KAPCSOLÓMEZŐ AXIÁLIS MÉRETÉNEK MEGHATÁROZÁSA FERDE FOGÚ HENGERES KÜLSŐ FOGAZATÚ FOGAS-KERÉKPÁR KAPCSOLÓDÁSÁBAN

DETERMINING THE AXIAL SIZE OF THE CONTACT ZONE IN THE MESHING OF CYLINDRICAL EXTERNAL HELICAL GEARS

Drágár Zsuzsa, Dr. Kamondi László PhD
University of Miskolc, Institute of Machine and Product Design

ÖSSZEFOGLALÁS
A tanulmány a ferde fogú hengeres külső fogazatú fogaskerékpárok kapcsolómezőjének tengelyirányú (axiális) méretének meghatározásával foglalkozik, általánosítva a kapcsolómező alakjától függetlenül. A nem szimmetrikus fogazatok jellemzője, hogy a szerszám alapprofilszögeik nem azonosak. A fogaskarékpárok tervezésénél gyakori megoldási lehetőség, hogy a fogszélességek nem azonosak és nem egyenlőek a homlokfelületek közötti távolságok, tehát nem szimmetrikus az elrendezés. A szerelés következtében is lehet elhelyezkedési eltérés, de ez általában nem számottevő, de az alkalmazott módszer alkalmas e jelenség kezelésére is.

1. INTERPRETING THE TOP LAND MERIDIAN OF MESHING GEARS

The meshing gears determine the contact zone, its shape and the meshing characteristics with the meridian of the top land surface and their tooth widths [1, 2, 6, 7]. The top land meridians can map a regular square-shaped or different contact zone. Typical top land meridians are illustrated in Figure 1.

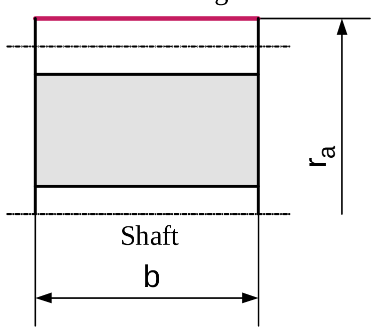

Figure 1. a)

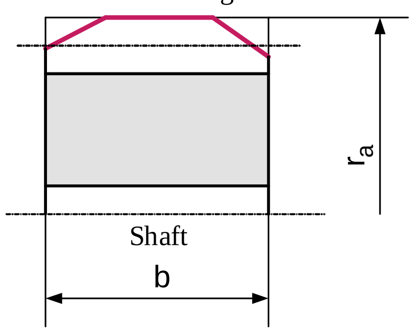

Figure 1. b)

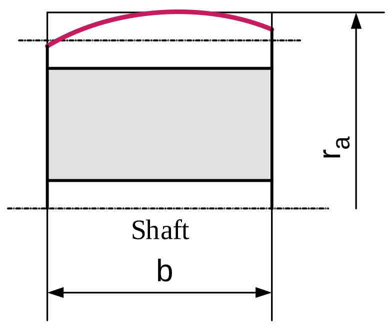

Figure 1. c)

Figure 1. Possible cases of top land meridians

The Figure 1. a) shows a straight line parallel to the axis of rotation, which produces the well-known cylindrical gear body by rotating it around the axis. The Figure 1. b) shows that the meridian is created from straight lines forming an angle with the axis and rotates it. The Figure 1. c) applies an arbitrary higher-order curve and rotates it around the axis to create the top land surface. The top land surface of the meshing gears can be produced with different meridians. It always depends on which parameter of the contact zone needs to be optimized. The top land meridians determine the shape of the contact zone [5]. The independent, straight meridian parallel to the axis forms a regular rectangular contact zone, the ones that differ from this form a generalized contact zone.

