Table 2

"TOE"

$$\frac{V}{H} = \frac{1.024 \text{ mm}}{-1.356 \text{ mm}}$$

φ_1	φ_2	U_{12}	X mm	Y mm	$\Delta\varphi_2 \times 10^5$	$\Delta U_{21} \times 10^5$
−23°53′46″	12°54′01″	6.8112	−18.59	16.09	−19.82	47.41
−11°40′20″	14°41′39″	6.8159	−16.21	13.71	−11.12	37.29
0°32′17″	16°29′06″	6.8218	−14.35	11.35	−4.10	24.62
12°44′12″	18°16′20″	6.8291	−12.98	8.62	−0.52	9.10
18°49′53″	19°09′52″	6.8332	−12.47	7.29	0.	0.
24°55′26″	20°03′21″	6.8377	−12.06	5.94	−0.52	−9.48
30°59′21″	20°57′38″	6.8425	−12.15	4.68	−	−19.5

Table 3

"HEEL"

$$\frac{V}{H} = \frac{-1.182 \text{ mm}}{1.508 \text{ mm}}$$

φ_1	φ_2	U_{12}	X mm	Y mm	$\Delta\varphi_2 \times 10^5$	$\Delta U_{21} \times 10^5$
−54°59′29″	6°36′35″	6.8258	6.54	17.09	−7.74	16.50
−42°43′38″	8°24′24″	6.8254	9.26	14.27	−3.95	16.87
−30°28′48″	10°12′03″	6.8281	11.21	11.34	−0.58	11.32
−12°08′16″	12°53′08″	6.8369	12.83	6.83	−0.12	−7.76
0°04′20″	14°40′13″	6.8460	13.13	3.79	−3.51	−27.20
6°10′20″	15°33′40″	6.8515	13.08	2.27	−6.85	−38.80
12°16′37″	16°27′02″	6.8570	13.04	0.69	−13.7	−50.59

Table 4

Helixform (9/43)

"MEAN"

$$\frac{V}{H} = \frac{0 \text{ mm}}{0 \text{ mm}}$$

φ_1	φ_2	U_{12}	X	Y	$\Delta\varphi_2$	ΔU_{21}
−23°58′42″	14°43′05″	4.7816	−3.36	6.98	0.	−17.01
−15°56′18″	16°24′00″	4.7793	−2.91	6.24	−1.39	−6.74
−7°53′29″	18°05′02″	4.7776	−2.60	5.46	−1.87	0.
0°09′36″	19°46′10″	4.7761	−2.39	4.21	−1.37	5.61
8°13′08″	21°27′24″	4.7760	−2.39	3.77	−0.34	7.78
16°17′04″	23°08′44″	4.7764	−2.53	2.87	0.78	7.23
24°21′24″	24°50′08″	4.7774	−2.86	1.96	1.45	4.12
32°26′34″	27°22′20″	4.7780	−3.32	1.06	1.82	−1.41
40°31′08″	28°13′05″	4.7798	−3.98	0.16	0.94	−8.86

Discussion

R. C. Huston[1]. The paper is divided into three parts. In the first of these the authors propose a new method of determining the cutter machine settings for the manufacture of "Formate" and "Helixform" hypoid gears. They thus have extended the work of Pismanic (Reference [1]) which is restricted to Formate gears.

In the second part of the paper the focus is on determining the cutter machine settings for the manufacture of Formate and Helixform **pinions**. This analysis is based on local surface geometry conditions which insure conjugate action between the gear and pinion.

In the final part of the paper the authors examine the effects of mismatch. This analysis is developed globally in the sense that conjugate meshing is sought at all contact points along the tooth surfaces.

Although specific numerical examples are given in each of the three parts the reviewer believes that the analysis is probably too abstract and brief to be accessible to the average design engineer. Hence, it will probably be of most interest to gear theoreticians and kinematicians concerned with surface geometry.

[1] Professor of Mechanics, Department of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio

Discussion

T. Krenzer[1]. This is another worthwhile paper on spiral bevel and hypoid gearing by Prof. Litvin and Dr. Gutman for which these authors are to be commended. The paper consists of three parts and I will present a short discussion on each of these parts.

Part 1: Calculations for Machine settings for Member gear Manufacture of the Formate and Helixform Hypoid Gears.

