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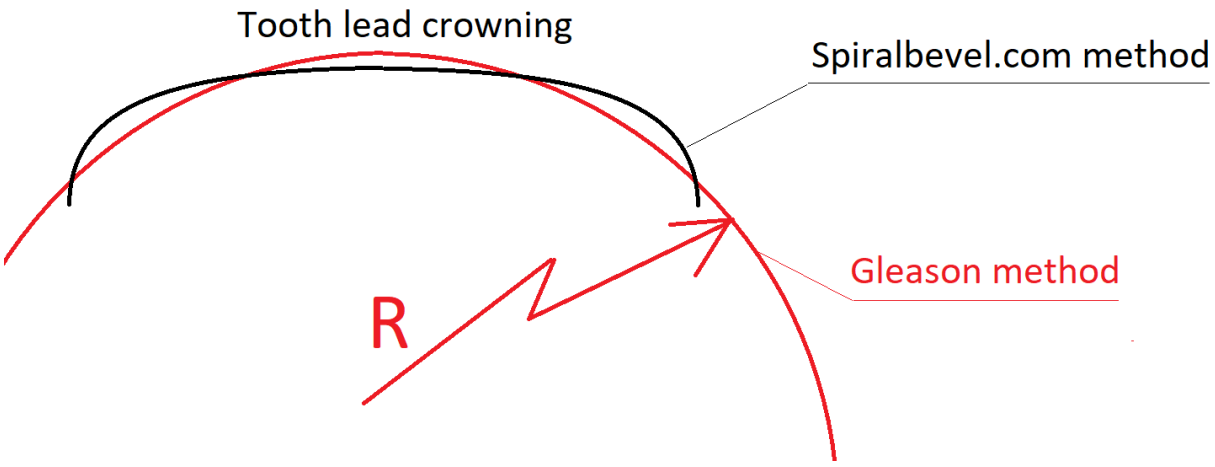
February 7, 2022

Why Gleason cannot win against 3d.

Gear tooth contact localization manufactured on Gleason machines is done by adjustment of the cutting head diameter and the rolling motion.[1] The resulting lead and profile deviate from the ideal conjugated topology similar to how two circles with slightly different radius deviate from each other. Gleason gear generating method does not allow to improve the shape of the circular tooth topology because of the nature of its method. In result, Gleason machines produce gears that are less in performance compared to gears machined on 5-axis CNC from 3d optimized models.[2] 3d gear modeling provides more freedom in gear tooth contact improvement that would be impossible to get out of Gleason methods. This publication presents a method of an accurate comparison between the tooth contact pattern from Gleason process and the tooth contact pattern optimized by spiralbevel.com software. The same method can be used for comparison of Gleason tooth geometry against, for example, geometry from KissSoft. Since KissSoft is the part of Gleason such of comparison has been probably conducted already and we are patiently waiting for the findings to be published. In this publication we examen spiral bevel tooth contact pattern in 3d SolidWorks, the most common engineering software.

Gleason disadvantage in tooth topology vs 3d optimized is explained on Picture 1.



Picture 1. Gleason vs spiralbevel.com method of tooth lead crowning.

Gleason tooth contact localization is achieved by a small increase/reduction of the gear cutter head radius R. For example, Gleason cuts the pinion concave with R=100mm (cutter head) and the mating gear convex with R=100-0.1=99.9mm. In result, the gap between the two mating surfaces increases, roughly in linear proportion when you move away from the contact point. In practice, the contact pattern sensitivity in the gear box is roughly in a linear proportion to the load. For example, if load increases for 2 times the contact shifts also for 2 times more. This is the natural problem of Gleason cut gears, which is impossible to solve on Gleason gear generating machines. The root cause of Gleason

problem is the key Gleason technology – using the cutter head for the tooth generation. Gleason cutter head is circular. It can cut only a circle. If you want to localize the contact pattern you are limited by the options: circle R and R+ΔR. We have to admit that the circular method of crowning has an advantage. Because the curvature remains constant along the tooth length the contact stress remains constant when gear shafts are misaligned. This advantage works with larger variations in assembly. Regardless of the shaft misalignments Gleason method provides constant contact stress as long as the contact does not get to an edge.

