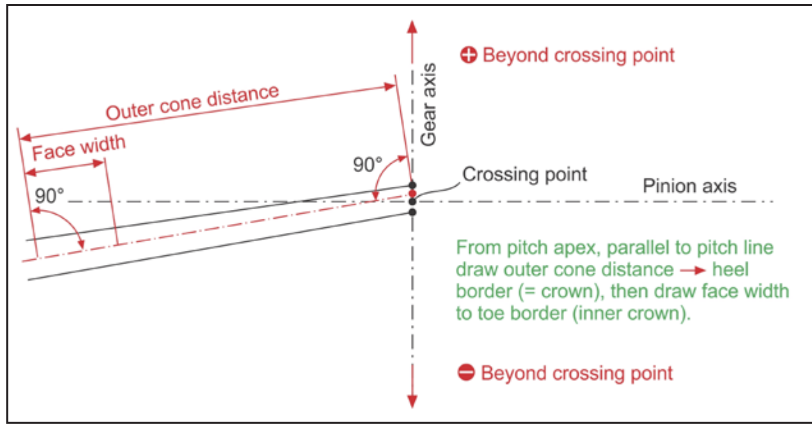

Figure 6 Draw outer cone distance and face width.

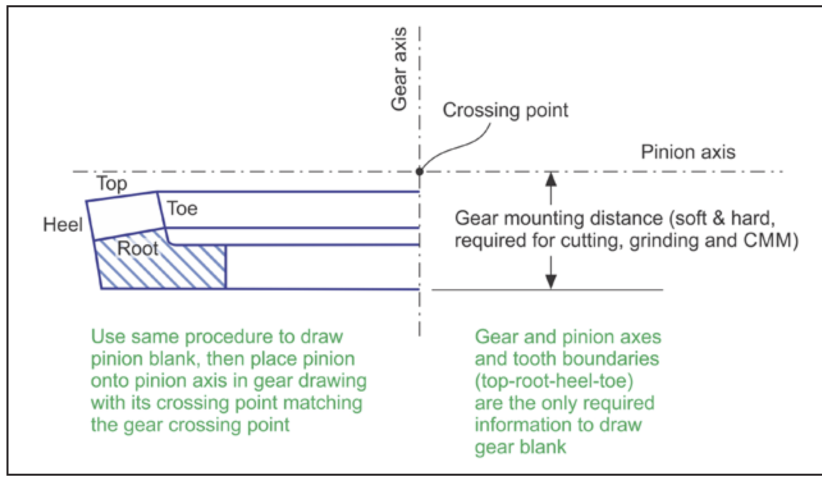

Figure 7 Fit the tooth and the gear or pinion body and define the mounting distance.

Literature

1. N.N. Gear Dimension Sheet Explanations Company Publication, The Gleason Works, Rochester, New York, June 1978

For more information.
Questions or comments regarding this paper? Contact Dr. Hermann J. Stadtfeld at *hstadtfeld@gleason.com*.

Dr. Hermann J. Stadtfeld is the Vice President of Bevel Gear Technology and R&D at the Gleason Corporation and Professor of the Technical University of Ilmenau, Germany. As one of the world's most respected experts in Bevel Gear Technology, he has published more than 300 technical papers and 10 books in this field. Likewise, he has filed international patent applications for more than 60 inventions based upon new gearing systems, gear manufacturing methods as well as cutting tools and gear manufacturing machines. Under his leadership and guidance, the world of bevel gear cutting has converted to, environmentally friendly, dry machining of gears with significantly increased power density due to non-linear machine motions and new processes. Those developments also lower the noise emission level and reduce the degree of energy consumption.

Over a span of over 35 years, Dr. Stadtfeld has had a remarkable career within the field of Bevel Gear Technology. Having received his Ph.D. with summa cum laude in 1987 at the Technical University in Aachen, Germany, he became the Head of Development & Engineering at Oerlikon-Bührle in Switzerland. Dr. Stadtfeld held a Professor position at the Rochester Institute of Technology in Rochester, New York From 1992 to 1994. In 2000 as Vice President R&D he received in the name of The Gleason Works two Automotive Pace Awards, one for his high speed dry cutting development and one for the successful development and implementation of the Universal Motion Concept (UMC). The UMC brought the conventional bevel gear geometry and its physical properties to a new level. In 2015, the Rochester Intellectual UC Property Law Association elected Dr. Stadtfeld the "Distinguished Inventor of the Year." Between 2015 and 2016 CNN-Networks featured him as "Tech Hero" in a Website dedicated to technical innovators for his accomplishments regarding environmentally friendly gear manufacturing and technical advancements in gear efficiency.

Currently, he continues next to his Senior Management position at Gleason Corporation to mentor and advice graduate level Gleason employees, and he supervises Gleason sponsored Master Thesis programs as Professor of the Technical University of Ilmenau, helping to shape the future of Gear Technology.