In this part of the paper, formulas for calculating Formate and Helixform gears are derived along with a sample calculation for each. Although the calculation procedures differ from those used at Gleason, they result in gear machine settings that are essentially the same. To demonstrate the point, calculations for the same gears were made using Gleason formulas. Table 1 shows the comparison of the basic machine settings using the two calculation methods. Small differences in values for the Formate gear are attributed to slight differences in selecting the mean calculation point. The larger differences for the Helixform gear result from the selection of the spiral angle. As explained in the paper, a nominal spiral angle must be assumed in the Helixform case. Gleason's procedure for making the assumption differs from

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that used in this paper and results in a slightly greater spiral angle. This difference is reflected in the machine spiral angle, the vertical setting and the horizontal setting. In either case the result has no effect on the final tooth contact since the pinion settings are calculated to match the gear.

Table 4

	FORMATE	HELIXFORM
Cutter Point Radius	151.73	77.58
Pinion Blade Angle	14°0′	10°0′

Table 1

	FORMAT*		HELIXFORM*	
Basic Machine Settings	Litvin/Gutman	Gleason	Litvin/Gutman	Gleason
Machine Root Angle	75°49′	75°49′	74°51′	74°48′
Vertical Setting	125.14mm	125.22mm	74.19mm	72.90mm
Horizontal Setting	73.03mm	72.90mm	30.64mm	29.69mm
Machine Center to Back - Mounting Distance	.06mm	.05mm	−7.62mm	−7.85mm
Helical Lead	0	0	39.48mm	38.99mm
Machine Spiral Angle	30°34′	30°33′	31°25′	32°48′

*Formate and Helixform are registered trademarks of the Gleason Works.

Table 2 contains the cutter specifications which are the same for both methods.

Table 2

Cutter Specifications	FORMATE	HELIXFORM
Nominal Cutter Radius	152.4mm	76.2mm
Blade Angles I.B.	22°30′	10°0′
O.B.	22°30′	28°0′
Point Width	2.54mm	2.03mm

In summary, Part 1 of the paper verifies, by using a completely different approach, the correctness of the present Formate and Helixform gear machine calculations.

Part 2: Machine Setting Calculations for the Pinions of Formate and Helixform Gears

This part of the paper presents a method for calculation machine settings to generate pinions that match Formate and Helixform gears [1]. First and second order contact characteristics are held to prescribed values. Several different pinion setups will satisfy these prescribed conditions. Gleason formulas were used to calculate the examples in the paper using the same set of conditions with the following exception. The meaning of the author's factor for contact pattern length was not fully understood. Therefore, we chose to hold the same cutter specifications as those used in the paper. Table 3 shows a comparison of the basic pinion machine settings for both the Formate and Helixform cases.

To evaluate and compare the meshing quality of sets calculated by the two methods, edge contact TCA's were calculated and plotted. The Formate comparison is shown in Fig. 1 with the TCA of the Litvin/Gutman settings on the left and the Gleason TCA on the right. Pattern length is the only significant difference between the TCA's. Since the same tool geometry was used in each case, the shorter length produced by the Litvin/Gutman setup is due to greater mismatch being introduced in the generation.

Fig. 2 is the TCA comparison for the Helixform set. Again the Litvin/Gutman TCA is on the left. Only small insignificant higher order differences can be noted. This comparison provides the opportunity to make an interesting observation. The Helixform method in its simplest form is a conjugate method of generation. In the example used here only lengthwise mismatch was introduced. In the Gleason *pinion setup: the machine root angle is equal to zero;* the offset is equal to the running offset; the head setting is equal to zero; and the ratio of roll is equal to the ratio of the number of teeth in the members. The calculation method used in the paper gives a machine setup which is substantially different as shown in Table 3. Yet, the TCA's are not significantly different. It demonstrates that meshing quality is not a function of a conjugate calculation method but depends on the ability to define and hold contact characteristics.

In summary this part of the paper provides an alternate method for calculating machine settings which will produce pinions that match Formate and Helixform gears.

Part 3: Analysis and Optimal Synthesis Methods for

Table 3

	FORMATE		HELIXFORM	
Basic Pinion Machine Settings	Litvin/Gutman	Gleason	Litvin/Gutman	Gleason
Machine Root Angle	−2°30′	−4°16′	0°0′	0°0′
Sliding Base	26.77mm	23.70mm	9.39mm	7.46mm
Blank Offset	25.49mm	23.75″	34.33″	31.75″
Heat Setting	−10.98mm	−5.36mm	−.54mm	0.0mm
Radial	133.09mm	134.59mm	84.30mm	80.58mm
Cradle Angle	84°2′	76°58′	89°50′	86°35′
Tilt Angle	9°7′27″	11°18′	16°14′23″	15°16′
Swivel Angle	307°11′41″	319°53′	332°35′58″	340°17′
Ratio of Roll	6.051437	6.29527	4.856019	4.777778