2. POSSIBLE RELATIVE POSITIONS OF THE GEARS

In addition to the top land meridians, the contact zone is also determined by the width of the gears and the position of the widths relative to each other [3]. In addition to the strength conditions, the width of the gears is also influenced by the manufacturing accuracy and the place of installation. Depending on the place of installation, whether the gear wheel is located as a console or between bearing supports can be characteristic. The width of the gears is often not the same either. Figure 2 shows an example of installation cases that also affect the width of the contact zone.

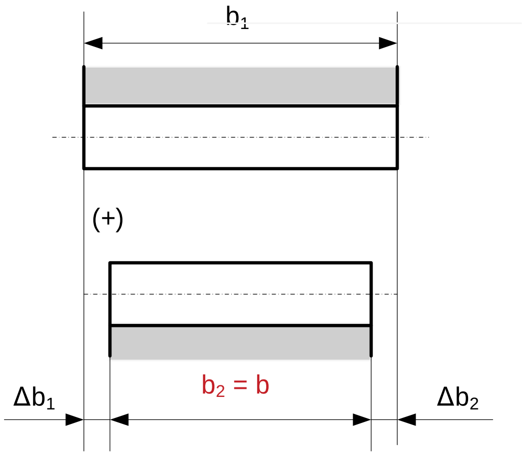

Figure 2.a) Drive gear is wider.

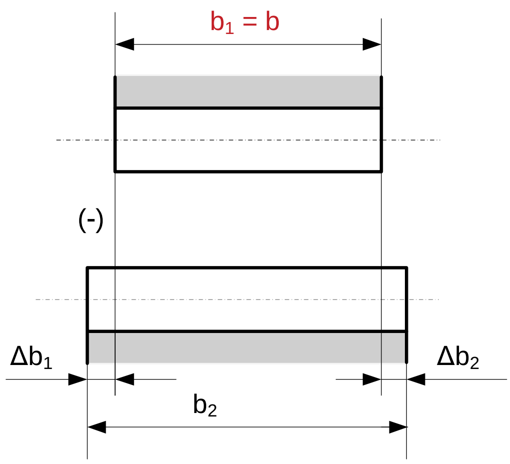

Figure 2. b) Drive gear is narrower.

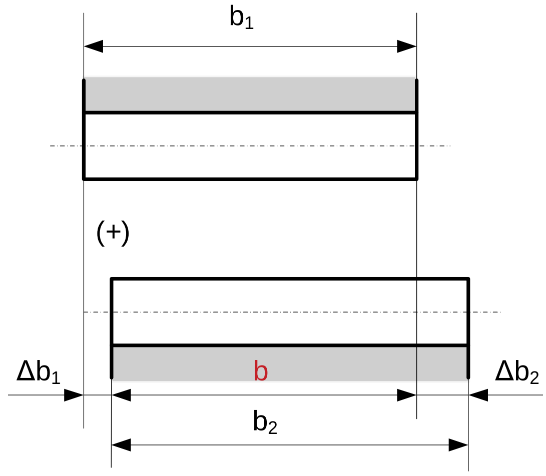

Figure 2. c) The gears are in any arrangement.

Figure 2. Arrangement cases of gears

3. GENERALIZED DEFINITION OF THE WIDTH OF THE CONTACT ZONE

An important part of the examination of the contact zone is the placement of the gear teeth geometry in the common contact zone [4]. On the one hand, this means determining the common width of contact zone depending on the arrangement. On the other hand, the derivative meridians must also be transformed into the contact zone, thus defining the lower and upper wrapping curves of the zone (zone lower border and zone upper border). Now we are only concerned with determining the common tooth width. For this, we introduce the coordinate system connected to gears (Figure 3).

Place a coordinate system $O_i(y_i, z_i)$ $(i=1,2)$ for each gear at the intersection of the bisector of the width of the gears $(b_i/2)$ and a component belonging to an arbitrary radius $(r_{a,i})$. The widths of gears b_i and the positioning parameter (placement size) Δb_1 can be found in the design drawing documentation. The three data determine the position of the gears in relation to each other, the opposite side deviation size Δb_2, thus enabling a generalized test. The value of Δb_1 must be specified according to Figure 2, with the correct sign. The third coordinate system $O(y,z)$ should be located in half of the common tooth width $(b/2)$ and on the component containing the pitch point (C).