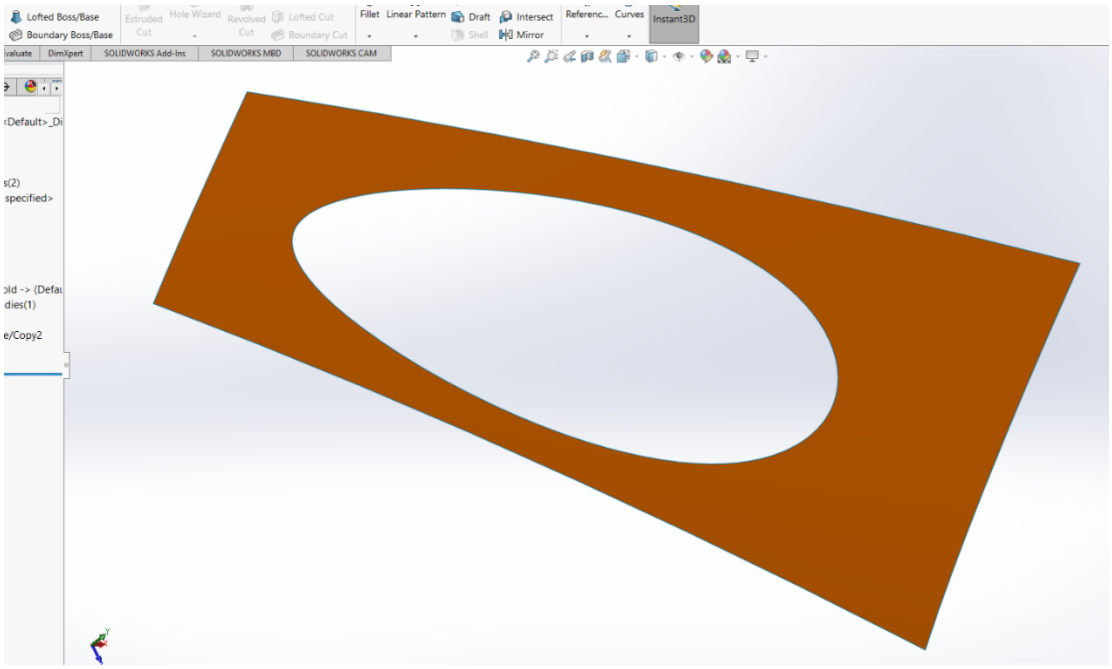
The modern gear industry has advanced to the point when the tooth contact position can be accurately predicted. Today we know better the position of the contact center thanks to the tooth contact simulation software. Modern tooth contact simulation methods provide the position of the tooth contact at the nominal operating torque as well as the position when the torque changes. If we know the most probable position of the tooth contact, we should be reducing the contact stress in this most probable position by reduced crowning around it. If we know that the tooth contact could get very much off the nominal position, we should be increasing the lead/profile crowning in that position. An example of the better crowning curve is marked as “spiralbevel.com method” on Picture 1. Spiral Bevel Co (spiralbevel.com) 3d tooth generating software offers parabolic crowning since 2021. Previous spiralbevel.com software versions used the traditional Gleason tooth contact localization method.