Table 4 contains the pinion cutter specifications

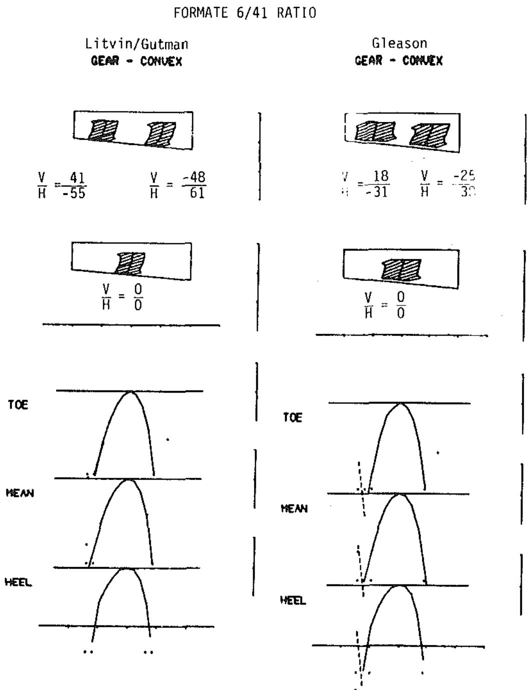


Fig. 1

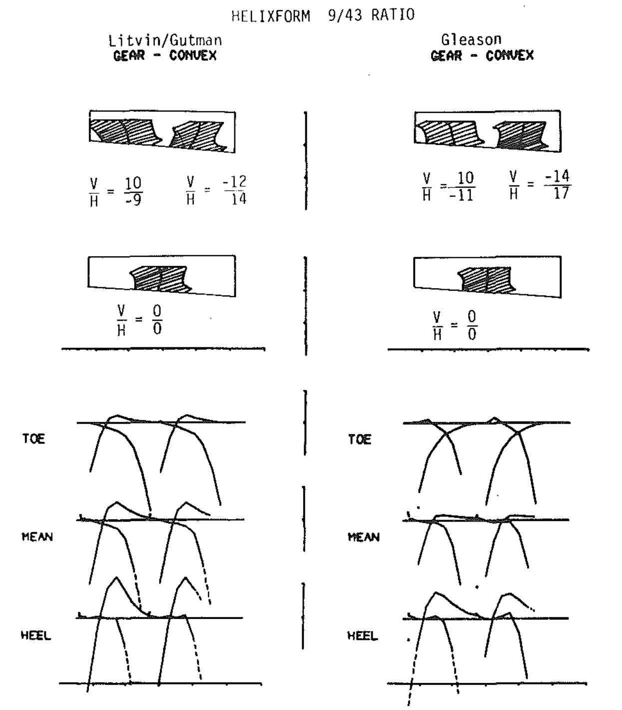


Fig. 2

Mismatch Gearing and It's Application for Hypoid Gears of Formate and Helixform.

In their first paper [2] Litvin and Gutman purposed a method for controlling the curvature of the path of contact. In the last part of this paper a method for minimizing the change in the motion variation as the contact is shifted on the face of the gear tooth is established. The concern which the authors are addressing in both of these papers is for control of third order contact characteristics in the manufacture of spiral bevel and hypoid gears. Gleason, as stated in the first discussion [1] has long been aware of the importance of these higher order characteristics. The approach we prefer is covered in that first discussion. It consists of a procedure to calculate the six third-order characteristics, a definition of a weighting function to establish their relative importance and an optimization technique to minimize the function by changing the machine setup.

In summary Litvin and Gutman in this last part of the paper have pinpinted an important contact characteristic and have set up a procedure for controlling it by changing pinion machine settings. Five other characteristics of equal rank exist and deserve equal treatment.

General Summary: This is an excellent theoretical paper in which alternative methods for calculating machine settings for manufacturing spiral bevel and hypoid gears are purposed. The calculation procedures and machine settings differ from Gleason's but TCA shows them to be correct. In calculations, where meshing contact is optimized, we look at all third-order characteristics as opposed to the one characteristic of motion variation along the tooth which is considered in the final part of the paper.

Author's Closure

We highly appreciate the thorough analysis of our four papers made by Mr. T. Krenzer (Gleason Works), Professor R. S. Husten and Mr. V. Simon.

In addition to his theoretical analysis, Mr. Krenzer calculated the machine settings and the tooth contact analysis with the Gleason Computer Programs and compared them with our results. We consider the coinciding of our results with the Gleason results as our important achievement, knowing the high theoretical and practical experience of Gleason collaborators.

Methods of our paper "A Method of Local Synthesis of Gears Grounded on the Connections Between the Principal and Geodetic Curvatures of Surfaces" are directed to improve the local synthesis in the neighborhood of the mean contact point. But this is only the first step. The second step must be to optimize the meshing over the entire area, as described in the third part of the paper titled "Analysis and Optimal Synthesis Methods for Mismatch Gearing and Its Application for Hypoid Gears of 'Formate' and 'Helixform'."

