СЕКЦІЯ 1.
ТЕХНОЛОГІЧНІ ПРОЦЕСИ ТА СИСТЕМИ МАШИНОБУДІВНОГО ВИРОБНИЦТВА

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CROSSED-AXES GEARING WITH HIGH-CONFORMAL CONTACT IN THE LENGTHWISE DIRECTION OF THE GEAR TEETH

Crossed-axes gearing (or just C_a – *gearing*, for simplicity) are used to smoothly transmit a steady rotation from the input shaft to the output shaft when the axes of rotation in a gear pair cross with one another. Worm gearing, hypoid gearing, spiroid gearing, face gearing, as well as numerous of other designs of gearing, perfectly illustrate the concept of C_a – *gearing* [3].

Design and production of gears that feature the highest possible power density is the mainstream of the present-day theory and practice of gearing. In case of C_a – *gearing*, the so-called $R-$*gearing* is used to improve the power density of gear-sets. $R-$*gearing* is a kind of geometrically-accurate C_a – *gearing* with line contact of the gear teeth [3]. Due to line contact, kinematic pairs of this sort (in $R-$*gearing*) become extremely sensitive to the displacements of the components in relation to one another [2]. The sensitivity to the displacements can be drastically reduced if line contact is substituted with point contact of the interacting tooth flanks $\mathscr{G}$ and $\mathscr{P}$ of a gear and its mating pinion. In crossed-axes gearing with high-conformal contact in the lengthwise direction of the gear teeth[1] the said substitution is managed so as to minimize losses of the bearing capacity of the tooth flanks $\mathscr{G}$ and $\mathscr{P}$. From this stand-point, the C_a – *gearing* of the design under consideration resemble the earlier developed high-conformal gearing of known design [1].

The concept of the proposed design of crossed-axes gearing with high-conformal contact in the lengthwise direction of the gear teeth is briefly outlined below.

It makes sense to begin the discussion from a brief analysis of principal features of $R-$*gearing*.

In $R-$*gearing* (see Fig. 1), a gear and a mating pinion tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, interact with one another along a line of contact, LC_{nom}, of a certain length, l_{LC}. Aiming a reduction of sensitivity of $R-$*gearing* to the linear and angular displacements of the gears in relation to one another under operating load, the length, l_{LC}, can be reduced to a

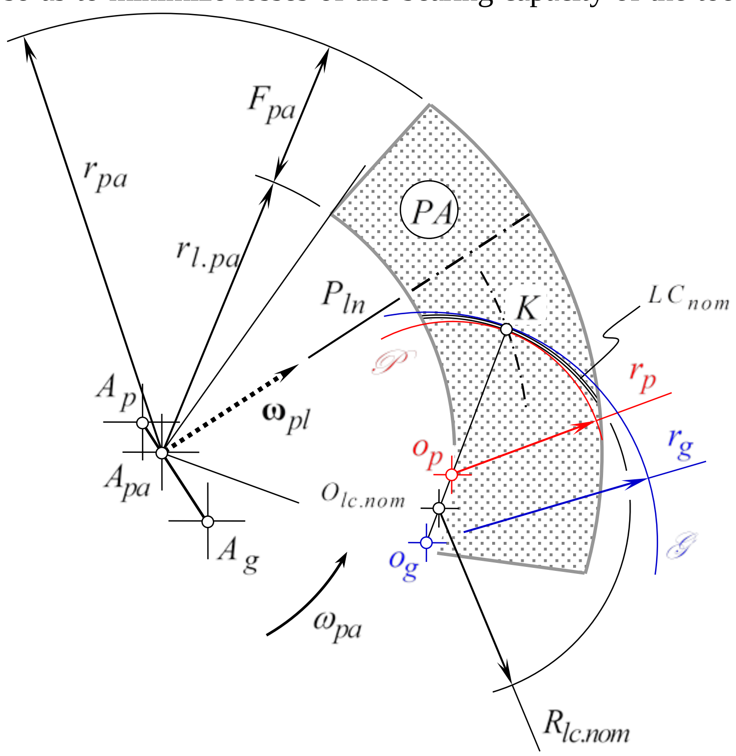

Fig. 1 – Schematic of crossed-axes gearing with high-conformal contact in the lengthwise direction of the gear teeth.

[1] Patent pending.

zero length ($l_{LC} = 0$). The rest of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, of a gear and a mating pinion are relieved. The line of contact of a zero length (contact point, K) traces paths of contact, P_c, on each of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$. The gear and the mating pinion teeth are relieved in their lengthwise direction in order to eliminate the not-functional portions of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, from interaction with one another. Under a light operating load, the displacements of the gears are of minimum values, and the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, are in point contact. Under a nominal operating load, the actual displacements of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, reach their nominal values. In this event the contact point spreads over a contact patch. The gears are designed so, as to ensure a maximum possible degree of conformity at contact point of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, in their lengthwise direction. Tooth flank geometry in the gearing (see Fig. 1) can be viewed as a kind of gear tooth flank lengthwise modification.

Profile of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, in the lengthwise direction of the gear and the pinion teeth can be shaped in a form of circular arcs centered at points o_g and o_p, correspondingly. The centers, o_g and o_p, are situated within a common perpendicular to the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, at point, K, of their contact. Actual values of the radii, r_g and r_p, of the circles are selected so, as to ensure high-conformal contact of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$. This means that the difference $\Delta r = r_g - r_p \leq [\Delta r]$, where the $[\Delta r]$ is the critical value (threshold) that separates conformal contact from high-conformal contact of the tooth flanks, $\mathscr{G}$ and $\mathscr{P}$, [1], [2].

Equality of the angular base pitches of a gear ($\varphi_{b.g}$) and that of its mating pinion ($\varphi_{b.p}$) to the operating base pitch of the gear pair ($\varphi_{b.op}$) is another important consideration in crossed-axes gearing with high-conformal contact in the lengthwise direction of the gear teeth. Fulfillment of the set of equalities:

$$\begin{cases} \varphi_{b.g} = \varphi_{b.op} \\ \varphi_{b.p} = \varphi_{b.op} \end{cases} \tag{1}$$

is a must in design geometrically-accurate gearing. As the gearing of the proposed design is a kind of approximate gearing, therefore, it is required to minimize the differences $|\varphi_{b.g} - \varphi_{b.op}| \to \min$, and $|\varphi_{b.p} - \varphi_{b.op}| \to \min$ when calculating coordinates of the centers, o_g and o_p.

Point contact ($l_{LC}=0$) gives an opportunity designing C_a gear pairs with conformal/high-conformal contact in the lengthwise direction of the gear teeth (certain similarity with Novikov/conformal/high-conformal gearing with favorable contact in transverse section of the gear teeth is observed).

The proposed design of crossed-axes gearing with high-conformal contact in the lengthwise direction of the gear teeth is the best possible compromise between geometrically-accurate line contact *C_a–gearing* (namely, *R– gearing*), and between point contact *C_a– gearing* of any other design.

References

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