Figure 2 also shows that

$$b_1 > b_2,$$
$$b_1 < b_2$$

base cases and $b_1 = b_2$ special situations may be the subject of the investigation.

Examining Figure 3, three additional basic cases can be distinguished, regardless of how the tooth widths are related to each other:

$$\Delta b_1 \le 0 \tag{1}$$
$$0 < \Delta b_1 \le |b_1 - b_2| \tag{2}$$
$$\Delta b_1 > |b_1 - b_2| \tag{3}$$

Examining the individual arrangement phases only for the basic case $b_1 > b_2$, the following relationships can be written. The parameters Δy_1 and Δy_2 represent the offset of the coordinate systems.

In the range $\Delta b_1 \le 0$:

$$\Delta b_2 = b_1 - \Delta b_1 - b_2 \tag{4}$$
$$b = b_2 + \Delta b_1 \tag{5}$$
$$\Delta y_1 = 0,5 \cdot (b_1 - b) \tag{6}$$
$$\Delta y_2 = 0,5 \cdot (b - b_2) \tag{7}$$
$$\Delta y_{12} = |\Delta y_1| + |\Delta y_2| \tag{8}$$

In the range $0 < \Delta b_1 \le |b_1 - b_2|$:

$$\Delta b_2 = b_2 + \Delta b_1 - b_1 \tag{9}$$
$$b = b_1 - (\Delta b_1 - \Delta b_2) \tag{10}$$
$$\Delta y_1 = 0,5 \cdot (b_1 - b) \tag{11}$$
$$\Delta y_2 = 0,5 \cdot (b - b_2) \tag{12}$$
$$\Delta y_{12} = |\Delta y_1| + |\Delta y_2| \tag{13}$$

In the range $\Delta b_1 > |b_1 - b_2|$:

$$\Delta b_2 = b_2 + \Delta b_1 - b_1 \tag{14}$$
$$b = b_1 - \Delta b_1 \tag{15}$$
$$\Delta y_1 = 0,5 \cdot (b_1 - b) \tag{16}$$
$$\Delta y_2 = 0,5 \cdot (b - b_2) \tag{17}$$
$$\Delta y_{12} = |\Delta y_1| + |\Delta y_2| \tag{18}$$

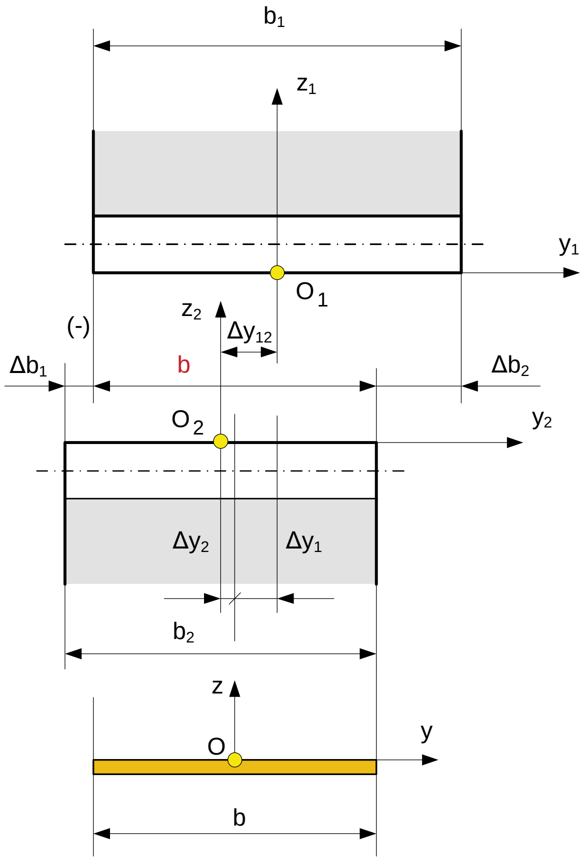

Figure 3. Interpretation of common tooth width

Table 1 illustrates the change of the common width of the contact zone in relation to the width of the gears.