We think it is important to emphasize that the methods proposed in our papers may be applied not only for hypoid and spiral bevel gears but also for other types of gears. In our opinion some results, for instance, general relations between principal curvatures, principal directions and geodetic curvatures of contacting surfaces, are new not only in the field of theory of gearing but in the differential geometry too. Maybe the same can be stated for the methods of local and optimal synthesis of contacting surfaces and for the new method of tooth contact analysis.

We agree with Professor Husten that the topic of our papers is a complicated one, but this results from the nature of the problems to be solved. And then our papers are completed with practical results – with working equations and computer programs for the calculation of machine settings for the to-be-generated gears.

It is surprising for us that Mr. Simon, who favored his own methods to ours, did not mention that he applied methods and equations which were proposed in the book [*a*] and papers [*b*,*c*] by F. Litvin and published many years ago.

We are very thankful to ASME for the opportunity to present our papers at the Power Transmission and Gear Conference (San Francisco 1980) and for publishing them in this journal. We are very thankful to our reviewers.

Additional References

a *The Theory of Gearing* by F.L. Litvin, Russian Edition in 1968, Hungarian Edition in 1972.

b "The Synthesis of Approximate Meshing for Spatial Gears," *J. Mechanisms*, Vol. 4, 1968, pp. 187-191.

c "The Mathematical Modelling and Optimization of Approximate Meshing of Gears," (in Russian), *Proceedings of the Third World Congress for the Theory of Machines and Mechanisms*, Kupari, Yugoslavia, 1971.

the unit normal vector at the main contact point which is given in the fixed coordinate system S_o.

The fulfillment of equations (70) and (71) guarantees the tangency of surfaces at the main contact point. Equation (72) guarantees that the instantaneous ratio of the gear-drive will be equal to the theoretical one. Equations (70), (71) and (72) permit one to obtain the machine and tool settings for gear cutting.

In accordance with the initial conditions of synthesis, the number of equations (73) may be equal four or five. Five equations must be obtained to satisfy equalities (65), equality $\Delta_2{}^* = 0$ (see equalities (65) and expression (69). In some cases of synthesis the requirement that $H_g{}^{(1)} = o$ is omitted (it declines the observing of equality $\Delta_2^* = o$). Then the number of necessary equations is equal four.

The fulfillment of equations (73) guarantees the optimization of meshing conditions in the vicinity of the main contact point. From these equations are determined the parameters of curvatures of both surfaces Σ_1 and Σ_2. When it is desired that one of these parameters must be a variable, it is necessary to omit the equation $H_g{}^{(1)} = 0$; and to vary in the process of synthesis the value of the derivative $U'_{21}(\phi_1)$ while holding it in acceptable limits.

An Example of a Local Synthesis of Hypoid Gear-Drive

The initial parameters are: the shortest distance between gear axes $E = 32$ mm; the theoretical value of ratio $U_{21} = N_1 : N_2 = 0.14634$ (N_i ($i = 1,2$) is the tooth number of gear i); the principal curvatures of surface Σ_2 are $H_s = 0$, $H_q = 0.00624$; the principal directions on Σ_2 are given by unit vectors $\mathbf{e}_s = (0.05321, -.32736, -0.94340)$, $\mathbf{e}_q = (0.66567, -0.71584, 0.21806)$; unit vectors $\mathbf{e}_s$ and $\mathbf{e}_q$ are projected on the axes of coordinate system S_C; the tangent to contact point path on surface Σ_2 has to coincide with unit vector $\mathbf{e}_s$; the coordinates of mean contact point in system S_o are (140.8, −5.15, −29.30); projections of unit normal vector $\mathbf{n}^{(M)}$ in the same system S_o are (−0.74435, −0.61677, −0.256); the approach of surfaces is $\delta = 0.007$ mm and the length of great axis of contact ellipsis is $2a = 18$ mm.

The following conditions must hold during synthesis (a) that the contact point path had to coincide at the mean contact point M with the geodetic line of surface Σ_2 (i.e., $H_g{}^{(2)} = o$); (b) that the derivative is $U'_{21}(\phi_1) = d/d\phi_1 (U_{21}) = -0.0008$

On the ground of article equations the following results were obtained: $G = 0.29053$ (see angle G in Fig. 3) $H_f = -0.03417$, $H_h = 0.00527$. After that, by known parameters of curvatures the machine and tool settings for gear cutting may be obtained.

Conclusion

An improved local synthesis method for gearings with approximate meshing is proposed. Unlike already known methods the proposed one is based: (1) on the connections between principal curvatures of two surfaces being: (a) point-contacted, (b) line-contacted; (2) on observing conditions under which the contact point path on the surface is a geodetic line in the local sense.