This is the input into spiralbevel.com 3d gear tooth simulation software:

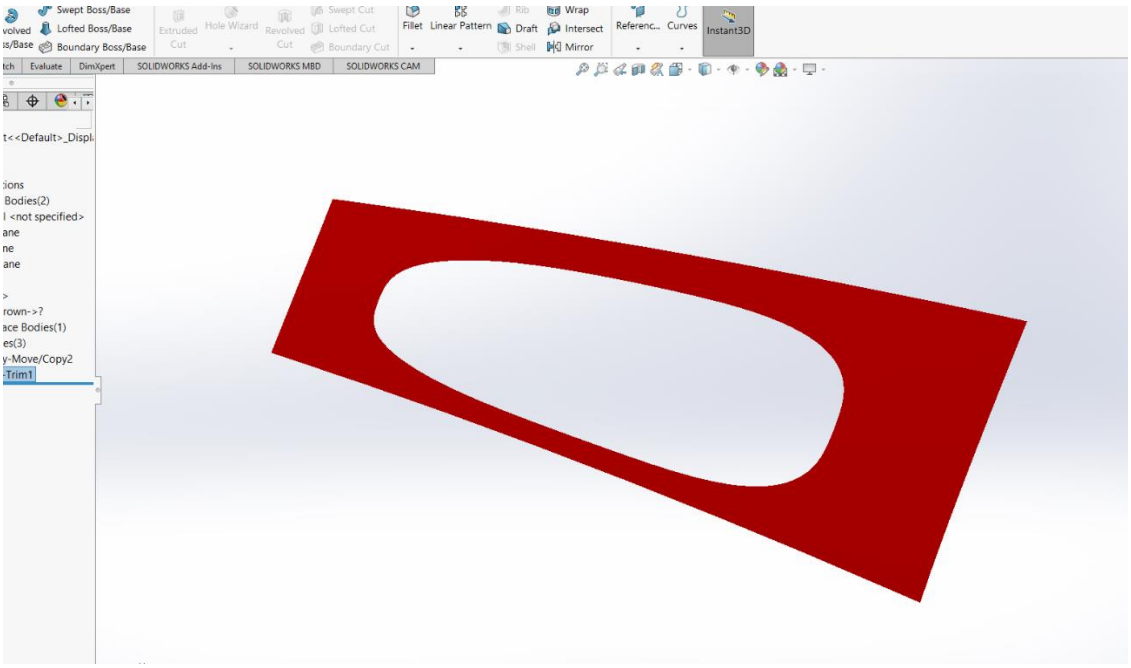
GEAR HEEL PITCH DIAMETER:	45.000
RATIO ([PINION RPM] / [GEAR RPM]):	1.00000
HAND OF SPIRAL ON GEAR (LEFT OR RIGHT):	RIGHT
UNITS (MM or INCH)	MM

STEP 2: Final input:	
SHAFT ANGLE [DEG]:	90
NUMBER OF TEETH ON GEAR:	20
NUMBER OF TEETH ON PINION:	20
GEAR FACE WIDTH:	11.5
PRESSURE ANGLE [DEG]:	20
SPIRAL ANGLE [DEG]:	20
GEAR TRANSVERSAL TOOTH THICKNESS ON HEEL:	3.5
ANGULAR BACKLASH ON GEAR [DEG]:	0.327741901
GEAR COEFFICIENT OF ADDENDUM:	1
COEFFICIENT OF TOOTH HEIGHT:	2.25
FACE CUTTER GENERATING DIAMETER:	300
GEAR PROFILE CROWNING:	0.01
GEAR LEAD CROWNING:	0.007
COEFFICIENT OF ROOT RADIAL CLEARANCE	0.25

Identical software input was used for the tradition Gleason contact pattern localization and for new parabolic method offered by spiralbevel.com since 2021. The 3d visualized comparison is done in SolidWorks.