Table 1. Change of the common tooth width

	$b_1 > b_2$	$b_1 < b_2$
$\Delta b_1 \le 0$	$b < b_2$	$b < b_1$
$0 < \Delta b_1 \le \|b_1 - b_2\|$	$b = b_2$	$b = b_1$
$\Delta b_1 > \|b_1 - b_2\|$	$b < b_2$	$b < b_1$

The character of the change of the common tooth width and the coordinate shifts is clearly shown by the gear pair, where the tooth widths (b_1, b_2) and the positioning parameter (Δb_1) can be changed (Table 2). The quantities in the table are in mm.

4. CONCLUSION, RESULTS

The article presented the determination of the axial size (common tooth width) of the contact zone depending on the installation arrangement of cylindrical external gears with helical teeth. Knowledge of the width of the contact zone is necessary to examine changes in the zone. The additional boundary elements of the contact zone (lower and upper wrapping curves) are determined by the top land meridians. The coordinate systems connected to the gears are not the same as the coordinate system of the contact zone, so it was necessary to determine the extent of the displacements so that the necessary analyses could be performed automatically with the knowledge of the construction drawings. The presented figures and revealed connections significantly help this work.

Table 2. Example for change of common tooth width

	$\Delta b_1 \le 0$					$0 < \Delta b_1 \le \lvert b_1 - b_2 \rvert$			$\Delta b_1 > \lvert b_1 - b_2 \rvert$	
b_1	100	100	100	100	100	100	100	100	100	100
b_2	80	80	80	100	100	80	80	80	80	80
Δb_1	-5	-2	0	-2	0	10	15	20	30	30
Δb_2	25	22	20	2	0	-10	-5	0	10	10
b	75	78	80	98	100	80	80	80	70	70
Δy_1	12,5	11	10	1	0	10	10	10	15	15
Δy_2	-2,5	-1	0	-1	0	0	0	0	-5	-5
Δy_{12}	15	12	10	2	0	10	10	10	20	20

5. REFERENCES

[1] Graf, H.-CHR. (1965). Die Entwicklung der Zahrad-Technik. Springer-Verlag. Berlin. P.: 1/532.

[2] Erney, Gy. (1983). Fogaskerekek. Műszaki Könyvkiadó. Budapest.

[3] Litvin, F. L. (1972). A fogaskerékkapcsolás elmélete. Műszaki Könyvkiadó. Budapest.

[4] Niemann, G., Winter, H. (1983). Maschinenelemente. Band II. Zweite Auflage. Springer Verlag. Berlin. P: 1/376. https://doi.org/10.1007/978-3-642-17468-1

[5] Drágár, Zs., Kamondi, L. (2018). A fogalak szerepe a fogazott elempárokat tartalmazó hajtásláncokban. In: Csibi, Vencel-József; Barabás, István (szerk.). OGÉT 2018: XXVI. Nemzetközi Gépészeti Konferencia: 26th International Conference on Mechanical Engineering.: OGÉT 2018. Marosvásárhely, Románia: Erdélyi Magyar Műszaki Tudományos Társaság (EMT) 544 p., pp. 232-235., 4 p.

[6] Roth, K. (1989). Zahnradtechnik. Band I. Stirnradverzahnungen-Profilverschiebungen, Toleranzen, Festigkeit. Springer Verlag. P.: 1/250.

[7] Roth, K. (1989). Zahnradtechnik. Band II. Stirnradverzahnungen-Geometrische Grundlagen. Springer Verlag. P.: 1/247.