References

1 Baxter, M.L., "Exact Determination of Tooth Surfaces for Spiral Bevel and Hypoid Gears," AGME - paper, No. 139, Oct. 1966

2 Baxter, M. L., "Effect of Misalignment of Tooth Action of Bevel and Hypoid Gears," ASME - paper -61-MD-20

3 Baxter, J. L., Second-Order Surface Generation, *Industrial Mathematics,* Vol. 23, part 2, 1973

4 Litvin, F. L., *The Theory of Gearings,* 2nd ed., in Russian, Nauka, Moscow, U.S.S.R., 1968

5 Litvin, F. L., and Gutman, Ye. I., "Obtaining of Connections between Surface Principal Curvatures by Arbitrary Value of Derivative of Ratio Function," in Russian, Proceedings "Mechanika Mashin," Mauka, No. 45, 1974.

6 Litvin, F. L., and Gutman, Ye. I., "A Common Solution of the Problem of Analysis for Optimization Mismatch Gearings with Application to Hypoid Drives," in Russian, Proceedings "Mechanika Mashin", Nauka, No. 45, 1974.

7 Litvin, F. L., "Die Beziehungen zwischen de Krummungen der Zahnoberflachen bei raumlichen Verzahnungen," "Zeitschrift fur Angewandte Mathematik and Mechanik," ZAMM, H. II, 1969.

8 *Understanding Tooth Contact Analysis,* Gleason Works, Rochester, N.Y., SD/3139, 1970, USA

Discussion

T. Krenzer[1]. The authors are to be congratulated on presenting a very theoretical paper which shows a deep insight into the geometry of spiral bevel and hypoid gears. ASME is also to be commended for their recognition of this significant accomplishment. The paper proposes an optimum method for determining gear tooth meshing based on calculations at the mean point. The mathematical techniques and notation employed differ from that used at Gleason. However, the basic underlying philosophy is the same in that surfaces are defined by the relative position and motions between the generating tool and the work.

My discussion of this paper is divided into three parts. First, in order to provide a tool for evaluating meshing of spiral bevel and hypoid gears, the concept of tooth contact characteristics is introduced. Second, the authors' proposed procedure for calculating machine settings will be discussed relative to the above concept. Finally, the differences and similarities between the Gleason approach and the proposed method will be presented.

[1] Senior Research Staff Engineer, Gleason Works, June 19, 1980.

Contact Characteristics. To describe conditions of gear meshing, that is contact pattern and motion variations, on spiral bevel and hypoid gears, it is convenient to use a set of numbers called contact characteristics. These numbers can be ranked according to order; first, second, third, etc. We will not consider higher than third order.

Two numbers define position which is first order. They are ΔF, the distance along the face of the gear from the center point of contact, P, to the mid-point on the tooth surface, M, and Δh, the distance in the profile direction form point P to point M. ΔF and Δh can be seen in Fig. 1 which is a sketch of a gear tooth in the tangent plane.

Three numbers define second order. They are:

B = length of the contact pattern as a proportion of the face width.

β = angle measuring the bias direction of the path of contact. Figure 2 is a sketch of a gear tooth showing B and β.

Yo = amount of gear lag (retardation from its theoretical position) at the point where the motion transmission is transferred from one tooth to the next tooth. To better understand Yo, look at Figure 3 which is referred to as a motion diagram. Gear rotation is plotted on the abcissa and the variation in gear rotation is plotted on the ordinate. This is a typical