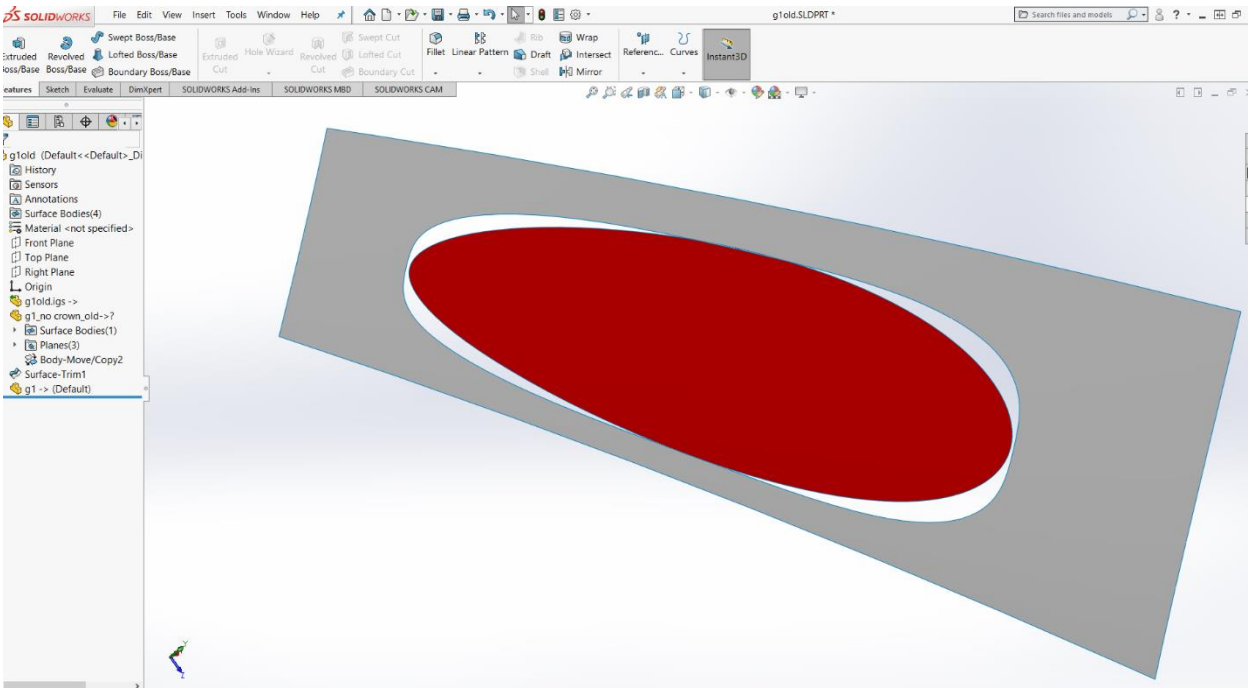


Picture 2. SolidWorks simulation of Gleason tooth contact



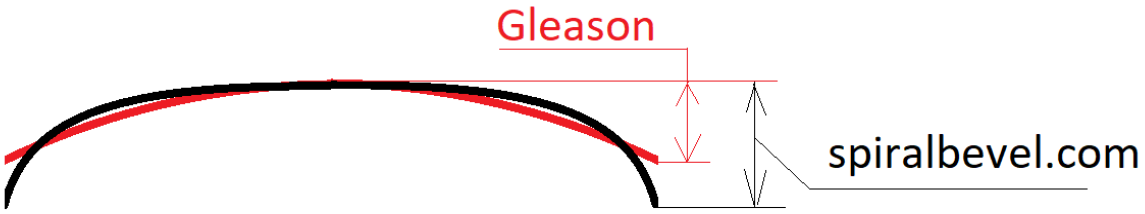
Picture 3. SolidWorks simulation of spiralbevel.com tooth contact

SolidWorks 3d simulation shows oval shape of Gleason tooth contact. Spiralbevel.com tooth contact is more like a rectangle with rounded corners. On the next simulation we place both, Gleason and spiralbevel.com together in order to make the difference more obvious.



Picture 4. Spiral bevel Gleason contact pattern (red) inside spiralbevel.com contact pattern.