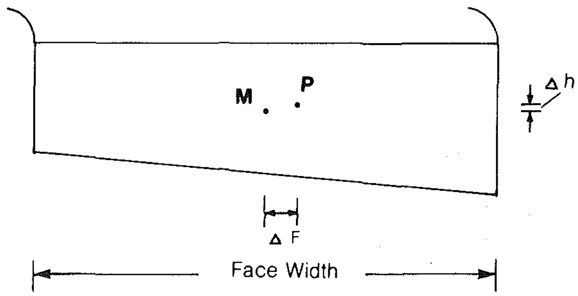


Fig. 1

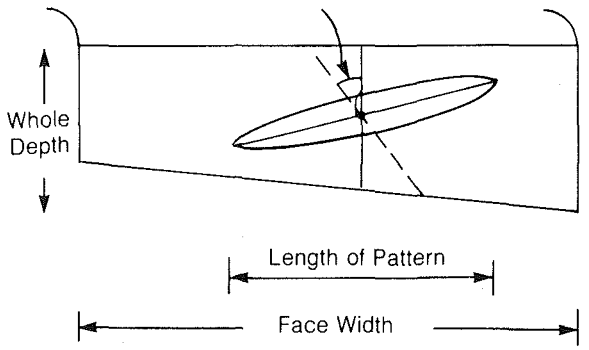
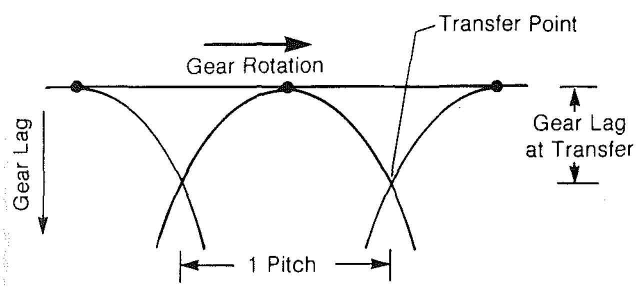


Fig. 2



Motion Diagram

Fig. 3

graph for a gear set where the tooth surfaces are relieved in the direction of the path of contact.

Six numbers define third order. They are:

ΔB_h = change in contact pattern length along the path of contact. See Fig. 4.

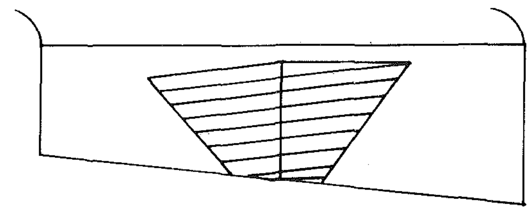
ΔB_F = change in contact pattern length along the face width. See Fig. 5.

$\frac{1}{\rho B}$ = curvature in the path of contact. See Fig. 6.

$\Delta\beta_F$ = change in direction of the path of contact along the face. See Fig. 7.

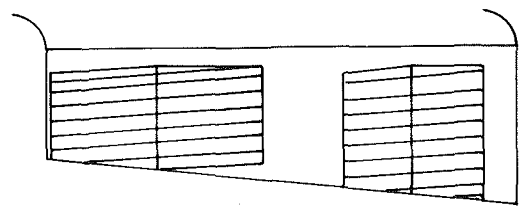
S_m = S-ness in the motion curve. See Fig. 8.

ΔM_F = change in curvature of motion curve along the face. See Fig. 9.



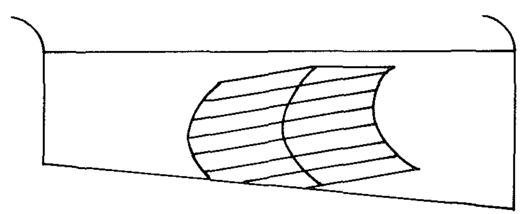
Change of Bearing Length
Along the Path of Contact

Fig. 4



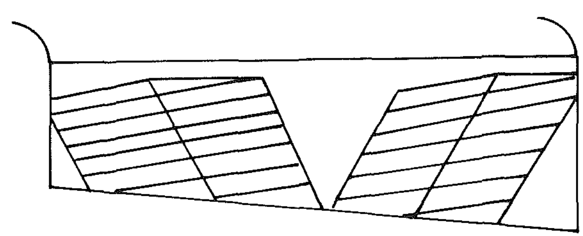
Change of Bearing Length
Along the Face Width

Fig. 5



Curvature in the Path
of Contact

Fig. 6



Change in Bias Along
the Face

Fig. 7

In defining changes in contact along the face, the effect of displacements, E, perpendicular to the plane of the gear and pinion axes and, P, along the pinion axis to shift the contact pattern along the face width are considered.

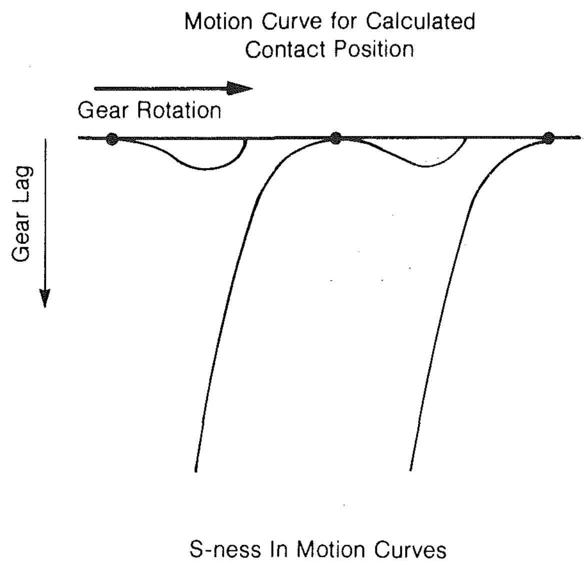


Fig. 8

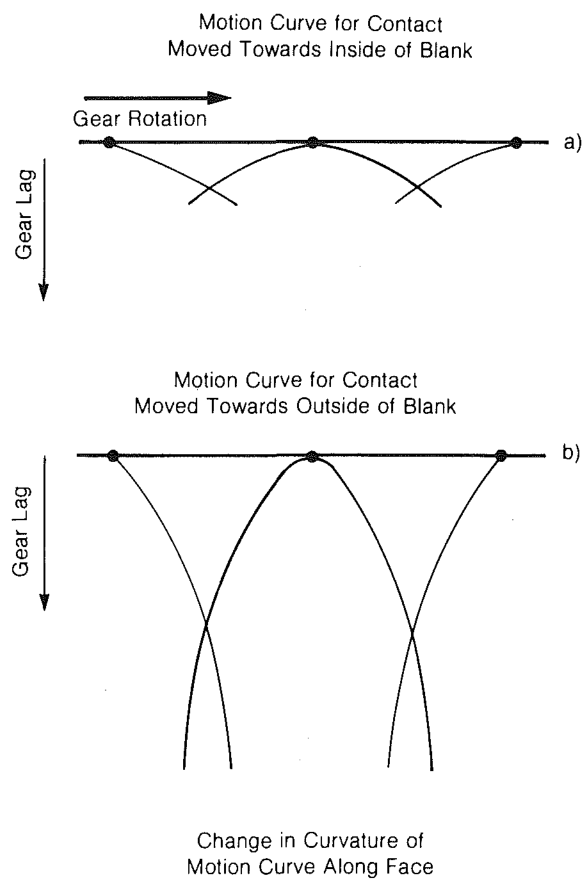


Fig. 9

Discussion of Paper Relative to Contact Characteristics. The paper recognizes the importance of defining tooth surfaces that hold specified first and second order characteristics. The authors go one step further in recognizing that curvature in the path of contact is a contact characteristic that should be controlled. They impose the condition that the triple scalar product of the contact normal at the mean point, the relative velocity between mating surfaces and the relative acceleration should equal zero. This insures no curvature in the path of contact which is in general a desirable contact characteristic.

Gleason has long recognized that contact characteristics beyond the second order must be considered when defining a desired contact condition, curvature of the path of contact is only one of the six third order characteristics. We believe that all third order is important and should be considered.

Procedures Presently in Use. We have successfully employed two methods to achieve desired third order contact: first TCA is used to evaluate machine setups which hold second order. The gear engineer then systematically changes the machine setups using the remaining available freedoms to give what he considers the optimum contact considering third order.

Our latest Formate* and Helixform* tilt programs calculate third order surfaces and third order characteristics. A weighted function is set up to define the relative importance of the third order characteristics and an optimizing technique is used in calculating a machine setup that minimizes this function.

Conclusion. In conclusion we agree with the authors on the need for machine setting calculations that include contact characteristics other than first and second order. Their procedure considers one such characteristic. We feel that this is not sufficient and have defined all the third order characteristics. Further, procedures have been set up to control these characteristics in the calculation of machine settings.

*Formate and Helixform are registered trademarks of the Gleason Works.

Discussion

R. L. Huston[1]. The authors propose a new method for determining cutting machine parameters to optimize the meshing kinematics. Because of the limitations of cutting machines and the restrictions of fabrication processes, the commonly used spiral bevel and hypoid gears have "approximate meshing" that is, the angular velocity ratio varies during the relative rotation of the gear and pinion. The essence of the authors' method, which is itself an approximation in the local sense and in the neglect of 3*rd* order terms, is to make the contact path coincide with a geodesic curve.

The reviewer finds this concept and method to be novel and intuitively satisfying. The development and exposition of it through differential geometry formulae however, is a bit abstract and it is probably not in a form which is immediately accessible to designers and engineers. Also, the style and notation may be difficult for some to follow. The reviewer believes the concept should be explained and developed further by the authors and/or other theoreticians with the objective of obtaining more explicit design criteria.

Finally, the paper should serve as a stimulus for further theoretical investigations of spiral bevel and hypoid gear meshing kinematics, and as such, it should be of interest to theoreticians and kinematicians, as well as designers.

[1] Professor of Mechanics, Department of Mechanical Engineering, University of Cincinnati, Cincinnati, Ohio.

Discussion

V. **Simon**[1]. These authors are to be congratulated for an excellent contribution to the geometry and kinematics of hypoid gears.