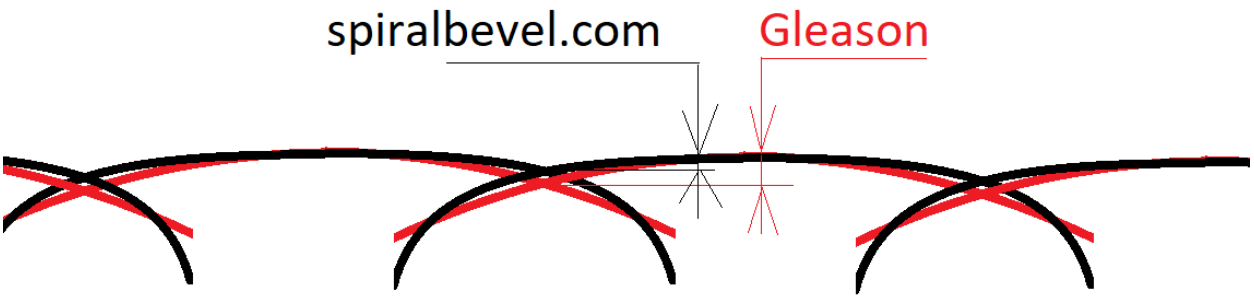
Picture 4 shows that Gleason contact pattern is smaller in size in comparison to the contact pattern from 2021 version of 3d tooth design software for 5-axis CNC machining. This overlap comparison is not entirely accurate but obvious. More accurate comparison would be even more disadvantageous to Gleason. When comparing two localized tooth contacts we need to look at the amount of overload that results in the contact pattern reaching the edge of the tooth.



Picture 5. Spiralbevel.com contact localization method allows more room for errors in shaft misalignment.

Picture 5 explains how spiralbevel.com crowning method provides more room for the tooth contact pattern to shift due to the shaft misalignments. The overlap comparison on Picture 4 is done for the same size (length and width) of the tooth contact. When the wight and size are the same spiralbevel.com contact pattern is winning is the contact area. In addition to larger contact area spiralbevel.com contact is winning in allowable misalignments. If to make both spiralbevel.com and Gleason contact with the same amount of allowable misalignment the contact area of spiralbevel.com could be 150% or better compared to the contact area from Gleason method.

Picture 6 shows transmission error comparison. Gleason method of contact pattern localization has larger tooth-to-tooth transmission error due to higher variation of local contact pass curvature.



Picture 6. 3d CNC machined gears are smoother because of lower transmission error.

To conclude, Gleason tooth contact localization method remains the most popular because of the wide spread of Gleason gear generating machines around the world. There are still some selective applications where Gleason tooth contact localization method is ok. However, reduction of carbon footprint does not favor Gleason. If we can make spiral bevel gears that are smaller is size, smother in operation, and can operate longer we should do so. We need to remember, that Gleason carbon emission is not just the larger size gears. Gleason is leading the gear industry in carbon oxides production because it takes several different Gleason machines for making one gear set. CNC machining out of 3d models takes just one machine which cost 5 times less compared to any one of Gleason machines. The emission of free carbon is proportional to the cost of manufacturing. Each of us should remember that while using Gleason tooth contact localization method we are not just getting mediocre bevel/hypoid gears but we also opting out of reducing carbon production for some 10x.

Bibliography.

1. “Gleason Bevel Gear Technology. The science of gear engineering and modern manufacturing methods for angular transmissions.” Prof. Dr. Hermann J. Stadtfeld, 2014, The Gleason Works, Rochester NY, USA Language: English. Order online at https://www.gleason.com/en/products/training/gleason-library-fundamentals-and-advanced-gear-technology
2. “Direct Digital Simulation for Gears” 2003. Prof. Dr. Veniamin I. Goldfarb and Dr. Stepan V. Lunin. Order online at www.stepanlunin.com/book1.html

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Dr. Stepan V. Lunin –Invented Direct Digital Simulation for Gears method in 1986. Founder of Spiral Bevel Corporation (2008).

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