The papers treat the machine setting calculations for manufacture the formate or helixform gear and the generated pinion in case of line contact of their teeth, and the synthesis method for mismatched hypoid gear pair with point contact of the teeth surfaces. The presented method includes the determination of the machine setting parameters through local synthesis which provides the conjugation of the teeth surfaces at the mean contact point and the optimization of the same parameters to decrease the maximum displacement error of the driven gear. Such a calculation ensures the direction of the path of contact only in the vicinity of the mean contact point and defines the instantaneous contact elipse for dry contact (omitting lubrication on the basis of the teeth surface curvatures. However, due to the actual operating conditions, a more complete optimization of the separation and the meshing of teeth surfaces, and consequently a more complete optimization of the corresponding machine setting parameters is needed. Such an optimization is presented in [A.1], based on the following conditions:

1. At the initially selected point of contact M (Fig. A1) the velocity ratio of the gear pair has the predicted value.
2. In the position of the gear and the pinion, with M as the contact point, the separation of the teeth surfaces in the point N is the desired Δn (N would be a point of the instantaneous contact line of the teeth surfaces in case of nonmismatched gear pair).
3. The path of contact should pass through an arbitrarily selected point L and the error in displacement of the driven gear against rotation of the driver pinion at the contact in the point L should not exceed the allowed value.
4. The angle of the tangential cone of the pinion root surface, in the middle of the tooth width, has the predicted value.

The mathematical interpretation of these conditions offers a systems of 22 simultaneous equations with 22 unknowns. Among the unknowns are 7 of the machine setting parameters for pinion manufacture.

The importance of such a complex optimization was proved by the results of the full thermoelastohydrodynamic analysis of the lubrication of hypoid gears. By applying the method presented in [A.2], the influence of the separation of the teeth surfaces in the point N (Δn) on the load carrying capacity of the oil film was calculated. Fig. A2 shows the obtained results.

It can be seen that the sensitivity of the load carrying capacity to the separation of the teeth surfaces is considerable. Therefore, the proper choice of the amount of mismatch is very important for maintaining optimal operating characteristics of hypoid gears, and a complete optimization of the corresponding machine setting parameters is necessary.

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References

A1 Simon, V., "Optimization of the Geometry and Kinematics of the Hypoid Gears," *Fifth World Congress on Theory of Machines and Mechanisms*, Montreal, Sept. 1979.

A2 Simon, V., "Elastohydrodynamic Lubrication of Hypoid Gears," *Third International Power Transmission and Gearing Conference*, San Francisco, Aug. 1980.

A3 Simon, V., "Tooth Contact Analysis for Modified Hypoid Gears," *Fourth World Congress on Theory of Machines and Mechanisms*, Newcastle upon Tyne, Sept. 1975.

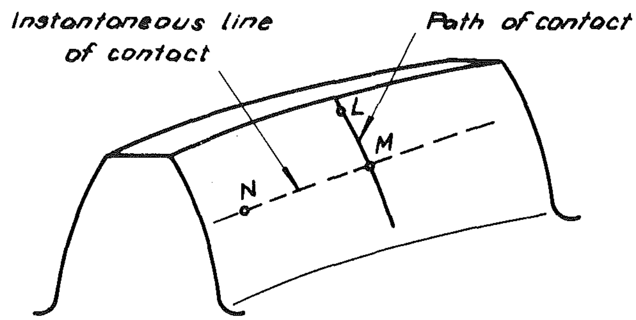

Fig. A1 Position of *M*, *N*, and *L* characteristic points on the gear tooth

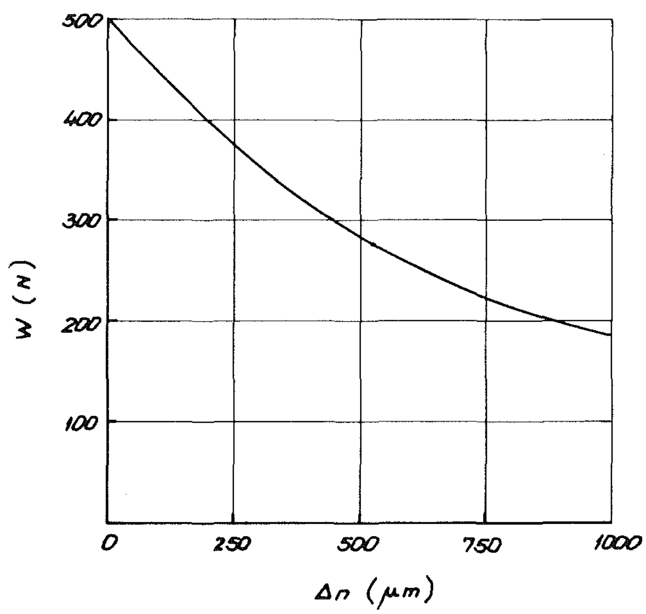

Fig. A2 Performance curve for various teeth surface separations